# Dairy Manure Anaerobic Digester Feasibility Study Report

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October 21, 2009

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# Executive Summary

In August of 2009 discussions were started between Volbeda Dairy, EC Oregon and Northwest Dairy Association regarding the development of an anaerobic digester. A feasibility study was initiated to determine if digestion is a technically and financially viable option for converting dairy manure to energy at the farm. To that end, EC Oregon assessed dairy manure degradability, reviewed relevant literature, identified locally available additional feedstocks, researched technology options, estimated energy/co-product outputs and system costs and produced pro forma financial analysis. The study was funded by the Energy Trust of Oregon and a Community Renewable Energy Feasibility grant from the Oregon Department of Energy.

Anaerobic digestion of dairy manure is proven technology, immediately available for commercial applications from an ample number of qualified vendors with flexible designs. For the most part, on farm practices at Volbeda Dairy are technically compatible with anaerobic digestion. However, financial viability could be slightly improved if the farm switched to scrape manure collection.

EC Oregon has not, to date, discovered a realistic combination of capital expenditure, operations and maintenance costs, conversion efficiencies, product price points and incentives that allows a manure-only digester to be profitable at a level required to attract investors. The widely preferred approach in Germany and Austria (the world leaders in AD) is to use “complete mix” digester technology operating at mesophilic temperatures while utilizing multiple co-digestion feedstocks. The ability to accept a wide variety of co-digestion feedstocks provides complete mix biogas plants a measure of operational security over conversion technologies. Based on this fact in conjunction with recent vendor responses, it is recommended that Volbeda Dairy consider a co-digestion scenario with a complete mix digester and a CHP in which electricity is sold under a “sell all” power purchase agreement.

A scenario is proposed that offers feedstock flexibility, consistent methane production, pathogen reduction, nutrient management, high quality fiber bedding and odor control. The potential for diversified revenue and/or avoided costs to the dairy could help mitigate recent fluctuations of milk prices and energy and feed costs. The proposed co-digestion scenario using straw and fats/oils/greases produces biomethane at a rate of approximately five times that of a manure only approach. However, financial modeling using conservative, yet realistic assumptions, results in returns that are likely not adequate to attract investment interest. The proposed biogas plant requires an initial capital expenditure of $6.8M, has a return on investment of 16.9 years and 7.6% internal rate of return.

Sensitivity analysis identified critical variables; the following methods are recommended to improve overall financial viability:

- Identify measures to mitigate straw acquisition costs
- Secure sources of food processor waste, potentially garnering tipping fees
- Incorporate straw as bedding to increase fiber revenues
- Negotiate a power purchase agreement exclusive of published utility rate schedules

# 1. Introduction – Project Details

## 1.1 REPORT ORGANIZATION

Thorough assessment of all technical and financial aspects of anaerobic digestion feasibility is a complex undertaking. In an effort to make the effort's results accessible, the body of the report has been distilled down to the essentials. However, supporting detail has been placed in appendices, arranged by chapter. This supplementary information is not required reading, but is made available for interested parties.

## 1.2 PROJECT ORIGIN/PARAMETERS

In August 2009 discussions were started between Volbeda Dairy, EC Oregon and Northwest Dairy Association regarding a feasibility study for an anaerobic digester. The Volbeda Study was fully funded, in part by a Community Renewable Energy Fund (CREF) grant awarded to EC Oregon by the Oregon Department of Energy; matching funds were provided by the Energy Trust of Oregon. The study was initiated in September 2009 to determine if AD is a technically and financially viable option for converting dairy manure to energy at the Volbeda Dairy farm in Albany, Oregon. To that end, EC Oregon assessed dairy manure degradability, reviewed relevant literature, identified locally available additional feedstocks, researched technology options, estimated energy and co-product outputs, and system costs and produced pro forma financial analysis.

## 1.3 EXISTING OPERATIONS

Volbeda Dairy is a conventional dairy permitted for 3,045 cows. Bedding is currently paper pulp, but the dairy is considering switching to composted manure solids or composted digestate solids. All barns are freestall barns with flush manure collection. Solids are captured at a 60% efficiency rate by a Biolynk System separator from Daritech. After flocculation and settling steps, recovered water is recycled for flushing. Other water is sent to a 4 cell lagoon with 120 acre-feet capacity. Volbeda Dairy has 351 acres of cropland to apply manure to, but 176 acres can only accept manure solids. An adjacent grass seed grower (Stutzman) accepts both solid and liquid manure for his 126 acres. A nearby grower (Eicher) currently accepts manure solids on their 185 acres; a pipeline is planned to supply this acreage with liquid manure in the future.

**Table 1 Current herd distribution**

| Milkers | Dry Cows/Heifers | Total Head |
|---|---|---|
| 1,450 | 525 | 1,975 |

## 1.4 ISSUES OF CONCERN

While dairy manure is being used as anaerobic digester feedstock in various scenarios throughout the world, it is by no means standard business practice; consideration must be given to the type and quality of livestock feed, rearing and handling practices, and potential antibiotic/hormone treatments. Numerous dairy manure anaerobic digesters exist in the U.S. – of the 135 farm-scale digesters reported to be operating in this country, 107 are located at dairy farms. These systems do not lend themselves to cookie-cutter application. The operational parameters of the dairy will determine the appropriate conversion technology, digester loading rate, biogas production and energy utilization specifics. Co-digestion substrate availability, heat recovery options and utility interconnection scenarios must also be identified for each project.

Therefore, each digester system must be designed to meet the specifics of the site and end product(s) desired.

Dairy manure is not a particularly energy dense AD feedstock; returns on dairy digesters are often marginal at best. EC Oregon has not, to date, discovered a realistic combination of capital expenditure, operations and maintenance costs, conversion efficiencies, product price points and incentives that allows a manure-only digester to be profitable at a level required to attract investors. Since most Oregon dairy farms typically do not have the fiscal means to secure financing without third-party investment (even for low cost digester options), this report assumes co-digestion of energy dense substrates to be a prerequisite to successful development.

Specifics of manure management and other farm practices could result in technically and financially challenging digester projects. For Volbeda Dairy areas of particular concern in this study include:

- The Volbeda Dairy collects manure by flush collection. Since digester technologies are designed to optimally handle specific ranges of total solids, the amount of moisture in a feedstock will dictate which technologies are suitable.

### 1.5 BENEFITS

Anaerobic digestion, when done properly, will generate diversified revenue while mitigating odor issues and providing nutrient management flexibility. This technology has the potential to solve waste handling problem while producing renewable gas, electricity, heat and fertilizer – a win-win for dairy farms, their neighbors and their utility providers.

Additional AD benefits include reduced lagoon loading, composting labor, and farm management of composted manure solids while providing potential bedding and non-clogging liquid fertilizer. Manure digester systems also have significant emission reduction benefits; methane is 21 times more potent than carbon dioxide as a greenhouse gas.

### 1.6 PROJECT GOALS & POTENTIAL SOLUTIONS

The Volbeda Dairy is interested in developing a biogas plant that utilizes the farm's manure provided digester management does not negatively impact current dairy practices. The surrounding agricultural land and proximity to an urban centers (Salem, Albany and Corvallis, Oregon) present numerous potentially suitable organic substrates for co-digestion. Potential co-generation of electricity and heat would also create an opportunity for the dairy to offset current propane use for water and space heating.

Dairy farms with more than 500 head are often quoted as being favorable for AD technology. However, at this level it is not clear if farms are actually generating revenue by installing an anaerobic digester or merely reducing waste management and energy costs. Volbeda Dairy is well above the suggested minimum size for successful AD development. Nevertheless, a feasibility study is necessary to optimize the farm's needs with an appropriate technology. Based on priorities from ongoing conversations with Volbeda Dairy, this feasibility study should determine the most appropriate technology that maximizes financial benefits while maintaining nutrient management compliance.

## 2. **Anaerobic Digestion Technology**

Anaerobic digestion (AD) is the controlled microbial decomposition of organic matter in the absence of oxygen. Biogas (mainly methane and carbon dioxide) is an end-product of AD. Traditionally, the primary use of AD has been to sanitize waste materials and reduce biological oxygen demand (BOD) and chemical oxygen demand (COD) associated with livestock operations, industrial facilities or municipal waste water treatment plants. The bio-methane in biogas is a renewable natural gas replacement. Anaerobic digestion is widespread throughout the European Union (EU) and Asia, but is under represented in the United States primarily due to historically low energy costs. As the interest in utilization of bio-methane as a renewable fuel has increased, more research and pilot projects have begun to assess various waste streams, known as feedstocks, specifically for energy production. Digester systems (known as biogas plants in the EU) are applicable to a wide range of situations. Synergy is most realized at facilities that have access to sizable organic feedstock at little to no cost, require electricity and heat that can be provided by a biogas-powered combined heat and power unit (CHP) or through the direct use of biogas (such as boilers), and can utilize or market the digester effluent as compost and liquid fertilizer. The technology can be instrumental in providing renewable energy to industry and the agricultural community while closing the loop on the nutrient cycle.

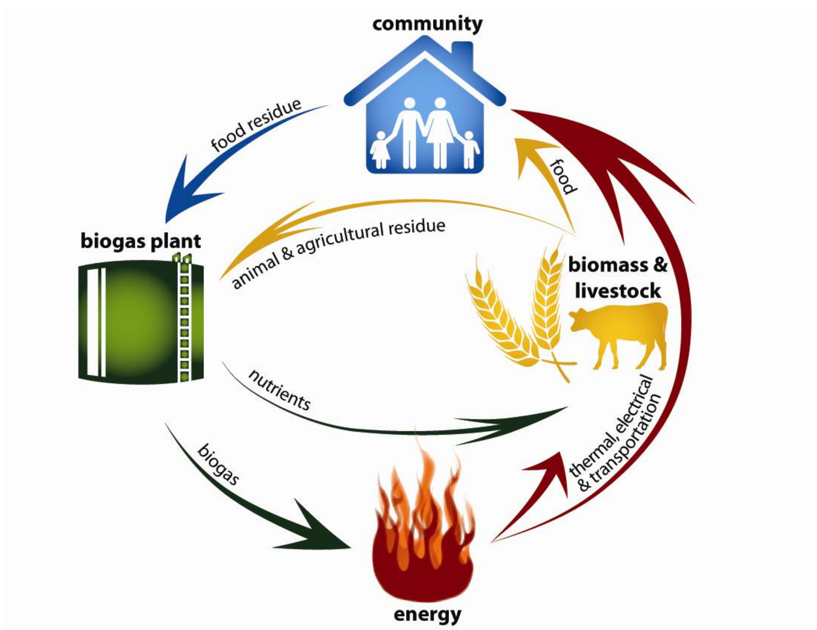



**Figure 1 Schematic illustrating the sustainability of AD (EC Oregon, 2009)**

Digester technology has been developed with a multitude of different approaches. The feedstock can be mixed or unmixed. The vessel can be a pond or tank of varying sizes, shape, and orientation. Operating temperatures range from psychrophilic (ground temperature) to mesophilic (37 to 41 ºC) to thermophilic (50 to 52 ºC). The amount of TS that can be processed by different technologies varies. Hydraulic residence time (HRT) and solids residence time (SRT) vary and can be coupled or decoupled.

## 2.1 DIGESTER TYPES

General categories of AD technology for dairy manure include: traditional, high rate, and contact. Traditional digesters, which include anaerobic lagoons, plug flow and complete mix reactors (mesophilic or thermophilic), are the most commonly used digesters for dairy manure. Due to clogging issues and the limitations for processing only soluble fractions, digesters such as anaerobic filters, both upflow and downflow UASB, anaerobic baffled reactors, various biofilm processes and fixed film packed bed reactors are not recommended for dairy manure systems. Certain modified UASB systems, such as the Induced Blanket Reactor (IBR) are designed to handle feedstock with slightly higher solids content, and may be applicable.

Traditional digesters are described in detail below. More information about high rate and contact type digesters is located in the appendices for this section.

### Anaerobic Lagoons

Anaerobic lagoons are essentially covered ponds which can be mixed or not mixed. Lagoons operate at a psychrophilic temperature which leads to seasonal production variability. They generally have poor bacteria to substrate contact; hence a very low processing rate (high HRT) and large footprint are required. Covered lagoons are a low capital investment for production of biogas, but tend to underperform other technologies for biogas production, electricity generation, and weed seed and pathogen reduction. Covered lagoons are largely used for odor control instead of biomethane production.

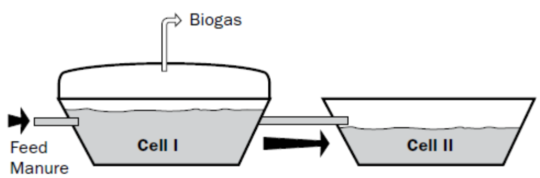



**Figure 2 Anaerobic lagoon (Ogejo, 2007)**

### Plug flow digesters

Plug flow digesters are linear (horizontal or vertical) shaped reactors - influent enters on one end and effluent exits on the other. They are typically not mixed; substrate moves through the reactor in a "slug" and HRT = SRT. Plug flow digesters have a narrow solids range to avoid stratification or obstruction. They have moderate capital and operational costs, and require periodic cleaning of the system which incurs downtime.

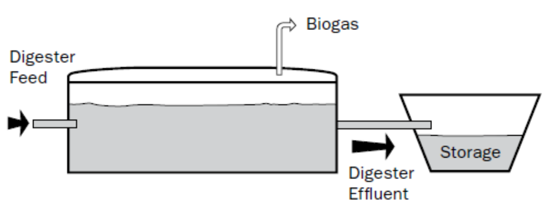



**Figure 3 Plug flow digester (Ogejo, 2007)**

These digesters were designed to handle feedstock at high percent solids as a simple push-through technique. As feedstock is added at one end, an equal proportion is removed from the other side. Although other designs exist, a typical design is a heated below grade rectangular tank covered with an air tight expandable membrane. With an expected HRT of 20-30 days, plug-flow digesters are typically designed to handle solids contents in the range of 11 to 13 percent, however there are numerous case studies where dairy manure is being fed to a plug-flow digester at 7- 8% solids.

Limitations associated with plug-flow digesters include sands and silt settling out, stratification of dilute wastes, unsuitability for dilute milking wastes, and lower methane production. Modified versions of the plug-flow digester exist that try to either improve efficiency or recover bacterial biomass such as:

- U-shaped digester: has a shared wall containing the heating elements
- Re-injected liquid: liquid sucked out of the bottom of the digester and outflowing digester sludge are reintroduced to help pre-heat the sludge and maintain bacterial biomass.

### Complete Mix or Continuous Stirred Tank Reactor

Complete Mix or Continuous Stirred Tank Reactor (CSTR) is typically a concrete or metal cylinder with a low height to diameter ratio. They can operate at mesophilic or thermophilic temperatures; mixing can be mechanical, hydraulic or via gas injection. Complete mix can accommodate a wide range of solids and generally, HRT = SRT. Higher capital and operational costs are balanced against the stability of the system and reliability of energy production. Additionally, the CSTR accepts multiple co-digestion feedstocks which may allow for an additional source of revenue through increased methane production and tipping-fees.

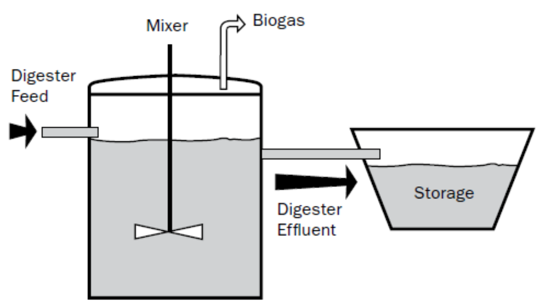



**Figure 4 Complete mix (CSTR) (Ogejo, 2007)**

### Induced Blanked Reactor (IBR)

An induced blanked reactor is a modified version of UASB digester designed for HRT of 5 to 8 days. With a sludge blanket maintained within the bioreactor, slow growing bacteria are retained in the tank which accelerates digestion of slurry. The technology consists of multiple above ground tanks with high height to diameter ratios, modular design allows for isolation and repair of failed tanks. Tanks are designed as flow through systems with influent entering at the bottom and effluent exiting through the top. Solids and slow growing bacteria are retained on a septum with a plugging control mechanism. Formation of a sludge blanket consisting primarily of bacteria occurs in the lower portion of the tank. As methane bubbles up, bacterial aggregates of methanogens float up to the septum, the septum separates the methanogens from the gas, bacteria return to the bottom of the tank and gas exits via the septum. Additional recirculation of the effluent helps retain any bacteria that got past the septum.

## 2.2 DIGESTER TECHNOLOGY ASSESSMENT

In the US, 94% of dairy farm based AD systems are plug flow, complete mix reactors or covered lagoon digesters. However, the relative distribution of these technologies does not necessarily reflect the needs of all dairy farms. Although economics are a key metric for some owners, other digesters are installed mainly to control odor and excess nutrient runoff. The two most often used technologies are plug-flow reactors and complete mix reactor digesters.

**Table 2 Distribution of current AD technology on US dairy farms (AgStar, 2009)**

| Digester Type | Number of digesters operating on dairy farm (%) | Number of digesters on dairy farms with herds greater than 1,500 head (%) |
|---|---|---|
| Covered Lagoon | 10 (9%) | 5 (10%) |
| Complete Mix | 26 (24%) | 8 (17%) |
| Fixed Film | 1 (1%) | - |
| Induced Blanket Reactor | 2 (2%) | - |
| Plug-flow | 65 (61%) | 34 (71%) |
| Unknown | 3 (3%) | 1 (2%) |
| Total | 107 | 48 |

As mentioned earlier, energy output per capital investment is not the only selection criteria for anaerobic digester technology. A matrix is provided to compare the relative features of each design as reported by various vendors.

**Table 3 Suitable digester technology matrix (EC Oregon, 2009)**

| | Covered Lagoon | Plug Flow | Complete Mix | IBR |
|---|---|---|---|---|
| Max allowable solids size | Fine | Coarse | Coarse | Coarse |
| Technology level | Low | Low | Medium | Medium |
| Operating Temperature | Psychrophilic | Mesophilic | Mesophilic or thermophilic | Mesophilic |
| Co-digestion compatible | No | Limited | Yes | Limited |
| Solids separation prior to digestion | Recommended | Not necessary | Not Necessary | Not Necessary |
| Foot print | Large | Small (if underground) | Medium | Small (modular) |
| OLR | Low | Medium | Medium | High |
| HRT | > 48 days | 20 - 40 days | 20 - 30 days | 10 days |
| VS reduction[(1)] | 35 – 45% | 35 – 45% | 35 - 45% | 50-55% |
| Biogas yields | Low | High | High | High |
| Costs | Low | Medium | Medium | Medium |
| Suitable % solids | < 3 | 7 – 13% | 3 –12% | 2 – 10% |

1. VS reduction of dairy cow manure.

Complete mix or continuously stirred reactor tank (CSTR) digesters represent a proven and effective technology for feedstock with a wide range of total solids. Complete mix systems run at a steady state with continuous flow of reactants and products; the feed assumes a uniform composition throughout the reactor and the exit stream has the same composition as in the tank. This homogenization ensures maximum contact between substrate and microbe, enhancing the digestion process and biogas quality. For this reason, complete mix (also known as vertical) systems are widely preferred over plug flow (also known as horizontal) systems in the EU.

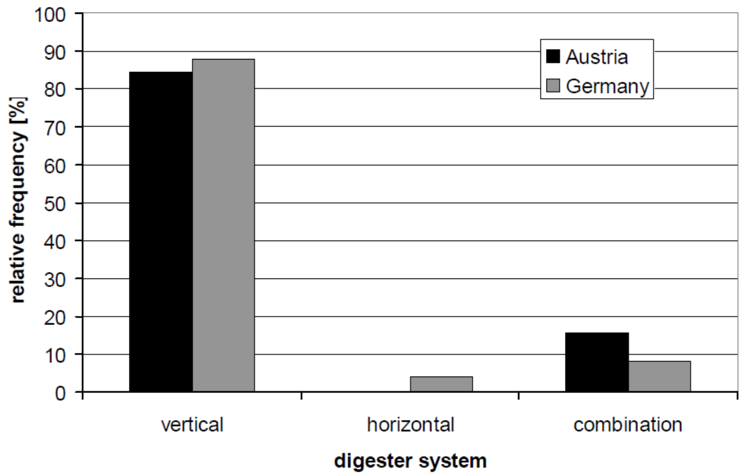



**Figure 5 Frequency distribution of digester technologies for AD facilities built in Austria and Germany between 2003 and 2005. (Hopfner-Sixt, et al. 2005)**

The preferred operating temperature range of new biogas facilities in the EU is mesophilic. The greater stability and lower parasitic heat load of mesophilic systems outweighs the decreased retention time and smaller footprint of thermophilic systems.

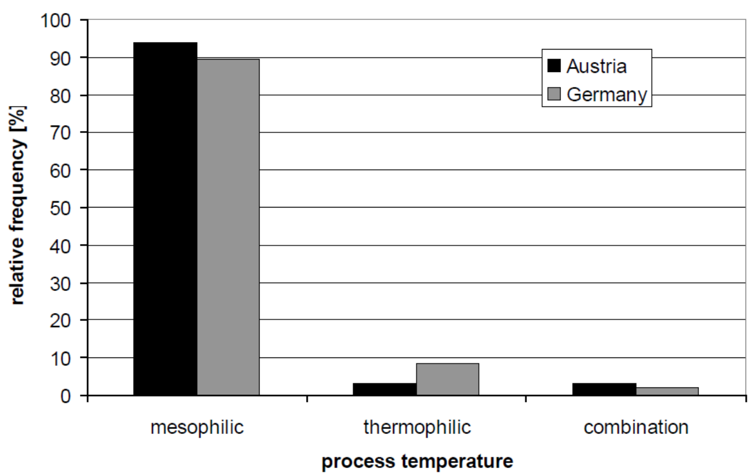



**Figure 6 Frequency distribution of operating temperatures for AD facilities built in Austria and Germany between 2003 and 2005. (Hopfner-Sixt, et al. 2005)**

# 3. **Feedstock Digestibility and Handling Assessment**

The microbial community found in AD systems requires a relatively steady stream of feedstock on a daily basis. Underfeeding will result in reductions in microbial population and methane production; overfeeding can result in excessive by-product formation, increased toxicity and potential digester "crash". Any changes in feeding regime quantity or type need to be incorporated gradually.

## 3.1 DAIRY MANURE ANALYSIS

A survey detailing waste stream availability and farm practices was completed by Darren Volbeda in September 2009. Survey data, Animal Waste Management Plan (AWMP) data (from 2009, provided by Tom Thomson of Northwest Ag Consulting), literature data and ongoing conversations with Darren Volbeda form the basis of estimates provided in the feasibility study.

The amount of manure impacts multiple design and feasibility variables such as methane production, required vessel volume and biomass producer tax credit; the use of conservative estimates prevents presentation of an overly optimistic financial model. According to literature, manure output has been shown to be correlated to milk production, dry matter intake, pregnancy rates, month in milk and season, among other factors. The AWMP indicates milk production of 65 lbs/day/cow corresponds to a manure output for milkers of 104 lbs/animal unit (AU)/day; dry cows, heifers and calves are estimated to produce 57 lbs/AU/day..

Since bedding invariably gets incorporated into the collected manure, this adds an additional tonnage of solids entering the reception pit. Volbeda Dairy is in the process of transitioning to composted manure solids for bedding. Since the actual quantity to be used is currently unknown, a rate of 10% of manure produced was assumed – an amount used by a similar dairy operation in the Willamette Valley.

Estimates for manure production and bedding are provided based on these assumptions.

**Table 4 Quantity of dairy manure and bedding**

| Total Head | Manure (tpd) | Bedding (tpd) |
|---|---|---|
| 1975 | 118.6 | 11.9 |

## 3.2 MANURE QUALITY ASSESSMENT

Methane yields of dairy manure are dependent on manure collection and handling methods. As long as manure is collected in a fresh state most of the methane potential will be recovered, however as manure ages the methane potential quickly decreases. Although it has been suggested that flushed and scraped methane recovery are essentially the same, tradeoffs exist between collection efficiency, digester volume, digester technology, parasitic heat load and odor control. If properly managed, both methods collect manure in a fresh state (i.e., no reduction in VS), but flush systems significantly increase the volume to be treated. The efficiency or convenience of a flush system is outweighed by the significantly larger volume of cold water that needs to be heated to at least mesophilic temperatures for efficient methane yields. The commercially proven digester technologies are designed to optimally handle specific ranges of TS. This means flushed manure will need to be thickened to reduce the mass and increase solids content.

***Manure Quality at Volbeda's Dairy*** – Volbeda Dairy practices flush manure collection and currently uses a multi-step separation system (Biolynk System from Daritech). This thickening step of this process could be utilized to raise the TS content of the flushed manure prior to anaerobic digestion. Since the infrastructure is already in place, capital costs to intertie to the digester will be minimal compared to installation of a new thickening system. Additional costs benefits are realized since removing the liquid from the flushed manure allows for reduction of the digester size by as much as 50%. Even with the high reported solids capture rate of the Biolynk System a proportion of volatile solids (hence methane potential) should be lost in the thickening step. Daritech indicated that if the flushed manure was thickened to 5% TS, little to no loss of VS should occur. However, if the manure is thickened to 13% TS up to 30% of the manure VS would be lost. These statements have been taken at face value and a linear relationship between thickening and VS loss has been assumed for modeling of methane production.

### 3.3 CO-DIGESTION FEEDSTOCK NEAR ALBANY, OREGON

Any loss of methane potential due to thickening of flushed manure can be easily remedied by importing other feedstocks. The ability to take in co-digestion substrates allows the owner to take advantage of the economy of scale principle while digesting higher energy feedstock. This in turn enhances the financial feasibility and profitability potential. Certain co-substrates can produce a disproportional increase in biogas production relative to the feed percentage.

An assessment of local co-digestion feedstock suggests each of the farm has access to sizable amounts of numerous co-digestion substrates. The dairy is closely located to two urban areas (Albany and Corvallis) and accessible to a slightly distant larger urban area (Salem/Keizer). Costs to acquire these feedstocks will vary from moderate to free; in some cases tipping fees may provide a further revenue stream. Producers and collectors of biomass used to produce renewable energy are eligible for state tax credits on a per ton basis – providing incentive over current end uses.

- The South Willamette Valley has approximately 130,000 acres in annual ryegrass seed production, resulting in over 250,000 tons of available annual ryegrass straw (ARS) per year.
- A by-product from biodiesel production, glycerin, is available in south Salem and well suited for storage and transportation.
- Fats, oils and grease (FOG) in the form of local food processor waste and grease trap waste are estimated to be available at the rate of 14.4 tpd.
- There are 6 broiler farms with about 12,700 tpy of poultry litter (manure and bedding).
- Based on active licenses as of September 2009, there are 19 large size (>$20million in annual sales) food processing companies (e.g. fruits and vegetables and potato chip processing) operating in close proximity.

Processors with relatively large residue streams include Norpac Foods Inc, National Frozen Foods Corporation, and Truitt Bros., Inc. Recent conversations with Norpac indicate their processing plant in Brooks has 13,000 tpy of cauliflower waste available during October through November. Norpac's repackaging facility in Salem has 1,200 tpy of mixed waste available on a consistent basis. These waste streams currently produce zero to negative income for Norpac.

Truitt Bros has a significant waste available (~40tpd) in the form of bean and pear waste from July through November. National Frozen Foods is the closest of these food processors and has a small consistent stream of 2.3 tpd, which increases to 20 tpd of corn, bean and squash waste during July through October.

The following small quantities of on farm sources of co-digestion feedstock could also be utilized:

- Silage liquor from the silage bunker.
- Wasted cow feed (silage and supplements).

The availability and suitability for anaerobic digestion of each co-substrate varies considerably. Certain co-digestion feedstocks, such as food processor residues, show substantial seasonal variability. Combining the energy density of each substrate with the wet weight availability helps identify any limitation in consistent AD feedstock supply and provides an estimate of the likely methane yield. Unless tipping fees are realized or acquisition costs are prohibitive, energy dense substrates with a higher %TS, %VS and methane yield (such as fats or potato chips) make more economic sense to source from a distance than less energy dense substrates (such as manures or raw potatoes).

**Table 5 Methane potential of co-digestion feedstocks (EC Oregon, 2009)**

| Co-digestion Feedstock | Tons per day | % TS | %VS of TS | Methane Yield ($m^3$ $CH_4$/ kg VS) | Mcf $CH_4$ per Day |
|---|---|---|---|---|---|
| *Dairy Manure (onsite)*[(1)] | 296.5 | 5 | 80 | 0.180 | 68 |
| ARS | 54 | 90 | 94 | 0.286 | 424 |
| FOG | 14.4 | 30 | 90 | 0.572 | 71 |
| Food Processor Residues[(2)] | 70 | 30 | 85 | 0.355 | 203 |
| Glycerin | 2 | 92 | 97 | 0.335 | 20 |
| Grass Silage[(3)] | 164 | 28 | 88 | 0.332 | 435 |
| MFW[(4)] | 44 | 30 | 85 | 0.435 | 158 |
| Potato | 8.4 | 18 | 92 | 0.333 | 15 |
| Potato Chip Waste | 9.2 | 80 | 97 | 0.508 | 116 |
| Poultry Litter | 35 | 70 | 75 | 0.240 | 141 |

1. Estimates characteristics of manure entering digester mix tank; after flush collection and thickening to 5% TS.
2. Value shown is an average value. Food processor residues have seasonal variability ranging from 14 tpd to 280 tpd.
3. This amount of grass silage is used to estimate the tonnage it would take to replace ARS as a co-digestion feedstock and still retain the biomethane yield per day.
4. This amount of MFW is from Portland. Although this is over 70 miles away, there is the potential for tipping fees.

## 4. **Proposed Digester Scenarios**

In mid December 2008, EC Oregon sent out a Request for Information and Budgetary Cost Estimate (RFI) for two dairy farms with approximately 1,500 head each. One farm has a flush based manure collection system while the other is scrape based. Vendors solicited were experienced with at least one of the following types of digesters: covered lagoon, plug-flow, hydraulic-mixed, induced blanket reactors and contact digesters. In addition to technical information and costs, vendors were asked to provide references for any recommended designs.

Most technologies were capable of addressing current farming practices or recommended minimal farming practice changes in order to utilize the co-digestion feedstocks. Vendor responses were reviewed by the following criteria:

- Suitability of technology to available feedstock
- Proven technology based on references
- Experience of the vendor and the availability of commissioning and support staff
- Conservative estimates based on true system evaluation data or reasonable literature values (non-extreme values or outliers)
- Competitiveness of the cost estimate

The final selection consisted of plugging variable data from RFI responses into a conservative financial model taking into account Oregon tax incentives, power purchase agreements, and other site specific variables to determining long term project viability and revenue. The model revealed that though capital expenditure is an important variable, three other variables were also influential when considering the lifespan of the project: 1) Energy Yield, 2) Parasitic Load and 3) Operations and Maintenance costs.

Although other technologies were less expensive, the combination of higher energy production, compatibility of co-digestion feedstocks, and lower operation and maintenance costs indicate certain types of complete-mix (aka, CSTR) technology were significantly more financially viable. This data supports conclusions drawn from literature as well; complete mix digesters offer the best solution for co-digestion of dairy manure.

Therefore, a complete-mix co-digestion scenario of flush manure collection is proposed. The Biolynk System will be used to thicken the flushed manure before addition to the digester mix tank. The existing screw press separator will be used post-digester to capture solids during effluent dewatering. This scenario fully utilizes on farm equipment with minimal disruption to current farming practices.

Accurately calculating potential carbon credits is dependent on numerous variables; flush systems and co-digestion further complicate the equation. Therefore, a conservative approach was taken and carbon credits were not valued as an additional revenue stream. Note though, the herd size at the Volbeda Dairy is approaching the threshold where monetizing carbon credits may be realistic.

## 4.1 PROPOSED BIOGAS PLANT SCENARIO

The feedstock blend includes annual ryegrass straw (ARS) which is locally available in quantities exceeding the proposed amount; this amount of ARS was chosen to optimize the C:N of the manure/straw blend. This scenario assumes cow bedding will be composted digestate solids. Fats, oils and greases (FOG) is added at a ratio shown to improve methane yields without overloading the digesters. It is further assumed that flushed manure is thickened to 6.5% TS – a level that minimizes volatile solids loss while keeping the TS of the blend below the required 13% for complete-mix technology. Any synergistic effects of co-digestion could further improve methane production, but due to their unknown magnitude have been ignored in this scenario.

**Table 6 Feedstock regime of hypothetical complete mix biogas plant at Volbeda Dairy with co-digestion (EC Oregon, 2009)**

Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush - 10/4/2009

| Feedstock | Annual Used | Used Daily | Total Solids (TS) *(as is basis)* | Volatile Solids (VS) of Total Solids | Methane Yield | Methane Production |
|---|---|---|---|---|---|---|
| | *US Tons / Year* | *US Tons / Day* | | | *$m^3$ $CH_4$ / kg VS* | *Mcf / Day* |
| Flushed/Thickened Manure | 93,660 | 257 | 6.5% | 68.6% | 0.180 | 65.97 |
| Dilution Water | - | - | 4.5% | - | - | - |
| Annual Rye Grass Straw | 7,000 | 19 | 90.0% | 94.0% | 0.286 | 148.62 |
| FOG / GTW | 2,000 | 5 | 30.0% | 90.0% | 0.572 | 27.12 |
| **Total** | **102,660** | **281** | **12.7%** | **81.9%** | **0.259** | **241.71** |

This conceptual complete mix biogas plant would require up to two acres of land, including all required vessels, reception hall and biogas utilization equipment. The biogas plant would likely consist of the following components:

- One reception hall with
  - Fiber/feedstock storage
  - control/lab room
  - pumping manifold
  - CHP or boiler unit(s)
  - dewatering equipment
- One feed storage tank for liquid feed (if necessary)
- One feed reception pit / mix tank
- Two anaerobic digester tanks
- One post digester with integrated biogas storage
- Lagoon (existing) for centrate storage
- Access road and long-term feedstock storage would require additional land

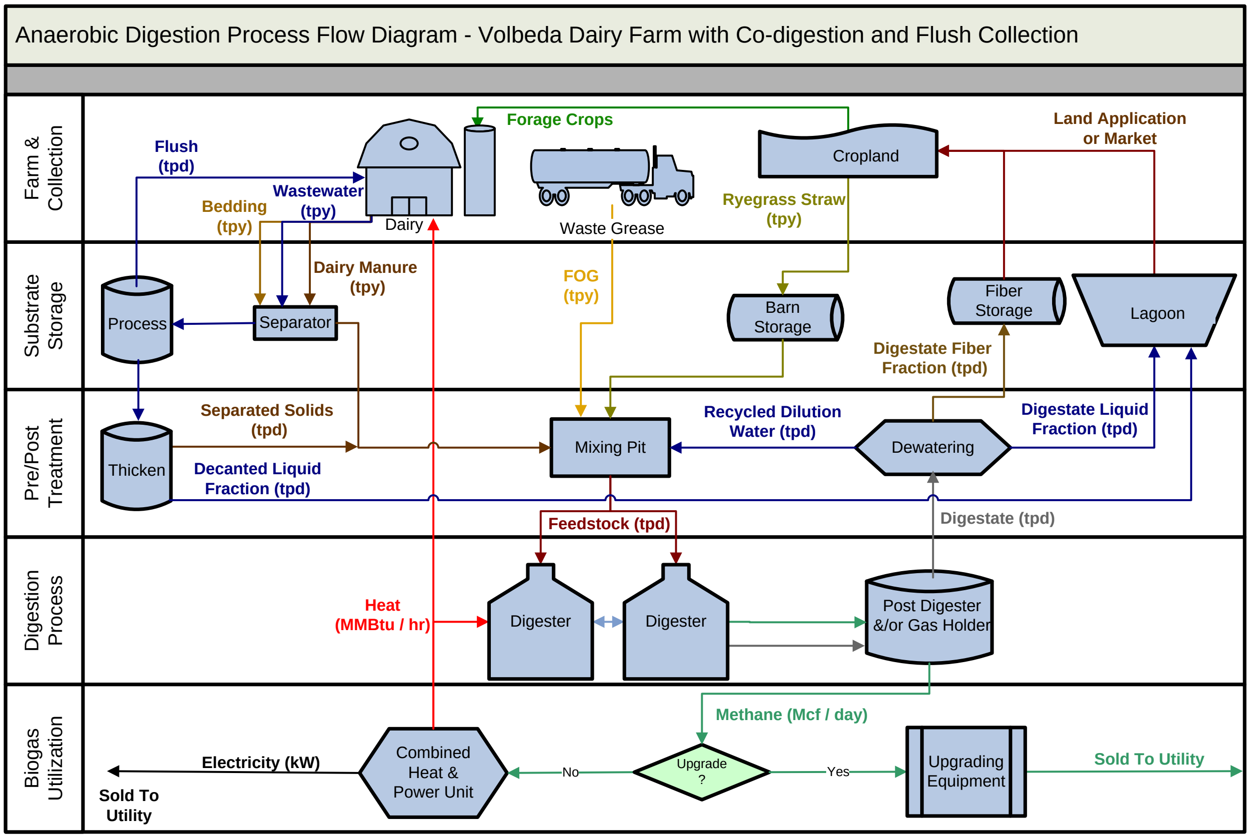



**Figure 7 Process flow diagram of potential on-farm biogas plant with co-digestion (EC Oregon, 2009)**

The process flow for this digestion system is presented above and the following table provides corresponding details. The kW estimate is net for a CHP operating at ~40% efficiency. Since biogas – and hence electricity – can be produced 24 hours/day, 365 days/year (unlike solar or wind installations), an estimate of 10 days of annual CHP maintenance is provided.

**Table 7 Process flow diagram values**

Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush - 10/4/2009

| **Feedstock** | *US Tons / Year* |
|---|---|
| Flushed/Thickened Manure | 91,590 |
| Dilution Water | - |
| Annual Rye Grass Straw | 7,300 |
| FOG / GTW | 2,000 |
| **Total** | **100,890** |

| **Digester** | *US Tons / Day* |
|---|---|
| Daily Feedstock Mix | 276 |
| Digestate | 259 |

| **Gas Yield** | | *Mcf / Day* |
|---|---|---|
| Biogas | | 411 |
| Methane | | 247 |
| **CHP Outputs** | | |
| Electricity | *kW* | 1,139 |
| Electricity | *kWh / Year* | 9,707,916 |
| Jacket Heat | *Million BTU / Hour* | 1.23 |
| Exhaust Heat | *Million BTU / Hour* | 2.46 |
| **Dewatering** | | |
| Fiber | *Yards$^3$ / Year* | 34,636 |
| Liquid Fraction | *US Tons / Year* | 78,850 |

In this co-digestion/CHP scenario, the amount of biomethane produced would produce more waste heat than could be used efficiently on farm. In that case, an investment into biogas upgrading equipment to allow for natural gas grid injection could be warranted. However, at the present time Northwest Natural has yet to accept upgraded biomethane into their grid. Therefore, upgrading and injecting biomethane is seen as more of a long term possibility rather than a short term reality. If upgrading and injection is implemented, a boiler will need to be installed to maintain mesophilic temperatures for the digesters.

Volbeda Dairy is located in Pacific Power (PacifiCorp) service area. In this co-scenario, more energy will be produced than is currently used at the Volbeda Dairy so a “sell all” power purchase agreement with Pacificorp is the preferred option. Interconnection, while costly (~$150k) and lengthy (up to 12 months), would be a requirement. In addition, since the electricity is produced from a renewable source, the biogas plant is eligible for Renewable Energy Credits (aka “green tags”).

Since a portion of digestate solids would be used as bedding, less fiber would be available for sale. On-site space for composting and storage of digestate solids will need to be identified; waste heat produced by the CHP could be captured to dry the solids if warranted. This scenario would have more nutrients available than currently present in the nutrient management plan. Therefore, additional acreage needs to be identified for consistent nutrient application or a market solution will be required.

## 5. **Financial Analysis**

Combining the assumptions, technology dependent variables, and feedstocks provides insight into overall biogas financial viability. Conservative, yet realistic, values were used to produce financial analysis. Feedstock is typically the primary operational expense for a biomass plant. The cost of collecting, transporting and delivering of external feedstocks will need to be carefully assessed once a supplier is identified. In all scenarios, manure is procured for the biogas plant under "business as usual" assumptions at no additional cost to the farm; a tax credit is also realized by the farm. For this proposed scenario annual ryegrass straw is purchased at $35/ton.

**Table 8 Financial model assumptions**

| | |
|---|---|
| **FEEDSTOCK** | |
| Dairy Manure | $5 / Ton Biomass Producer Tax Credit (through 2012) |
| Dilution Water | None required |
| ARS (purchase price) | $35 / Ton harvest and transport |
| FOG (purchase price or tipping fee) | $0, (tipping fee needs to be negotiated) |
| **BIOGAS PLANT** | |
| Digester Technology | Complete Mix |
| Organic Loading Rate (kg VS/ $m^3$/ day) | 4.0 |
| Retention Time (primary reactors only) | 28 days |
| Capital Expenditure Contingency | 30% |
| **RENEWABLE ENERGY** | |
| Year One On-Peak Price per kWh | $0.0568(1) |
| Year One Off-Peak Price per kWh | $0.0434(1) |
| Starting Dollar per REC | $7.75 |
| CHP O&M ($/kWh) | $0.012 |
| **NUTRIENT RECOVERY** | |
| Solids Capture Rate | 60% |
| Fiber Value ($ US / $\text{Yards}^3$) | $4.50 |
| % Fiber to sell | 60% |
| Liquid Nutrient Value / US Ton | Assumes land applied. Since liquid from lagoon is already land applied, there is no revenue nor avoided cost. |
| **FINANCIAL** | |
| Debt : Equity (% Ratio) | 75 : 25 |
| PTC/ITC option | ITC Grant |
| Loan terms | 10 year, 6.5%, 2 points |
| Inflation Rate | 3% |
| Business Energy Tax Credit | Passed-through (sold at 33.5% of eligible project costs) |
| Depreciation | MACRS + ARRA-enabled Bonus |
| Other incentives | $500k USDA grant |

1. PacifiCorp Power Purchase Agreement (Assumes commissioning date of January, 1 2011), [PacifiCorp - Oregon Schedule 37 (September 9, 2009)].

Other major annual expenses include operation and maintenance (O&M) for both the anaerobic digester and the CHP. In addition, both the digester and CHP have electrical demands, slightly reducing the net amount of available electricity. These parasitic loads are usually relatively small compared to some other conversion technologies. Major financial components are detailed below.

**Table 9 Proposed co-digestion scenario**

| Anaerobic Digester at Volbeda Dairy Farm with Co-digestion and Flush Collection | |
|---|---|
| Manure Collection | Flush with Thickening |
| Digester Technology | Complete Mix |
| % Manure of Co-digestion Feedstock Mix(1) | 38% |
| Mcf Methane / Day | 247 |
| Biogas Utilization | Combined Heat and Power |
| Electricity Production (kW) | 1,139 |
| Biogas Plant Capital Expenditure(2) | $6,774,218 |
| • *Digester Capital Expenditure* | $4,455,590 |
| • *CHP Capital Expenditure* | $1,146,600 |
| • *Other Project Costs*(3) | $1,172,027 |
| Revenue in Year One(4) | $652,167 |
| • *Electrical Revenue* | $494,367 |
| • *Fiber Revenue* | $82,563 |
| • *Green Tag Value* | $75,236 |
| Total Expenses in Year One(5,6) | $(511,755) |
| • *Feedstock Direct Expense* | $(263,165) |
| • *Digester Operations & Maintenance* | $(105,906) |
| • *CHP Operations & Maintenance* | $(123,701) |
| Baseline Operating Net Income(7) | $140,412 |
| Return on Investment(8) | 16.9 years |
| Return on Equity(8) | 1.5 years |
| Internal Rate of Return(8) | 7.6% |
| Net Present Value(9) | $691,043 |

1. On volatile solids basis
2. Assumes the total capital expenditure for the project can be controlled at a contracted amount
3. Includes feedstock handling/storage, dewatering, project management, permits, interconnection, etc
4. On-peak rate and off-peak rates stated in Financial Model Assumptions Table
5. Total Expense / Year excluding depreciation and interest expense
6. For "baseline" year (i.e., will increase with inflation)
7. Earnings Before Interest, Taxes, Depreciation and Amortization
8. Calculated on pre-tax basis
9. Net Present Value assume 5% discount rate

Much of the daily operation of a modern biogas plant is automated. A well designed process control system will collect data, monitor performance, sound alarms (remotely) and provide process control via feedback loops. A low-tech digester operating on manure alone would require 1 hour/day of oversight, plus an additional 15 hours of monthly maintenance. A full scale biogas plant, importing multiple feedstocks, and running on CHP, could require one or more full-time employees.

Multiple ownership models are available to Volbeda Dairy depending on financial goals, fiscal situation and level of acceptable risk. If the dairy is able to provide adequate equity and collateral, a single owner scenario is a possibility. Another common scenario is to create a business entity (project company) with one or more third party investors. Exact ownership details would be dependent on the terms of a resource agreement between the farm and the project company. Likely terms include: the dairy supplies land and manure to the project company in return for dewatered fiber in sufficient quantities for use as bedding and liquid effluent in sufficient quantities to fertilize existing forage acres; excesses are managed by the project company. All capital and operational expenses are also typically covered by the project company.

## 5.1 Cash Flow

The cash flow for this scenario is not sufficient to recoup the initial investment in a timely manner. After commissioning (year 2011) multiple renewable incentives are monetized. However, over the next several years the cash at the end of the period decreases due to debt financing. Printouts of the pro forma are provided in the appendices for this section.

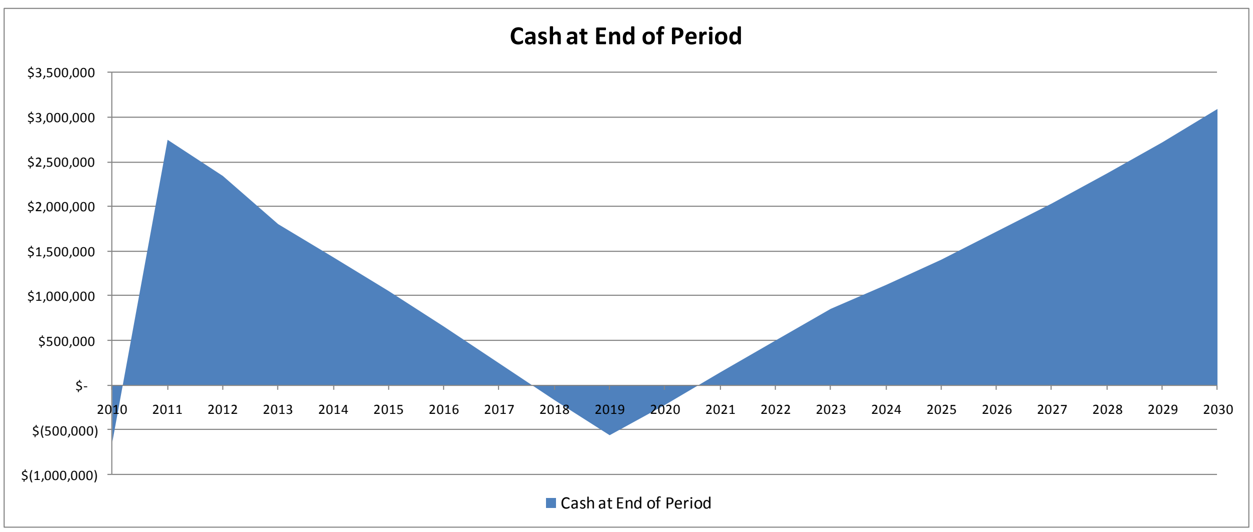



**Figure 8 Biogas plant projected cash flows (EC Oregon, 2009)**

Since this scenario is modeled somewhat conservatively, a number of measures can improve the overall financial outlook. The most notable measure is mitigating high feedstock costs, which is discussed in detail in the next section. Others include:

- Identify a use for the waste heat from the CHP. For example, monetizing jacket and exhaust heat could produce over $109,000 in additional annual revenue (based on current natural gas hub prices of $3.69 / MMBtu) or even more in avoided costs if the client's cost of heat is considered.

- Develop the market for the effluent co-products. In these scenarios, dewatered fiber has been valued at $10 / ton. However, market studies suggest fiber could have a niche in the nursery industry as a planting media (peat moss replacement) with potential for $20 / ton or more. Further, the nutrients in the digestate liquid stream have not been valued here.
- This report assumes electricity will be sold to the local utility provider, PacifiCorp, at the avoided cost schedule. While this sale is guaranteed by a mandate from the Oregon Public Utility Commission, it is possible to negotiate a better rate by bundling renewable energy with the electricity and/or wheeling the power to a distant utility.
- As noted, accurately calculating the quantity and value of carbon credits related to a digester project is a complicated undertaking. The utility of verifying and monetizing the carbon credits of this project is questionable at the current time, but could prove to be more lucrative depending on future carbon market activity.

## 5.2 Sensitivity Analysis

As noted, Volbeda Dairy motivation for anaerobic digestion are nutrient management compliance and to provide fiscal security. This sensitivity analysis is provided to address both of the issues under a "what if" pretense. In order to address nutrient management compliance the baseline scenario was adjusted to account for the herd size approaching CAFO permit limits. Improving financial returns on the baseline scenario is required to attract investment interest and provide fiscal security. Since feedstock acquisition costs are the highest annual expense, an assessment was done to determine what impact reducing the cost would have on overall financial viability. The exposure to annual costs associated with annual ryegrass straw can be minimized by sourcing food processor residue, which can likely be had for free or garner a modest tipping fee. Details on the alternative feedstock regimes are provided in the appendices for this section.

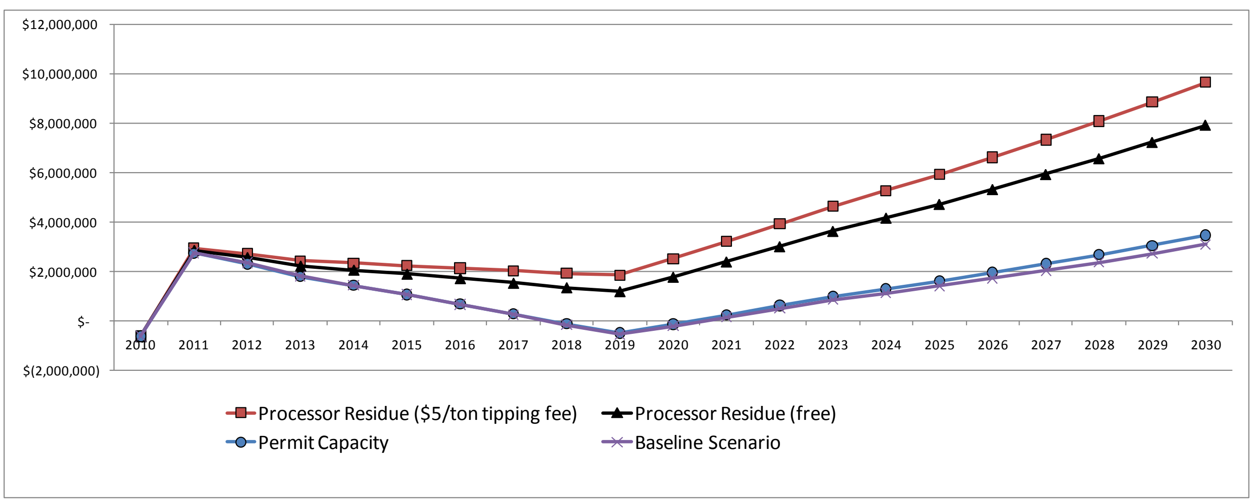



**Figure 9 Sensitivity analysis**

The sensitivity analysis indicates identifying ways to reduce feedstock acquisition costs and sourcing energy dense substrates will improve the financial viability. The analysis also shows that nutrient management compliance will not limit the financial viability as the herd approaches the CAFO permit capacity. However, the increased manure stream is approaching the limits of the proposed system – specifically, the retention time has been decreased to a point where methane yields are starting to be negatively affected.

**Table 10 Sensitivity analysis**

| Parameter Changed | ROI (years) | ROE (years) | IRR | NPV |
|---|---|---|---|---|
| Current | 16.9 | 1.5 | 7.6% | $691,043 |
| Permit capacity | 16.2 | 1.5 | 8.1% | $863,640 |
| Food processor residue [(1)] | 10.9 | 1.5 | 15.1% | $3,382,370 |
| Food processor residue + $5 per ton tipping fee[(1)] | 9.7 | 1.5 | 17.5% | $4,361,164 |

1. Assumes no additional capital expenses incurred while accepting food processor residue.

In the event that the purchase price of ARS becomes cost prohibitive, identifying cheaper energy dense substrates will be imperative. Sources of feedstock that warrant tipping fees, thereby generating revenue as well as energy, would be clearly be preferred. Modest tipping fees can also offset transportation costs and allow for sourcing from a larger radius. As noted there are numerous food processors within close proximity to Volbeda Dairy. Alternatively, large amounts of municipal food waste (MFW) from Portland are a possibility. Although MFW will likely require additional capital expenditure in the form of sorting equipment and a hygenisation unit, the associated sizable tipping fees make it attractive.

## 6. **Conclusions & Recommendations**

Anaerobic digestion of dairy manure is proven technology, immediately available for commercial applications from an ample number of qualified vendors with flexible designs. For the most part, on farm practices at Volbeda Dairy are technically compatible with anaerobic digestion.

The widely preferred approach in Germany and Austria (the world leaders in AD) is to use “complete mix” digester technology, operating at mesophilic temperatures and utilizing multiple co-digestion feedstocks. Based on this fact in conjunction with recent vendor responses and financial modeling, it is recommended that Volbeda Dairy continue to consider a co-digestion scenario with a complete mix digester, producing electricity from a CHP sold under a “sell all” power purchase agreement.

Since dairy manure is not a particularly energy dense AD feedstock, returns on dairy digesters are often marginal without co-digesting energy dense materials. Volbeda Dairy has access to sizable amounts of manure and energy dense co-digestion substrates. Annual ryegrass straw is an abundantly available material, with high relatively high energy density, and is a good match for liquid dairy manure. Fats, oils and greases, sourced in small quantities, can disproportionally boost biomethane production.

The scenario proposed offers feedstock flexibility, consistent methane production, pathogen reduction, nutrient management, high quality fiber bedding and odor control. The potential for diversified revenue and/or avoided costs to the dairy could help mitigate recent fluctuations of milk prices and energy and feed costs. The proposed co-digestion scenario using straw and fats/oils/greases produces biomethane at a rate of approximately five times that of a manure only approach.

However, financial modeling using conservative, yet realistic assumptions, results in returns that are likely not adequate to attract investment interest. The proposed biogas plant requires an initial capital expenditure of $6.8M, has a return on investment of 16.9 years and 7.6% internal rate of return.

In order to improve financial viability, it is recommended that Volbeda Dairy develop a business case that addresses the following:

- Identify measures to mitigate straw acquisition costs
- Source food waste(s) under contract, ideally with associated tipping fees
- Negotiate power purchase agreement that considers wheeling and green-tag bundling
- Develop markets and identify off-take agreements for fiber and fertilizer co-products
- Identify an on-farm use for CHP waste heat, potentially adsorption chilling of milk
- Incorporate straw as bedding to increase fiber revenues

Sourcing food waste that receives a modest tipping fee of $5/ton can alone bring the pre-tax ROI to under 10 years. Additional measures can further improve the investment opportunity.

## Appendices for Section 1

### Additional Benefits

The Oregon Department of Energy sites the following advantages and benefits of manure digesters in conjunction with livestock operations:

1. Greatly reduce odor levels, by 90% or more.
2. Reduce bacteria/pathogens: heated digesters reduce pathogen populations dramatically in a few days; additional post-digester composting can ensure pathogen-free end products.
3. Nutrient management - In the process of AD, the organic nitrogen in the manure is largely converted to ammonium, the primary constituent of commercial fertilizer, which is readily available and taken up by plants. Much of the phosphorus is removed through the solids, allowing for more balanced nutrient applications.
4. Co-generation and energy cost reduction - Anaerobic digesters produce methane gas which can be captured for generating electricity for on-farm use. If the operation is large enough, potential sales of excess power back to the grid may be possible.
5. Final products - the final products of AD are quite suitable for composting and used either on the farm as bedding material or as a soil amendment, or sold off the farm as an organic-based fertilizer/soil enhancer.

### Fertilizer

Effluent from the AD process, called digestate, includes a wet fraction that can be utilized as a marketable agricultural fertilizer and a solid fraction which makes an ideal compost component. The AD process should render all weed seeds unviable. By coupling AD and fertilizer/compost production, the feedstock is optimally utilized and provides excellent soil amendments while reducing the amount of material in local landfills and wastewater treatment plants. In the EU anaerobic digestate is becoming an important source of certified organic fertilizer as petroleum-based fertilizer costs rise and conventional acreage is converted to organic.

Fertilizer Solids remaining in the digestate effluent after separation will be smaller than the liquid fraction of undigested dairy manure. A low and smaller sized liquid fertilizer should be easier to land apply as it will be unlikely to clog fertilizer equipment as often. This in return benefits the farmer in reduced operation and maintenance costs.

### Pathogen Reduction

In addition to weed seed destruction, AD results in dramatic reduction of the bacterial pathogen populations. Anaerobic digestion significantly reduces total pathogenic organisms. The reduction rates of the following specific pathogenic organisms: environmental *Streptococcus* species, coliform bacteria (including: *Escherichia coli*, *Klebsiella* species, and *Enterobacter* species), *Mycobacterium Avium paratuberculosis* (Johnes disease bacterium) have been frequently monitored and show better than 92% reduction in each species or group. Other organisms not listed as a genus are often grouped, such as total gram negative organisms, and are also significantly reduced with anaerobic digestion. Common pathogens in poultry litter (a potential co-digestion feedstock), such as *E. coli*, *Salmonella*, and *Campylobacter*, are unlikely to survive AD due to prolonged exposure to at least mesophilic temperatures. Further, if AD is combined with post-digester composting a pathogen-free end product is virtually assured.

### BEDDING FOR DAIRY COWS

Although anaerobic digestion has been shown to reduce pathogenic organisms by > 92% and in some cases greater than 99%, there is some slight risk of mastitis associated with improper management of digested solids. In incidences where mastitis occurred, veterinarians suggested that the solids were not dry enough and that the moisture contributed to mastitis.

Cases have been shown where digester effluent showed 2-3 log fold decrease in some pathogens and composting the effluent solids reduced the pathogenic levels even further. However, composting may reduce the bedding volume by up to 40%. Using composted digested solids as bedding seemed to improve cow comfort, showed better foot and leg health and cows spent more time lying down. Owners believed this increased comfort was due to an increased bedding thickness from < 25 mm (0.98 in) to a bedding thickness greater than 25 mm (0.98 in) and less than 75 mm (2.95 in). Proper ventilation allowed the solids to dry in the stalls which may have helped reduce pathogenic growth and transfer. Since the bedding still contains some organisms, the maintenance plan for stalls, bedding, drying solids, alley cleaning, and removing organisms from teat prior to milking must be properly followed so that mastitis risks are minimal (Meyer et al., 2007).

For dairies already using composted manure solids, no increase of somatic cell counts or incidence of mastitis is anticipated using composted digested solids as bedding as long as moisture is controlled. A common practice in the Willamette Valley is to apply hydrated lime as a bedding drying agent. Additional moisture control of bedding may be available to dry composted solids with waste heat from a CHP system should it be utilized; this may reduce or eliminate the need for hydrated lime.

One digester vendor indicated that since the digestate has had 99% of the pathogens removed, the digestate can be used safely as bedding without composting or the use of hydrated lime. Before switching to a non-composted practice for digestate solids, EC Oregon recommends testing the solids for pathogens.

## Appendices for Section 2

### ADDITIONAL BACKGROUND

Biogas production is the result of a complex sequential biological process, in which the substrate is continuously broken down. Hydrolytic enzymes reduce complex organic polymers to monomers and oligomers; acidogenic bacteria utilize these simpler compounds to form organic (volatile fatty) acids; acetogenic bacteria then convert the long chain acids to acetic acid; finally, methanogens create methane ($CH_4$), $H_2O$ and $CO_2$ from precursors formed in the previous steps.

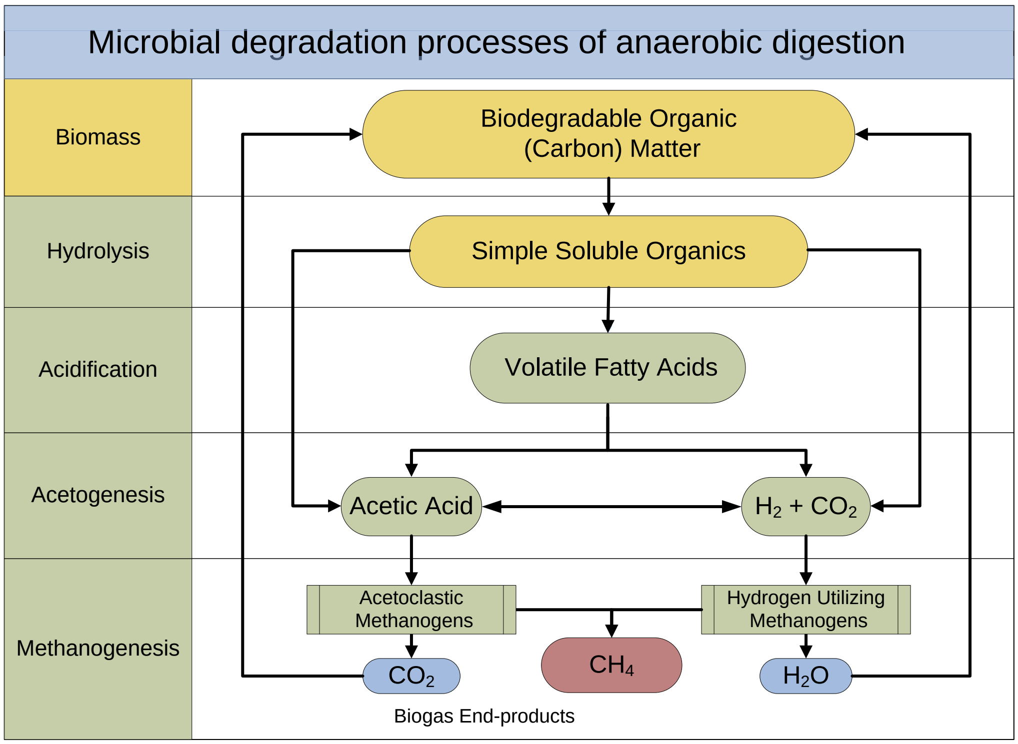



**Figure 10 Microbial degradation processes of anaerobic digestion (EC Oregon, 2009)**

There are multiple reasons for the increased interest in biogas, foremost being energy efficiency. Based on life cycle analyses, biomethane has 3-5 times more energy yield from an acre of land than other biofuels (De Baere, 2007). It also has versatility as fuel for electricity, heat and vehicle fuel, and can be transported efficiently via natural gas pipeline to optimal end-users. Biomethane can be created from numerous high-yielding energy crops, from multiple harvests and – perhaps most significantly – from a wide variety of waste streams.

In Germany, the world leader in renewable energy production, biogas plants produced over 11 billion kWh in 2008. There are approximately 4,000 biogas plants in Germany alone with installed electrical capacity of 1,400 MW, including large scale facilities with capacity greater than 20 MW. A partial summary of biogas facilities illustrates the widespread use of the technology.

**Table 11 Anaerobic digestion facilities worldwide (EC Oregon, 2009)**

| Region | Feedstock Type | Number of Facilities | Source | Year Published |
|---|---|---|---|---|
| Worldwide | Municipal Solid Waste (MSW) | 185 | International Energy Agency, Bioenergy Taskforce | 2002 |
| United States | Municipal wastewater | 3500 | US Dept of Energy, (EERE) | 2005 |
| Worldwide | Industrial wastewater | 1600+ | Journal of Chemical Engineering | 2003 |
| Germany | Agricultural wastes | 4000 | German Biogas Association | 2009 |
| Worldwide | Ethanol distillery stillage | 149 | Journal of Biomass and Bioenergy | 2000 |
| China | Village & farm waste | ~15 million | UN Economic and Social Commission for Asia | 2005 |
| United States | Livestock manure | 135 | AgSTAR Program (USDA, EPA, Dept of Energy) | 2009 |

## HIGH RATE DIGESTERS

High rate digesters attempt to improve upon the traditional technology and tend to reduce the SRT while increasing the OLR. Due to clogging issues and only being able to process soluble fractions, high rate digesters do not tend to be recommended for dairy manure systems. Examples of high rate digesters follow which describe appropriate conditions for their use.

### Upflow Anaerobic Sludge Blanket (UASB)

Granulated sludge remains fixed in the base of the reactor, as effluent is passed upwards through the sludge bed. UASB is considered very high rate and as such has a small footprint, however it is only applicable to waste streams with low solids content. Although UASB reactors are compact, produce methane, have low operational costs and produce little sludge when treating wastes that are dilute and easily digested, they have had mixed results when harder to digest wastes are used. The granules are sensitive to common AD parameters, such as, pH, alkalinity, temperature and OLR. If gas flow or production suddenly increases within the UASB the granules may undergo shearing due to the increased velocity. High concentrations of calcium (associated with lime) or iron can create precipitates that could clog the reactor. Not easily digested solids could also clog the digester. Although fats, oil and grease (FOG) have been shown to increase methane production in other types of AD, problems like low efficiency, low granulation, foaming, scum formation, and sludge washout may occur when FOG is added as a waste substrate to UASB system.

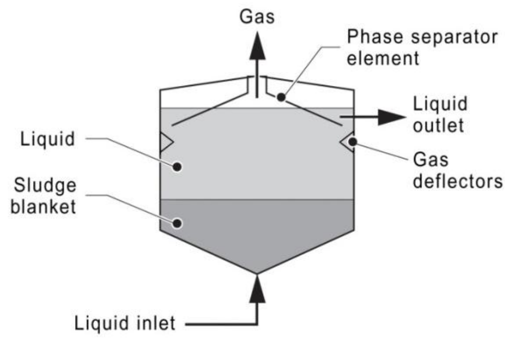



**Figure 11 Upflow anaerobic sludge blanket (Scott, 2005)**

### Induced Blanked Reactor (IBR)

An induced blanked reactor is a modified version of UASB digester designed for HRT of 5 to 8 days. With a sludge blanket maintained within the bioreactor, slow growing bacteria are retained in the tank which accelerates digestion of slurry. The technology consists of multiple above ground tanks with high height to diameter ratios, solids and slow growing bacteria are retained on a septum with a plugging control mechanism, subsequent formation of a sludge blanket consisting primarily of bacteria occurs in the lower portion of the tank, tanks are designed as flow through systems with influent entering at the bottom and effluent exiting through the top, and modular design allows for isolation and repair of failed tanks. As methane bubbles up, bacterial aggregates of methanogens float up to the septum, the septum separates the methanogens from the gas, bacteria return to the bottom of the tank and gas exits via the septum. Additional recirculation of the effluent helps retain any bacteria that got past the septum.

### Fixed Film (or Anaerobic Filter)

In a fixed film, bacteria are retained in the digester and attached to a media with high surface area (sand, beads, matrix, etc); processing at a high rate, as little as hours, with a small footprint. Fixed film systems are very efficient at degrading soluble constituents, but not particulates (i.e., only suitable for very low solids). Fixed film designs require separation of solids prior to digestion and are still prone to clogging under dairy farming practices. For example a fixed-film digester which was fed manure and calcite (calcite was added to the barns and stalls) clogged due to calcium buildup requiring conversion to high-rate vertical plug-flow AD.

### CONTACT DIGESTERS

Contact digesters retain biomass in the system, reduce the loss of microbial mass and increase SRT. Since bacteria are recirculated through this system, raw material and energy are not required to replace bacteria which results in more feedstock being converted to methane.

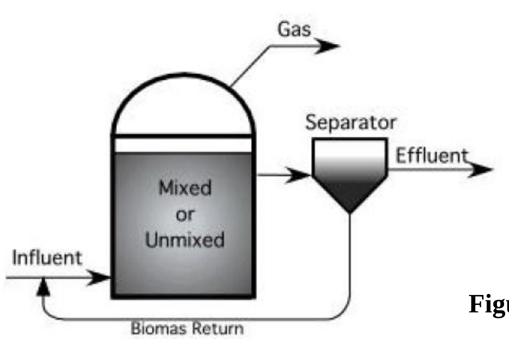



**Figure 12 Contact reactor (Burke, 2001)**

After digestion, effluent is degassed and settled in a separator or gravity tank; solids are returned to the main digester for further degradation. Mechanical methods such as centrifuges, presses, and membranes have been used to speed the separation process.

### Anoxic Gas Flotation (AGF)

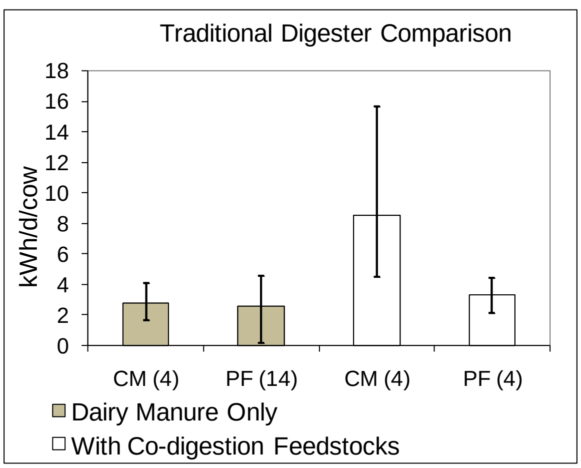
Separation is performed by bubbling effluent with anoxic gas – degassing is not necessary – and solids are skimmed off the top. AGF vendors claim the technology is physically gentler on the bacterial colony than mechanical separation allowing for greater productivity.

### Sequencing Batch Reactor (SBR)

The same tank is used for digestion and separation. Multiple tanks are operated in batch mode: feed, stir, settle, decant. Different feedstocks may be routed to smaller, parallel tanks to accommodate varying degradability. Tanks may be taken off-line when not needed.

## SUPPORTING DATA FOR TECHNOLOGY ASSESSMENT

When comparing case study data for digester technology with dairy manure as the sole feedstock there was not any difference between plug-flow and complete mix reactors. The range of energy output varied widely suggesting that either designs or operating and maintenance issues may contribute to differences in energy output for plug-flow designs. Since dairy manure has rather low energy density, one does not expect to see too much of a difference in energy output between digesters when dairy manure is used as the sole feedstock. However, when energy dense feedstocks are added as part of a co-digestion feedstock practice, the range of energy output greatly increases. Complete mix reactors show the largest potential energy output compared to plug-flow designs.




- Shows actual production values in kWh/day/cow for complete mix (CM) and plug flow (PF) digesters
- Number (n) of samples in parenthesis
- Y-axis = mean kWh per day per cow
- Error bars represent minimum and maximum values
- Mean (brown and white boxes), minimum (black error bars) and maximum (black error bars) kWh per day per cow were calculated for each digester.
- Dairy Manure Only (brown) shows case study data for when dairy manure is the sole feedstock.
- With Co-digestion Feedstocks (white) shows case study data for when co-digestion feedstock was available.

Data was compiled (EC Oregon, 2009) from Kramer 2004, Kramer 2008, Lusk 1998, Wright 2003, Wright 2004, Topper 2008, Martin 2003, Martin 2006, Martin 2007, Walters 2007, and Sjoding 2005.

**Figure 13 Energy output based on digester design and feedstock practice**

# Appendices for Section 3

### CO-DIGESTION BACKGROUND

Co-digestion refers to the process of utilizing multiple waste streams in an AD system for the purpose of increasing the biogas yields and optimizing the degradation of the waste. This process can potentially allow biogas plants to increase their renewable energy generation beyond site demands, thereby producing surplus electrical power for supply to the grid and surplus heat energy for supply to co-located facilities. For agricultural users, certain energy crops can be grown and stored for the express purpose of co-digestion, buffering seasonal processing feedstocks while adding value to rotational crops. The use of agricultural residue, as well as purpose grown energy crops, is rapidly increasing at European biogas plants.

The ability to take in co-digestion substrates allows the owner to take advantage of the economy of scale principle while digesting higher energy feedstock. This in turn enhances the financial feasibility as well as the profitability potential. Certain co-substrates can produce a disproportional increase in biogas production relative to the feed percentage. The high energy content and low acquisition cost of these substrates can justify the sourcing of smaller quantities and collection from longer distances. In Europe, farms compete for the limited supply of fats, oils and grease (FOG) based on its co-digestion amenability.

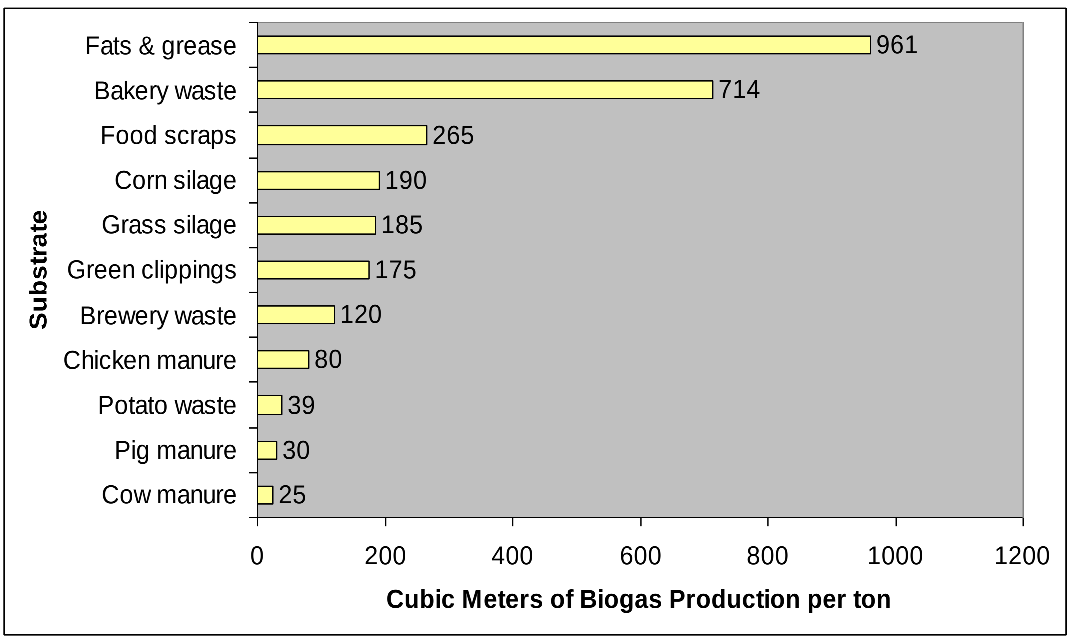



**Figure 14 Cubic meters of biogas production per ton of substrate (Redrawn from Kramer, 2008)**

A single feedstock rarely contains the proper balance of micronutrients for optimal methane production. Though dairy manure is not as energy dense as other substrates, it provides a good buffering system and essential micronutrients for AD while benefiting from the addition of high methane feedstocks. Multiple feedstock co-digestion is often the best way to ensure a balanced biological system. The frequency distribution of anaerobic digester systems utilizing multiple feedstocks or substrates in the EU is presented.

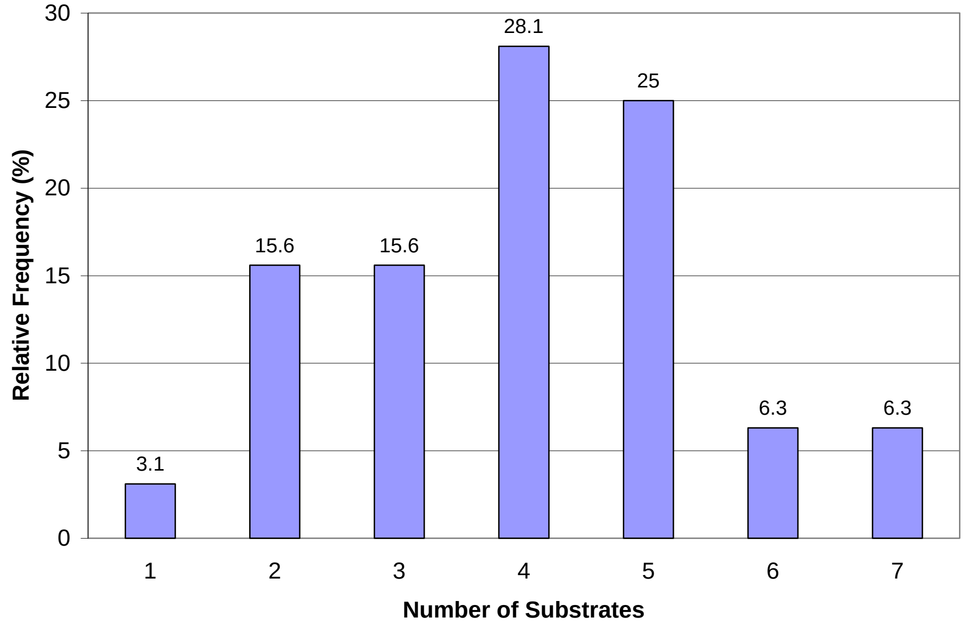



**Figure 15 Frequency distribution of "Number of Substrates" for AD facilities built in EU, 2003 – 2005 (Hopfner-Sixt, et al. 2005)**

An optimized mix of co-digestion substrates can greatly increase methane production; however a non-optimal mix will produce adverse effects resulting in decreased methane production and VS destruction. Adverse effects may be related to pH, ammonia toxicity, alkalinity or high volatile acid concentrations. The potential pitfalls of a non-optimal mix can be mitigated by adding manure to the mixture which increases the buffering capacity and provides essential nutrients. Feedstocks high in lipids and carbohydrates (e.g. oil and fresh pasta) with high VS are good feedstocks for co-digestion with manure.

The following table indicates the increased methane yields as other substrates are co-digested with dairy manure. Values for the methane yield of dairy manure as a sole feedstock can vary; conservative values tend to be more true to realistic applications.

**Table 12 Examples of co-digestion with dairy manure**

| % Manure | % Co-digestion feedstock | Methane yield $m^3$ $CH_4$ / kg VS | Data Source |
|---|---|---|---|
| Manure (92 %) | FOG (8 %) | 0.379 | Crolla, 2006[1] |
| Manure (88 %) | FOG (12 %) | 0.403 | |
| Manure (50 %) | Corn Silage (50 %) | 0.361 | |
| Manure (80 %) | Canola press cake (20 %) | 0.423 | |
| Manure (68 % ) | Food waste (32 % ) | 0.219 - 0.429 | El-Mashad, 2007[1,2] |
| Manure (52 % ) | Food waste (48 % ) | 0.277 - 0.556 | |
| Manure (100 %) | - | 0.140 | Chen, 2008[3] |
| Manure (94 % ) | Glycerin (6 % ) | 0.220 | |
| Manure (91 % ) | Glycerin (9 % ) | 0.310 | |
| Manure (100 %) | - | 0.243 | Labatut, 2008[3] |
| Manure (75 % ) | Plain Pasta (25 %) | 0.354 | |
| Manure (75 % ) | Vegetable Oil (25 %) | 0.361 | |
| Manure (50 %) | Dog food (25 %)<br>Ice cream (25 %) | 0.467 | |

1. Values for methane yields shown for these references were calculated assuming a 55% methane content of the biogas yields listed.
2. Varied loading rate at 2 g VS / L / day and 4 g VS / L /day in a continuous flow system.
3. Methane yields were reported for these references and not calculated.

## BIOMETHANE YIELD LABORATORY TRIALS

Biochemical Methane Potential (BMP) is an analytical tool that describes the volume of methane ($CH_4$) that can be produced from a given amount of volatile solids (VS) for a particular feedstock; it is expressed as $m^3$ $CH_4$ / kg VS. The BMP assay was designed to simulate a favorable environment where degradation will not be impaired by nutrient or bacterial deficiencies, toxicity, oxygen, pH, over-feeding, etc. In this way, relative biodegradability of various materials can be compared. It should be noted, BMP values reflect the ultimate methane production from a feedstock; actual yields in commercial applications may vary.

### Area Dairy Manure Samples

Representative samples from two dairy farms operating under “normal” practices for dairy farms in the Willamette Valley were collected in November of 2008. Both farms have a freestall barn layout; however, manure collection at one farm used a scrape-based method versus a flush-based system at the other farm. In both cases homogenized samples were sent to Woods End Laboratories in Mt Vernon, Maine for analysis using a variation of the method DIN 38414 from German Standard Methods for the Examination of Water, Wastewater and Sludge, which calls for a 21 day trial length.

Results of the BMP testing for all samples showed degradation started immediately (no lag time) and neared completion around 21 days. The BMP tests were done at two different organic loading rates (OLR) with the higher OLR (4 kg VS/L) twice that of the lower OLR (2 kg VS/L). In all cases, BMP results were consistent with literature values and had a biogas content of 63% methane or better. As OLR increased, the flush samples produced higher methane yields indicating the higher loading rate did not overload the methanogens; a result that may carry over to commercial scale. Conversely, the scrape samples resulted in decreased percent methane of the biogas, as well as methane yield; this indicated the digester system had been overloaded. The microbial environment becomes unstable due to accumulation of volatile fatty acids, pH shifts, ammonia accumulation, or changes in alkalinity. The end result is bacteria are stressed which results in decreased productivity than in an optimized and stable environment. This indicates there are tradeoffs to be considered regarding throughput and digester size. On one hand a low OLR requires a larger and potentially more expensive digester, but will yield more methane. The other option of using a smaller and potentially less expensive digester will require higher loading rates with reduced methane yields.

**Table 13 Local dairy manure biochemical methane yields (EC Oregon, 2009)**

| Manure Handling | Organic Loading Rate | $m^3$ $CH_4$ / tonne fresh weight | $m^3$ $CH_4$ / kg VS[1] | % Methane[1] |
|---|---|---|---|---|
| Scrape Collection | 1 X (2 kg VS/ L) | 16 | 0.190 | 67 |
| Scrape Collection | 2 X (4 kg VS/ L) | 13 | 0.155 | 63 |
| Flush Collection | 1 X (2 kg VS/ L) | 3 | 0.167 | 67 |
| Flush Collection | 2 X (4 kg VS/ L) | 4 | 0.222 | 69 |
| | Overall Average | 9 | 0.18 | 66 |

1. Data is from manure samples at two dairy farms in the Willamette Valley.

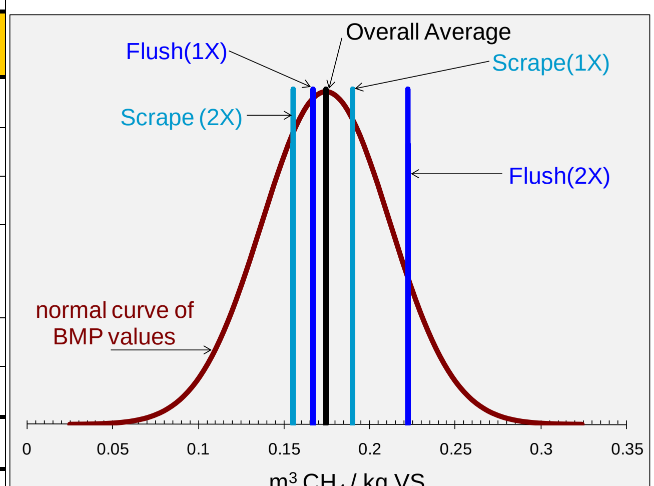
Literature BMP values for dairy manure range from 0.126 $m^3$ $CH_4$/kg VS to 0.243 $m^3$ $CH_4$/kg VS and have a 14 value average of 0.175 $m^3$ $CH_4$/kg VS. The results (0.155 to 0.222 $m^3$ $CH_4$/kg VS) for these representative samples were generally in line with literature values and suggest process optimization, such as loading rates tied to manure handling conditions, will control methane production.

**Table 14 Reported methane yield values for dairy manure with different diets, VS loading rates and temperatures**

| Literature Source | Methane yield $m^3$ $CH_4$/ kg VS |
|---|---|
| Amon, 2007[1] | 0.126 – 0.166 |
| Kishore, 2007 | 0.130 |
| Ghaly, 2000[2] | 0.151 – 0.208 |
| National Institute of Industrial Research, 2004 (Hashimoto) | 0.200 |
| Mashad, 2007 | 0.240 |
| Labatut, 2008 | 0.243 |
| **Willamette Valley (2009)** | **0.183** |
| **Overall Average[3]** | **0.174** |

1. Impact of dairy cow diet was assessed for methane potential (Amon, 2007).
2. Assessed VS loading rate and AD temperature for dairy manure (Ghaly, 2000).
3. Average is based on Willamette Valley BMP results and 14 literature values.

**Figure 16 Comparison of Willamette Valley manure to literature methane yield values (EC Oregon, 2009)**




Digestion trials were based on a homogenized sample from two collections on one day; actual methane yield for dairy manure will vary by collection, time of year, diet, or digester technology.

### Evaluation of Local Co-Substrates

A biogas plant located at either dairy farm has a lot of flexibility in choosing locally available co-digestion substrates to optimize biomethane yields and to provide for energy security. From a financial perspective, it is logical to transport co-digestion feedstocks low in moisture that are energy dense. Some examples of such substrates include potato chip waste, ARS, glycerin and FOG. To examine the impact on methane yields, samples for BMP assays were setup with manure collected by scrape collection and mixed with energy dense low moisture substrates. Mixtures with about 80% dairy manure, less than 20% ARS and 5% glycerin or FOG were prepared and tested in BMP assays. The results indicated a 17% addition of ARS can increase the methane potential by 30%. Adding a 5% mix of FOG or glycerin to the ARS/dairy manure blend can increase methane potential by 60-90% over dairy manure alone. Digestion trials were based in each case on a single sample from a single point in time; actual methane yield for each of these feedstocks may vary.

**Table 15 Co-digestion feedstock trials (EC Oregon, 2009)**

| | Feedstock | % moisture of feedstock | % of mix | BMP ($m^3$ $CH_4$ / kg VS) |
|---|---|---|---|---|
| Individual Feedstock | Dairy Manure (Scrape) | 89.5 | 100 | 0.172 |
| | ARS | 12.6 | 100 | 0.286 |
| | FOG (Waste Grease) | 4.2 | 100 | 0.572 |
| | Glycerin | 7.8 | 100 | 0.352 |
| | Potato Chip Waste | 19.8 | 100 | 0.508 |
| | Poultry Manure | 30.0 | 100 | 0.240 |
| Mixture | Dairy Manure | 89.5 | 83 | 0.226 |
| | ARS | 12.6 | 17 | |
| | Dairy Manure | 89.5 | 79 | 0.269 |
| | ARS | 12.6 | 16 | |
| | Glycerin | 7.8 | 5 | |
| | Dairy Manure | 89.5 | 79 | 0.319 |
| | ARS | 12.6 | 16 | |
| | FOG | 4.2 | 5 | |

### CO-DIGESTION FEEDSTOCKS NEAR ALBANY, OREGON

***Corn Silage* and *Silage Leachate*** - Corn silage and silage liquor are on-farm feedstocks with good BMP values of 0.319 and 0.417 $m^3$ $CH_4$ / *kg VS*, respectively, though available in relatively small quantities. Good silage management seeks to minimize the amount of silage liquor (leachate and surplus waste) that is produced. As long as moisture is minimized, little leachate will be produced. Since this leachate likely already drains to the reception pit collection of the silage liquor should be easy. Since the collectable amounts are likely low, neither the silage liquor nor the silage waste is anticipated to make a sizable impact on methane production under current handling methods.

***Dairy Manure*** – Dairy manure is the most common agricultural digester feedstock in the United States. Most on-farm digesters in Europe also use some percentage of livestock manure. Dairy manure is a good buffering agent for higher energy feedstocks. In a co-digestion scenario, manures will buffer pH, supply nutrients and provide consistent feedstock from a point-source. With a high moisture content and low methane yield, acquiring offsite dairy manure could prove to be cost prohibitive. Volbeda Dairy already has a substantial amount of dairy manure onsite that should provide appropriate buffering capacity for most co-digestion feedstock mixtures.

***ARS* -** Annual rye grass shows promise as a high energy co-digestion feedstock. The low moisture content and high energy density of annual ryegrass straw (ARS) make it an attractive co-substrate for dairy manure, but there are some risks to ARS being incompatible with some digesters. Size reduction will be required for more rapid degradation and so that ARS does not form a mat within a digester. Digester systems that have thorough mixing will prevent any stratification. Although there is a large amount of ARS available within the Willamette Valley, the logistics of collecting and transporting this feedstock have not been fully assessed. A preliminary estimate for the cost of harvesting and transporting ARS less than 40 miles would be approximately $35 per ton; the $10 per ton Biomass Tax Credit would be available to the producer or collector. A mandate prohibiting field burning has the potential to drive down the cost of ARS due to an increase in supply or government subsidies.

***Grass Silage* –** The same land used for production of grass seed, with annual ryegrass straw as a by-product, could be used to cultivate grass silage specifically for a biogas plant. As such the silage would be considered “closed loop biomass” and would be eligible for a $0.021/kWh Production Tax Credit on top of the $10 per ton Biomass Tax Credit. The methane yields for straw and grass silage are not that different on a volatile solids basis, however, grass silage (72% moisture) contains much more water than ARS (8% moisture). In order to get similar biomethane production from one ton of ryegrass straw it would take roughly 3 tons of grass silage. Since seed maturity would not be necessary for harvesting, multiple crops could be grown in succession to optimize the methane yield per hectare per year. Depending on specific methane yield, local acreage yields and energy inputs, crops, such as grass silage, grown as “closed loop biomass” can be high value feedstocks for anaerobic digestion, but are politically sensitive.

***Glycerin* -** Glycerin has relatively high energy and low water content; it is easily stored with good shelf life; it is pumpable and originates from a single point source. Heating glycerin makes it easier to handle. Although, sizable quantities (2-5 tpd) of glycerin exist within close proximity, competitive uses of this co-digestion feedstock may make acquisition challenging. In order to accommodate for infrequent glycerin deliveries and to prevent overloading the digester an appropriate holding tank that allows for controlled glycerin additions would need to be installed. Glycerin has high degradability and attractive material handling qualities but also competing uses; with low moisture and high C:N, it is suitable as a co-digestion substrate to balance high nitrogen livestock manures.

***FOG* -** There are different qualities of fats, oils and greases (FOG), so competition for some sources exists. Recycled cooking oil (known as yellow grease) is currently coveted by companies producing biodiesel so its acquisition is unlikely. However, the screening of impurities from yellow grease creates a waste stream usable in digestion. Also, grease trap waste (known as brown grease) which is not suitable for biodiesel production is available from urban areas. Extrapolation of data supplied from a regional hauler approximates the combined total available grease trap waste from Salem, Albany and Corvallis urban areas at 12 tpd. With 2.4 tpd waste grease from a local potato chip food processor, the combined total of FOG available is

14.4 tpd. Fats, oils and grease, like glycerin, would be an excellent additive to a co-digestion biogas plant by significantly enhancing biogas output when used in small quantities.

***Municipal Food waste (MFW)*** – While variable, a literature review determined that municipal food waste (MFW) is an excellent anaerobic digester feedstock with very good specific methane yield. Food waste quality and composition are greatly variable depending on source, region and collection method, but is significantly more biodegradable than other commonly used feedstocks. It also has relatively high macro- and micro-nutrient contents to facilitate healthy digester bacterial growth and enhance effluent fertilizer value. However, impurities (i.e., plastic, metal, glass) must be removed from the municipal food waste stream to prevent mechanical failure of facility components and produce marketable co-products.

The Portland Metro area (METRO) post-consumer food waste collection system currently recovers over 16,000 tons MFW per year. Currently METRO MFW is hauled over 150 miles to a Cedar Grove composting facility in Washington. The amount of MFW collected could grow to 80,000 tons in 2 years if capacity at transfer stations accommodates. However, there are only 2 transfer stations and each transfer station only has capacity for 20-23,000 tons. If the transfer station could accommodate more MFW, long term estimates indicate that over 135,000 tons MFW per year could be available.

Since the logistics for collection of METRO MFW have already been worked out and a potential tipping fee of $50/ton is not unreasonable for this waste stream, acquiring MFW from over 70 miles away to Volbeda Dairy may be financially rewarding. A recent news article (March 9, 2009) quoted Cedar Grove's Vice President Jerry Bartlett saying rather than ship this feedstock towards Northern Washington, Cedar Grove Composting is still trying to find a facility closer to Portland that could use this waste stream. Whether or not a biogas plant at Volbeda dairy qualifies as a local destination for MFW is unknown at this point.

Digesting municipal food waste, which would include some amount of animal by-product (ABP), raises issues related to public, animal and environmental health. According to a current European Commission Regulation (No 1774/2002), ABP are categorized (Category 1 = very high risk, Category 2 = high risk, and Category 3 = low risk). Category 1 materials include carcasses infected with BSE or suspected of BSE infection, specified risk material (SRM) such as, skull, brain, eyes, vertebral column, spinal cord, tonsils, intestines, spleen and ileum. All Category 1 material is banned from anaerobic digestion. Category 3 materials include catering waste, food factory waste, supermarket waste, parts of slaughtered animals that are suitable for human consumption but are not intended for consumption due to commercial reasons, parts of animals unfit for human consumption, but do not contain communicable diseases and didn't come from diseased carcasses. Category 2 materials are those that don't fall into the other categories. EU standard requires a hygenisation unit capable of holding Category 3 material at 70 ºC (158 ºF) for 60 minutes and Category 2 requires sterilization ≥3 bars, ≥ 133 ºC, ≥ 20 minutes prior to anaerobic digestion. There are currently no rules or regulations in place in Oregon specifically dealing with anaerobic digestion of ABP; this will likely change in the future. EC Oregon strongly recommends following EU guidelines concerning the anaerobic digestion of ABP.

*Bottom line*: Provided the dairy qualifies as a "local" destination, the amounts of municipal food waste available combined with likely tipping fees, make MFW an appealing co-digestion substrate.

***Potato and Potato Chip Waste* -** One local food processor has about 8.4 tpd of potatoes and 9.2 tpd of potato chip waste and 2.4 tons of waste grease on a daily basis. Potato waste currently goes to animal feed and, with only 18% TS, may not make much sense to ship unless tipping fees could be garnered. In contrast, at 80% TS, 97% VS of TS, and a BMP of 0.508 $m^3$ $CH_4$ / *kg VS*, the potato chip waste is an energy dense co-digestion feedstock, as is the waste grease. The potato chip waste and waste grease would make excellent energy dense co-digestion substrates.

***Poultry Litter* -** There are multiple poultry broiler operations within close proximity. With 10,500,000 broilers per year within 30 miles of Volbeda Dairy an estimated 35 tpd of poultry liter would be available. Broiler litter, consisting of chicken manure and wood shavings for bedding, is collected on a six week interval. The long period of time between collections likely allows the manure to degrade on-site, decreasing its energy potential. Wood shavings are generally problematic in digesters since woody biomass is resistant to rapid anaerobic degradation. Even if another poultry bedding material would be used (e.g., grass seed screenings) and collection occurred more frequently to reduce volatile solids loss, pretreatment in the form of settling tanks are required to remove and prevent grit and feathers from entering the digester. Although the relative amounts of poultry litter are high, the current state of the litter, wood based bedding, does not make it as attractive of a co-digestion feedstock as other substrates.

***Food Processing Residue* -** Food processing residue (typically fruit and vegetable residue) is available at various quantities and qualities (70-90% moisture). A seasonality assessment shows that for 5 months of the year at least 70 tpd of food processor waste is available; with over 250 tpd in October and November. For 7 consecutive months there is less than 15 tpd available.
The amount of annual vegetable residue available on a consistent basis is low (2 tpd). However, the amount of vegetable residues available significantly increases by 30 to 100 fold during July through November. Fruit residues have a consistent annual base of about 8 tpd; in July through August there is a slight increase in berry waste (1.5 tpd).

Processors with relatively large residue streams include Norpac Foods Inc, National Frozen Foods Corporation, and Truitt Bros., Inc. Recent (July, 2009) conversations with Norpac indicate their processing plant in Brooks has 13,000 tpy of cauliflower waste available during October through November. Norpac's repackaging facility in Salem has 1,200 tpy of mixed waste available on a consistent basis. These waste streams currently produce zero to negative income for Norpac. From July through November Truitt Bros., Inc has a significant waste available (~ 40tpd) in the form of bean and pear waste. National Frozen Foods is the closest of these food processors and has a small annual waste stream of 2.3 tpd. However, National's waste increases to 20 tpd during July through October.

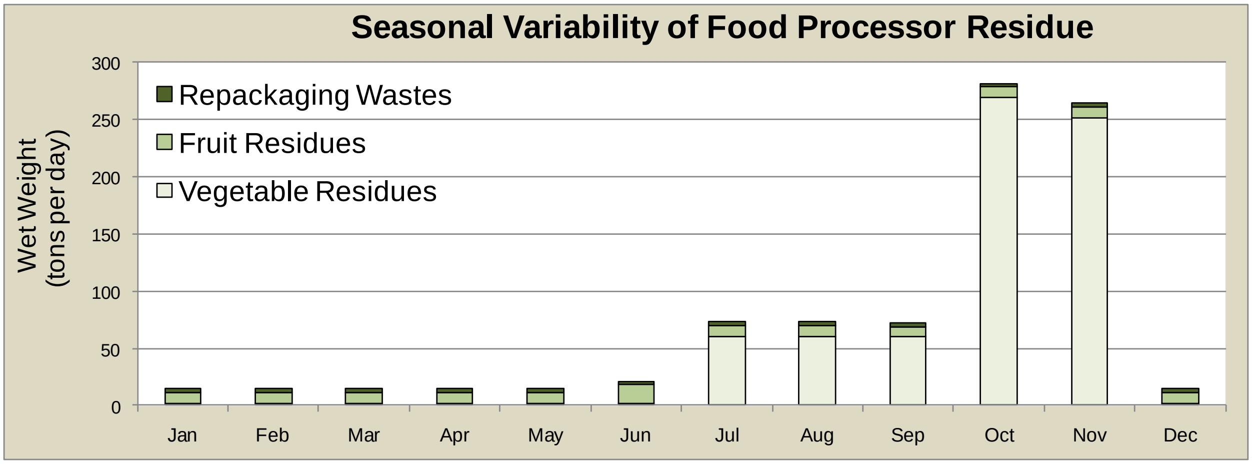


**Figure 17 Seasonal variability of food processing waste**

Additional locally available suitable substrates exist, but their availability, transportation logistics or other reasons do not make these feedstocks as attractive as others already mentioned. For instance Norpac has indicated an additional vegetable residue stream of 150,000 tpy is seasonally produced (August through September), but is currently going to cattle feed. During August and September, Norpac has 6,000 tpy of beet peel (2% TS) available from another one of their facilities in Salem. At 98% moisture the beet peel may not make much sense to ship.

Ensiling is a way to mitigate seasonal fluctuations in processor waste quantity, but variations in quality will persist. Storing food processing waste with grass straw will preserve the nutritive value of these feedstocks with little to no loss of methane potential and provide for a guaranteed supply of consistent quality feedstock year-round. Ensiling is a well documented process that takes place in an anaerobic environment where naturally occurring bacteria produce lactic acid from carbohydrates, which lowers pH and prevents spoilage. In fact, the silage process largely mimics the first two steps of the AD process, hydrolysis and acidification - effectively acting as a pretreatment. Silage, along with the dairy manure, would buffer the digesters and allow for addition of moderate amounts of various other feedstocks as available. However, ensiling will significantly increase biogas plant capital expenditures as well as operation and maintenance expenses.

***Bottom line*:** Food processor residue is available in substantial, if inconsistent, quantities and shows wide variability in type, content and methane yield. It can likely be had for free (or garner tipping fees) and has minimal contamination issues.

### CO-SUBSTRATE RECEPTION, PRETREATMENT, STORAGE

If co-digestion feedstocks are utilized, some pretreatment may be necessary depending on the type of feedstock. Annual ryegrass requires particle size reduction. Other feedstocks, such as potato chip waste, glycerin and FOG may not require any specialized pretreatment equipment other than appropriate storage receptacles.

Lignin and cellulose, components of plant cell walls, are resistant to degradation. Pre-treatment of a feedstock is intended to increase digestibility of lignocellulose, resulting in higher biogas yields and/or faster complete degradation. Hydrolysis is the rate limiting step in the use of lignocellulosic feedstocks in AD. Ideally, pre-treatment would increase the surface area, break polymers into more easily accessible soluble compounds and reduce the lignin content and the crystallinity of the cellulose. Pre-treatment of ARS, with relatively high lignin and cellulose contents, likely will enhance biogas production.

Particle size reduction enhances hydrolysis by increasing the available surface area. However, numerous studies have shown that the law of diminishing returns applies. The threshold particle size under which further reduction becomes unnecessary varies based on feedstock type, grinding method and site-specific energy economics but is widely agreed to be above 1 mm (0.04 in). Particle size reduction of ARS, with its disproportionate length:width ratio will certainly enhance biogas yield to a degree. Additionally, chopping/grinding straw will allow it to remain in suspension and prevent a floating mat on top of the liquid level in the digesters.

Physical receiving equipment at the digester for offsite feedstock will be standard to material handling (i.e., hoppers, conveyors, and/or augers). A hammermill or grinder will likely be required to reduce remaining large substrate particles. Studies (Mshandete 2006, Sharma 1988) have shown that biogas production is inversely proportional to feedstock particle size, but with diminishing returns. Optimal particle size, and therefore grinder specifications, will be determined by the particular feedstock, digester design and vendor recommendations.

Liquid feedstocks can be collected in a receiving pit or dosing tank and pumped into the digester. For dry feedstocks, the direct feeding system used in at least half of new energy crop biogas plants in Europe is a modified feed mixer, a common piece of equipment in the livestock feed industry. A feed mixer ensures a well mixed substrate that can be fed at a constant rate.

For grower biomass producer tax credit purposes, all material to be used as feedstock must be weighed, either at the time of collection or feeding. A weigh-scale incorporated into a receiving hopper or the feed mixer will accommodate all feedstock and allow for accurate feeding rates.

### FARM FACTORS AND DAIRY MANURE QUALITY

Multiple on farm factors can impact the quality of manure and subsequently impact methane yields as well.

#### Low Concentration of Total Solids

Dairy manure is typically excreted at 12-15% TS. Any process water or rainwater incorporated into manure collection could drastically dilute out the manure. Dilution of the manure may be incompatible with certain digester designs. For instance, low % solids have created crusting or foaming in a plug-flow digester. Even though a lower % solids is compatible with certain AD technologies, a low % solids is not recommended. Since significantly larger volumes of cold water will need to be heated to at least mesophilic temperatures for efficient methane yields, having excess quantities of water in the digester will lower the efficiency of methane production and revenue generated. Likely reasons for manure dilution are from the dairy process water, flush manure collection and the wet winters in Linn County. Maintaining a high % TS for the manure may be challenging during Oregon's winter months. Nevertheless, rainwater and other water need to be minimized or prevented from co-mingling with manure.

Though technologies such as thickeners exist to increase solids contents of slurries from flush collection, they are not recommended. If a thickener is used, VS will be lost resulting in a net loss in manure methane that is roughly inversely proportional to the solids capture rate of the thickener. Alternatively, scrape based collection captures the manure closer to an excreted state (high % TS). Therefore, scraped based collection is the preferred approach over flush collection. Similarly, a feasibility study on anaerobic digestion for Idaho dairy farms concluded that dairy manure needs a high solids content to be a viable energy producer and therefore flush collection would not be a viable biomethane approach (Mountain View Power, Inc.).

Automated scrape based manure collection systems exist with similar efficiencies and conveniences to flush based collection systems. Electric, programmable alley scrapers are touted as labor saving devices that are safe for cows lingering in the alleys. A hinged scraper blade is pulled down the alley on a cable or chain by a geared low-horsepower motor; the blades retract for the return trip. Increased scraping frequency may contribute to cleaner barns. Manure management related incentives, such as the USDA's NRCS Environmental Quality Incentives Program (EQIP) can provide capital cost share. Since the switch to scrape is recommended for more efficient digester operation and would be directly involved in collecting feedstock for renewable energy production, an automated scrape system may also qualify for Oregon's Business Energy Tax Credit (BETC).

### Incompatible Dairy Bedding

Common practices for dairy farms in the Willamette Valley are to use straw, recycled paper or composted manure solids as bedding. Though wood shavings and sawdust are available in the area, they are not recommended for AD. Plug-flow digesters have experienced mat formation from the use of wood shavings and clogging due to wood chips. Fortunately, when AD is combined with post-digester composting, virtually pathogen-free bedding can be produced from the digestate solids.

### Inhibition and Toxicity

There have been reported instances where on farm chemicals have impacted the methane potential of anaerobic digesters. For example, an anti-freeze leak in a barn killed much of the digester bacteria when the tainted manure was included in the feedstock. Another incident involved sanitizing footbath added to the digester feedstock which also depleted the bacterial population.

To assess toxicity of chemicals commonly found on dairy farms researchers have done anaerobic toxicity batch assays. Inhibitory concentrations that caused a 50% decrease in methane production rate ($IC_{50}$) were established for a wide array of chemicals commonly used on dairy farms. The most problematic chemicals found were quaternary ammonium chloride and a methanogen inhibitor feed additive (Rumensin). Both of these had an $IC_{50}$ 0.1 (v/v), whereas copper sulfate, a common hoof sanitizer, had an $IC_{50}$ 4.0 (v/v). Some other products, like surfactants, actually showed increases in methane production. Additional studies have shown when bacteria are repeatedly exposed to low doses of a compound the bacteria can acclimate to higher concentrations.

Since dairy manure has a strong buffering capacity, it is unlikely hydrated lime - a common drying agent for bedding - will raise the pH of the manure to a level incompatible with AD. However, certain technologies, such as fixed film digesters, may accumulate calcium precipitates and eventually clog if lime is routinely used.

Large spills or other ways of introducing a large quantity of farm based compounds into the digester may be problematic. Addition of co-digestion feedstocks might help dilute out any potential farm based inhibitory compounds. As a precaution EC Oregon recommends storage of farm chemicals that limits spills into the reception pit area, as well as implementing a spill response and control plan.

**Dairy Cow Diet**

It is important to note that diet of a cow directly impacts the lignin and crude protein in the cow manure. Increased crude protein increases methane yields, whereas increased lignin content lowers methane yields. Switching from a hay based diet to more of a summer based feed, such as clover grass, can increase methane yield as well. In an extreme case, the type of feed has been shown to impact dairy cow manure methane potentials by as much as 24%. Some AD systems have experienced foaming that coincided with dietary changes. EC Oregon is not recommending a change in current feeding practices. Some seasonal differences in methane production from dairy manure are anticipated.

**Performance Related Problems**

Compilations of case study data shows that some of the complaints owners have had with on farm digesters can be grouped into the following categories: selection of a design that was incompatible with manure harvesting, design was not compatible with location, design operation and maintenance was more complex than necessary, digester was not large enough to process manure capacity, existing structures and equipment were not utilized to full potential, poor process control, maintenance was not followed and digester was not compatible with on farm practices.

In order to avoid these problems it is essential that the digester design fits a dairy's farming practice. Operation and maintenance performance data compatible with respective farming practices should dictate technology and not necessarily the lowest cost option.

Specific items that may be noteworthy for the Volbedas are that low % solids have created crusting or foaming in a plug-flow digester and wood shavings formed a mat within a plug-flow digester and wood chips clogged a different plug-flow digester.

# Appendices for Section 4

## SIMILAR FACILITY CASE STUDIES

### Expected Gas Yields and Electrical Production

Case study information was assessed for US dairy farms that had anaerobic digesters with only dairy manure as sole feedstock. As long as a digester is designed to match dairy farm practices, manure handling is optimized and the digester is well maintained, it is possible to get values higher than the upper ranges. Conversely, a digester not matching the dairy farm needs, a poorly maintained digester, or inefficient manure collection will result in performance levels below the ranges shown.

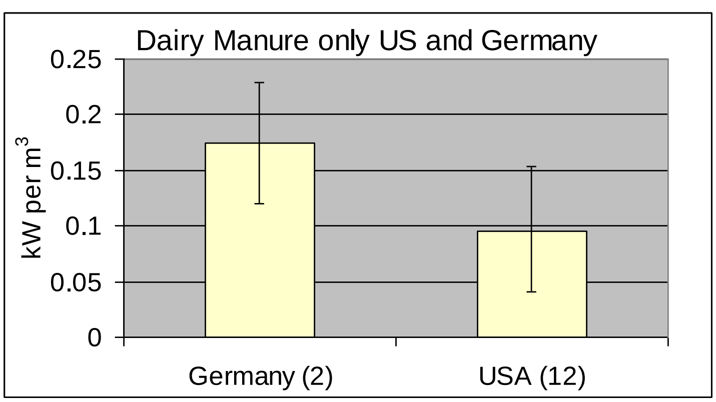
**Table 16 Case study summary table of dairy manure as sole feedstock**

| | Average(1) | Expected performance range(1) | Number of case studies(1) |
|---|---|---|---|
| $ft^3$ biogas /day/cow | 66 | 46 - 86 | 17 |
| $ft^3$ $CH_4$ /day/ cow | 33 | 25 - 40 | 13 |
| kWh /day/ cow | 2.6 | 2.0 - 3.3 | 18 |

1. Data from Kramer 2004, Kramer 2008, Lusk 1998, Wright 2003, Wright 2004, Topper 2008, Martin 2003, Martin 2005, Martin 2007, Walters 2007, and Sjoding 2005 was compiled by EC Oregon (2009).

### Anaerobic Digestion: Europe (EU) and United States (US)

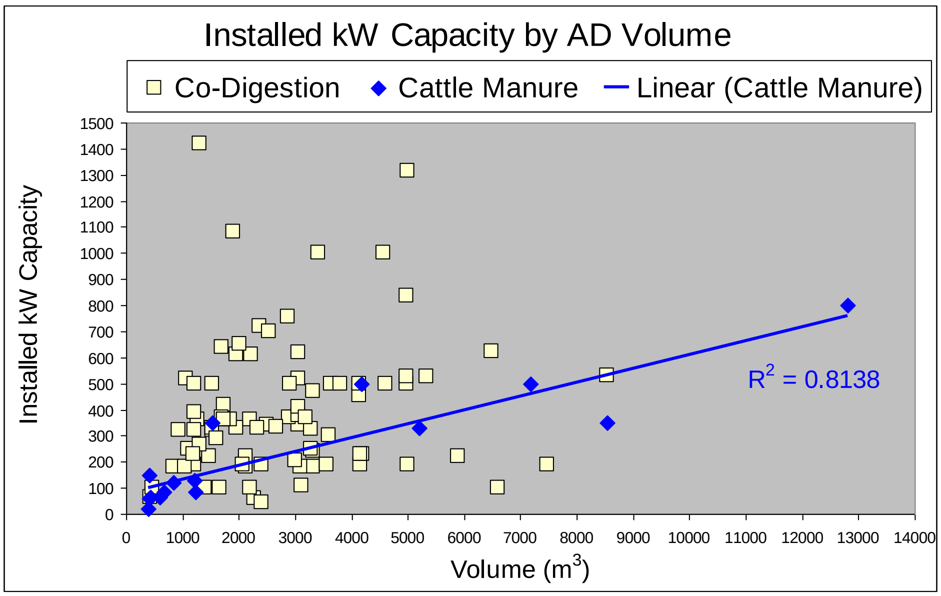
Directly comparing anaerobic digestion of dairy manure in the US to European data is difficult, because most biogas plants built in Europe practice co-digestion. In the US, even with manure as the sole feedstock, the process might not be optimized given a certain volume digester. One should note that true performance data is elusive and that just because something is installed doesn't mean its meeting capacity. Perhaps a better way to look at this data is that in Europe co-digestion is the preferred practice. Given that certain feedstocks are more energy dense than other feedstocks, the installation of more electrical capacity allows a biogas plant flexibility to optimize their respective system without having to install additional digester capacity.




- X-Axis is biogas plant country with the number (n) of samples in parenthesis
- Y-axis = mean kW installed per $m^3$ of digester volume, and error bars represent minimum and maximum values.
- Mean (yellow bars), minimum (black error bars) and maximum (black error bars) kW per $m^3$ values were calculated for each country (Data compiled from Biogas-Nord 2008, Topper 2008, Lusk 1998 and Martin, 2005).

**Figure 18 Germany vs. United States kW per digester volume (EC Oregon, 2009)**

If co-digestion feedstocks are assessed for electrical potential by volume of digester, it is clear that the process isn't optimized when only dairy manure is added to the digester. The installed electrical potential per digester volume of cattle manure was compared to co-digestion data where at least a portion of the co-digestion feedstock contains cattle manure. A regression analysis of using only dairy manure as the feedstock showed a decent correlation ($r^2 = 0.81$), indicating there is a strong correlation to digester volume and electrical capacity if only dairy manure is used. However, regression analysis of co-digestion feedstock failed to show any correlation ($r^2 = 0.026$) to digester volume and electrical capacity. This is due to differences in energy density of regionally available feedstock. It clearly indicates that co-digestion can increase the electrical capacity of a given size digester by a magnitude up to 5 times greater than that of dairy manure.




- Chart of anaerobic digester volume ($m^3$) by installed kW capacity.
- Blue diamonds represent cow manure as the sole feedstock.
- Blue line represents regression line for dairy manure as sole feedstock. Yellow squares represent co-digestion feedstocks.
- All data points were from either complete mix or plug-flow digesters

Compiled from Biogas-Nord 2008, Topper 2008, Lusk 1998 and Martin, 2005.

**Figure 19 Installed kW by volume; EU and US data (EC Oregon, 2009)**

If only dairy manure is used the return on investment would be less attractive since the potential for energy produced from dairy manure is much lower than energy dense feedstocks.

## ANCILLARY TECHNOLOGY OPTIONS

### Biogas to Electricity and Heat via Co-generation

If electricity is a desired end product of biomethane, the most common production method is a combined heat and power (CHP) unit, also known as co-generation. The unit is typically a stationary internal combustion engine and integrated generator specifically engineered to operate on biogas (or natural gas). Dozens of vendors worldwide, with a range of experience, provide biogas compatible CHP units with varying performance specifications. Implementation of CHP at biogas plants is proven, straightforward and well documented; for this reason it will be summarized briefly.

The electricity generated has potential for use at the facility or sale to the utility. Multiple smaller CHP units would provide redundancy while situated at different locations within the facility to maximize waste heat depending on specific needs.

Ideally, the site surrounding the biogas plant would utilize some or all of the heat generated by the CHP engine. Electricity production with an internal combustion engine and generator is approximately 40% efficient; recovery of thermal energy from a CHP unit can raise the overall efficiency to roughly 80%, improving the energy balance of the project. Engine jacket heat can be routed through a heat exchanger to produce hot water; exhaust heat can be routed through a heat exchanger to produce steam.

The resulting hot water is used to pre-heat incoming feedstock and maintain mesophilic (or thermophilic) temperatures in the digester vessels. Other possible applications for thermal energy carried by water include powering an adsorption or absorption chilling system and heating a building/space or greenhouse.

The best use for thermal energy depends on the nature and needs of co-located operations and neighboring facilities, if any. If no use for thermal energy can be developed on the project site, options other than CHP become more attractive (e.g., biogas upgrade for injection to natural gas pipeline).

### NUTRIENT RECOVERY EQUIPMENT

All macro- and micronutrients present in a feedstock will pass through the digester and be present in the digestate, a product well suited for *agronomic, horticultural, and silvicultural uses.* Nitrogen (N) in the digestate will be primarily in the form of soluble ammonia and thus present in the liquid after dewatering, whereas phosphorus (P), typically insoluble in compound form, will largely end up in the fiber fraction. The distribution ratios of N and P in the fiber and liquid fractions will depend on the solids capture rate of the dewatering equipment.

Dewatering could occur with a rotary screen and roller press and/or a decanter centrifuge, belt press or screw press. Separator technologies, such as centrifuges and belt filter presses, are available that could double the % TS captured compared to a screen separator. Digested solids have different characteristics than undigested manure solid and are generally considered more easily separatable.

**Table 17 Solids capture percentage for separator technology**

| Separator | % Capture |
|---|---|
| Screen Separator | 20-30 |
| Biolynk System | 55-60 |
| Centrifuge | 75-90 |
| Belt Filter Press | 80-95 |

Since all the captured solids will have moisture associated with them, there is a net reduction in both macronutrients (nitrogen, phosphorous and potassium) and liquid going to the lagoon. As mentioned earlier, nitrogen (N) will be mainly soluble and associated with the liquid fraction while phosphorous (P) and potassium (K) will be collected mainly with the fiber. The efficiency of the separator dictates what percent of the digestate balance goes to fiber storage and what percentage goes to the lagoon. A separator with a higher % TS capture will capture more fiber (P and K) with a percentage of the moisture (N) being retained in the captured fiber and both will be diverted from the lagoon. The dry, fiber fraction of dewatered digestate can be used as a compost component, soil amendment, nursery planting media or animal bedding. An added benefit of the high solids capture rate is the lagoon will not needed to be dredged as often. Whereas a separator with a low capture rate will allow fiber (hence more P and K) to flow to the lagoon along with the centrate. Provided a market is established, an increase in recoverable fiber would allow for increased revenues from digestate solids.

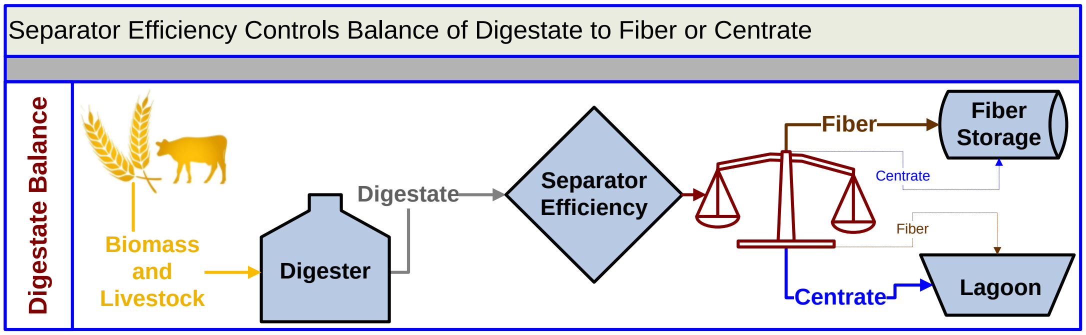



**Figure 20 Separator efficiency and digestate balance (EC Oregon, 2009)**

Since Volbeda dairy already has a separation system with a good capture rate, upgrading the separation technology would not be warranted unless market value of digestate solids increased significantly.

Depending on the biogas plant location and nutrient management plan, it may be possible to land apply the centrate directly to adjacent agricultural fields or store in a lagoon. Concentration is an option that will allow for storage, transport to remote growing areas and/or sale as liquid fertilizer. A market assessment would be required to determine whether and how much concentration would be beneficial.

Since the digestate solids will not include any plastic material nor any other unwanted byproducts, potential outlets for digestate solids would include organic recyclers, agricultural commodity haulers and annual ryegrass straw growers. The relatively dry, fiber fraction of dewatered digestate can be used as compost component, soil amendment, nursery planting media or animal bedding. Although no formal opinion has yet been requested, Oregon Tilth believes digestate can be used in certified Organic crop production. Literature sources suggest the nationwide average prices for digestate composted solids are $15 to $25 per ton and fresh, uncomposted digestate solids are $3 to $6 per ton. Whether the increased revenue from composted digestate solids warrants the additional labor and space costs is a case-by-case farm decision. As more anaerobic digesters are built the market for solids may become saturated. So at this time it's best to use conservative values for digestate as additional revenue.

### PERMIT LIST

Oregon Department of Environmental Quality (DEQ) Air Quality Division will require an Air Contaminant Discharge Permit (ACDP) to install and operate any generator(s). The type of ACDP that will likely be required ("Simple") has a 5 year duration, $5,000 initiation fee and $1,600-$3,200 annual fee. A public notice and comment period is part of the permit process. The DEQ has up to 120 days from when an ACDP application is deemed complete to issue a permit.

Oregon DEQ Water Quality Division will also require a biogas plant to have a Water Pollution Control Facility (WPCF) or National Pollution Discharge Elimination (NPDES) permit in order to discharge digester effluent to a lagoon or as a land application. Volbeda Dairy currently has a NPDES as part of their CAFO permit and no additional permitting is expected. Application processing and annual fees for a new permit, if necessary, would amount to approximately $9,000 and $3,000, respectively.

A construction stormwater permit (1200-C) will also be required by the DEQ if more than one acre of land is to be disturbed during construction (including access roads and on-site mined gravel source). The construction stormwater permit application must include an Erosion and Sediment Control Plan (ECSP). Fee = $795. Volbeda Dairy has a Standard Industrial Classification (SIC#) of 0214: dairy farm, and as such is exempt from the industrial stormwater permit (1200-Z) requirement.

According to Oregon DEQ, a biogas plant will require a solid waste permit prior to bringing in outside feedstocks is they are deemed "solid waste". Solid waste is defined as "*useless and discarded*" material (ORS 340-093-0030.82) from the perspective of the generator, regardless of whether it is sold, given away for free or disposed of at a cost. By-product streams generated on-site and used as a feedstock for another process in the same facility – such as manure in a digester – would not be considered solid waste. ARS, for example, could be treated as solid waste by the definition above, but it is unclear if DEQ will take this position. DEQ is currently developing rules that will authorize "Beneficial Use Determinations" for certain solid waste materials which, when used in designated processes, do not create adverse impact to human health or environment – effectively short-cutting the need for a solid waste permit.

Oregon law requires state agencies to ensure that a permitted activity is consistent with local zoning districts, comprehensive plans and land use regulations. Any state-issued permit application must be accompanied by a land use compatibility statement (LUCS) signed by the local county authority. In all likelihood, an anaerobic digester will be considered an "allowed use" as ancillary equipment for an existing dairy. In addition local building codes will need to be followed. If a DEQ solid waste permit is required for a facility, then local Planning Departments usually consider the site to be a solid waste disposal site for the purpose of reviewing a Land Use Compatibility Statement. However, it is possible that the case can be made that the facility's main purpose is energy generation, if this is beneficial.

## RENEWABLE ENERGY INCENTIVES

### Renewable Energy Certificates (RECs)

Renewable Energy Certificates (RECs) are also commonly known as Green Tags, Renewable Energy Credits, or Tradable Renewable Certificates (TRCs). One REC represents the environmental and social benefits from one megawatt-hour (MWh) of electricity generated from an eligible source fed to the grid. While this is the generally accepted definition, variations do occur depending on the certifying agency.

A dairy manure-based biogas plant generating renewable electricity will qualify for REC certification. Actual certification will require knowledge of project specific variables which include, but are not limited to: site location, interconnection utility, power purchase agreement terms, feedstocks utilized, electric generation technology, and facility commissioning date. Reliable reference price indexes for RECs in the Compliance and Voluntary Market are not available. However, EC Oregon recently negotiated two Voluntary Market REC contracts for a biomass based project in the Willamette Valley where opening offers ranged from $4.00 to $8.00 a tag.

**Carbon Offsets**

The potential exists for an anaerobic digester project to earn carbon offsets from offsetting lagoon emissions and other carbon-equivalent sources. The Chicago Climate Exchange's recent pricing history indicates a high of $7.40 per metric ton $CO_2$ (June, 2008) and a low of $1.10 (November, 2008). The determination process is complex and time consuming and depends on project specific variables such as, but not limited to: project site, project boundary definition, current regulatory environment, technological and/or financial barriers, additionality and other protocol specific requirements.

**Biomass Producer Tax Credit**

The producer or collector of biomass is eligible through 2012 for a tax credit of $5.00 per wet ton of animal manure and $10.00 per green ton for biomass produced on the farm, such as straw or grass. Collection of offsite biomass may also be eligible at the rate of $10.00 per green ton.

**Oregon Business Energy Tax Credit (BETC)**

Investments made in Oregon for energy conservation, renewable energy, recycling, sustainable buildings, and alternative fuel and hybrid vehicle projects may qualify for Oregon's Business Energy Tax Credit (BETC).

For renewable energy projects, a tax credit of 50% of the qualified project costs is available. The tax credit can be utilized over a five year period, at 10% of project costs per year. Any unused credit can be carried forward for an additional three years if necessary. Additionally, the tax credit has the added flexibility of a pass-through option. The whole value or portion of the tax credit can be transferred to a pass-through partner in exchange for a lump sum payment at the net present value (currently 33.5%) of the tax credit as determined by the Oregon Department of Energy.

Anaerobic digestion is a recognized eligible technology and the qualified costs include all costs directly related to the project, including equipment costs, engineering and design fees, materials, supplies and installation costs. Loan fees and permit costs also may be claimed. Replacing equipment at the end of its useful life, equipment required to meet codes or other government regulations, and operation and maintenance costs are not eligible.

**Renewable Production Tax Credit (PTC)**

The federal Renewable Electricity Production Tax Credit (PTC) is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources. Anaerobic digestion, as proposed in this study, is considered "open loop biomass" and as such is eligible for $0.01/kWh. Whereas corn or grass silage grown solely for use in a biogas plant would qualify as "closed loop biomass" and be eligible for a $.0021/kWh tax credit.

Since it was enacted, the PTC has been renewed multiple times, typically for 1-2 year extensions. Currently, the open loop biomass clause expires on Dec 31, 2013. To claim the credit, facilities must be “in service”, as defined by IRS tax code, by that date. Facilities that qualify can claim the credit for 10 years after the in service date.

**Net Metering**

Current Oregon Administrative Rules require PacifiCorp to allow “net metering” for non-residential customers with small renewable energy generation facilities (2 MW or less); larger generators may be considered on a negotiated basis. Net-metering allows for any net excess generation (generation over facility consumption) to be credited to the consumers account. When the consumer produces less than the demand it draws from the credit retained. At the end of the 12 month period any residual credit is forfeited by the consumer – therefore a net-metering scenario only makes sense if production is equal to or less than on-site demand. Net metering is also eligible for Renewable Energy Credits.

**Funding Opportunities**

The USDA Rural Energy for America Program (REAP), formerly known as Section 9006, is undergoing revision per the 2008 Farm Bill. As new rules are released, the following information may change slightly. Anaerobic digestion is an eligible technology under REAP, which has grant and loan guarantee components; both require that the applicant own and control operations of the project and be a rural small business or agricultural producer. Grants, which require the applicant show a “demonstrable financial need” for assistance, are available for 25% of eligible project costs, up to $500k. If lender so requires, they may also apply with the applicant for a loan guarantee for a maximum of $25M, or 75% of project costs. A grant/loan guarantee combination request may increase the odds of a grant award.

The Oregon Department of Energy administers the Small Scale Energy Loan program (SELP), which is funded by bonds sales. Loans for up to 50% of project costs are available 10-15% owner equity Technical eligibility criteria for SELP are largely the same as for the Oregon BETC, so an on-farm digester would qualify. There are additional financial performance measures that are considered; a pro-forma financial analysis and business plan are required for application.

The American Recovery and Reinvestment Act of 2009 (also known as the stimulus bill) authorized the U.S. Department of Treasury to implement a renewable energy grant program. Essentially, projects that are eligible for the renewable PTC (see above) can receive an up-front grant for 30% of eligible project costs instead of the tax credit. Other non-governmental organizations, such as Energy Trust of Oregon or Bonneville Environmental Foundation, may have the means to support the development of anaerobic digestion projects on a case-by-case basis.

# Appendices for Section 5

## SCENARIO A FINANCIAL MODEL – SUMMARIES AND PRO FORMA

### Complete Mix Digester with Co-digestion Feedstocks at Volbeda Dairy

# Volbeda Dairy

**Scenario = Complete Mix, Co-digestion and Flush**

# AD Financial Feasibility Model v2.3

Confidential!

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**

**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**

**RNG: 0 MCF/Hour**

**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**

**Version: 10/4/2009**

**Developed by:**

E·C·Oregon
Cultivating Renewable Energy Solutions

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# Legend

| Legend | Notes |
|---|---|

Nav

## Static Text Labels

The Static Text Labels show up in the following formats and should not be changed.

| | |
|---|---|
| **Tab Name** | Name for tab |
| **Section Heading** | Heading for main sections |
| **Section Sub Heading** | Heading for sub sections |
| Item label | Label for items |
| Item label for item with special emphasis | Label for items which warrant emphasis |
| **Confidential!** | Label for items which warrant special consideration |
| **Notes:** Notes and instructions for use of the model will appear here. | Notes, comments and instructions pertaining to the use of the model. These note boxes can be collapsed or expanded as needed by clicking the "**+**" or "**-**" sign at the far left. |
| Notes and Comments | Notes and comments pertaining to calculations and the use of values. Additional notes provide guidance to acceptable input values. |

## Input Variables

The Input Variables show up in the following formats. These inputs are used in calculations and formula drive calculations. Enter and adjust these input variable to model out the desired scenario. It is recommended to document the basis for these variables in the notes fields provided.

| | |
|---|---|
| **Tab Name - Input Variable** | Variable driven Name for tab |
| **Section Heading - Input Variable** | Variable driven heading for main sections |
| **Section Sub Heading - Input Variable** | Variable driven heading for sub sections |
| Input Variable | Variable driven label for items |
| Choice 1<br>Choice 2<br>Choice 3 | List driven variable selection for items |
| Input Variable - Notes and Comments | Notes and Comments for Input Variables |

## Calculations and Formula Driven Labels

Calculations and Formula Driven Labels show up in the following formats. Do not change these calculations.

| | |
|---|---|
| **Section Heading - Formula Driven** | Formula driven heading for main sections |
| **Section Sub Heading - Formula Driven** | Formula driven heading for sub sections |
| Item label - Formula Driven | Formula driven label for items |
| 1,000 | Calculation driven value |
| **2,000,000** | Calculation driven total value |
| **$ 12,345** | Calculated value is used on other tab(s) referred to in the notes. The background color mirrors the tabs they represent. |
| **98%** | Calculated value which is in a acceptable range |
| **113%** | Calculated value which may be out of an acceptable range |
| Look up value | Input variables which are driven by a lookup table |
| Formula driven notes and comments | Notes and comments which are formula driven |

## Insert Zone

The Insert Zone labeled as "**InsZone**" allows for the inserting additional rows while keeping the integrity of formulas intact. To use this feature, right click on the row number which contains the InsZone and select Insert. Multiple rows can be highlighted and added at once as long as the selection begins with the row which contains the InsZone.

| | | |
|---|---|---|
| Value for item 1 | 123.00 | |
| Value for item A | 456.00 | |
| InsZone | | Right click on this rows reference number to insert additional rows |
| | 579.00 | |

## Navigation

Navigation links are provided to quickly go to the Navigation Switch Board or another tab. Click on the Navigation link to go to the tab referenced. These links show up in the following formats.

| | |
|---|---|
| Nav | Clicking the Nav link goes to the **Navigation** tab<br>Navigation link background colors mirror the tabs they represent |
| GoTo Item label - Formula Driven | Clicking the GoTo link goes to the tab with the specified item |
| www.ECOregon.com | Clicking the link goes to the specified web site |
| Dean@ECOregon.com | Clicking the link starts a new email in the default email application addressed to the referred to recipient |

## Navigation Switch Board

**Navigate To Tab** *(Click Hyperlink to Navigate to tab)*

| EC Oregon Hidden Control Tabs | Information and Setup Tabs | Client / Scenario Tabs | Feedstock Tabs | Investment and Operations Tabs | Investment and Operations Summary Tabs | Tax Credit and Depreciation Tabs | Funding Tabs | Projected Proforma Tabs | Summary Tabs |
|---|---|---|---|---|---|---|---|---|---|
| ECO-Control | Title | Client | Manure | AD | Invest Sum | ITC | Draws | Income | Stats |
| ECO-Parameters | Legal | | Feedstock | CHP | CapEx Sum | BETC | Funding | Cash Flow | Compare Cash |
| ECO-Scenario | Legend | | Feedstock Eval | PPA Rates | Op Sum | BETC-App | Funding 2 | Balance Sheet | Feasibility-1 |
| ECO-CHP | Navigation | | | PPA Income | O&M Sum | Depreciation | | | Feasibility-2 |
| | Data Flow | | | PTC | | Credit Summary | | | |
| | | | | RNG | | | | | |
| | | | | Nutrients | | | | | |
| | | | | Storage | | | | | |
| | | | | Labor | | | | | |
| | | | | Land | | | | | |
| | | | | Carbon | | | | | |
| | | | | Carbon Income | | | | | |
| | | | | Tags | | | | | |
| | | | | Tags Income | | | | | |
| | | | | Project | | | | | |
| | | | | Invest Exp | | | | | |

## Client Parameters

### EC Oregon - AD Financial Feasibility Model v2.3

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

| Client, Project and Scenario Version | *Units* | Value | Notes |
|---|---|---|---|
| Client Name | | Volbeda Dairy | |
| Scenario Name | | Scenario = Complete Mix, Co-digestion and Flush | |
| Project Start | *Date* | 1/1/2010 | Assumed not until 2010 (DV 9/17/2009)<br>The Project Start Date should coincide with the first financial transaction. For example, the first loan draw or investor contribution. |
| Scenario Version | *Date* | 10/4/2009 | Input last update |

| Clients Cost of Energy | *Units* | Value | Notes |
|---|---|---|---|
| Clients Cost for Conventional Electric | *US $ / kWh* | $ 0.0624 | Average of Pacificorp schedule 41 (pumps) and Schedule 28 |
| Clients Cost for Conventional Natural Gas | *US $ / Therm* | $ 1.0311 | NW Natural Schedule 31 |

| Clients Tax Rate and Rate of Inflation | *Units* | Value | Notes |
|---|---|---|---|
| Effective Federal Tax Rate | *Percent* | 32.0% | Unknown - Not Provided |
| Effective Oregon Tax Rate | *Percent* | 9.0% | Unknown - Not Provided |
| Rate of Inflation | *Percent* | 3.0% | |

## Manure Collection

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

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**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

### Manure Source

**Herd Notes:**

| | |
|---|---|
| 1 | Toggle number to increase herd (permit max is 3045 head) |

| Livestock Type | Livestock | Average Weight | Total Weight | | Manure | Manure | Notes |
|---|---|---|---|---|---|---|---|
| | *Count* | *Pounds* | *Pounds* | *Animal Units* | *Pounds / Day / Animal Unit* | *Pounds / Day* | |
| Lactating Cows | 1,450 | 1,350 | 1,957,500 | 1,958 | 104.0 | 203,580 | AWMP Tom Thomson 9/16/2009, # from Darren |
| Dry Cows & Heifers | 525 | 1,125 | 590,625 | 591 | 57.0 | 33,666 | AWMP Tom Thomson 9/16/2009, # from Darren (wt ave of 1500 & 750) |
| | - | - | - | - | - | - | |
| Bedding | - | - | - | - | - | 23,725 | match fiber to keep on nutrient tab |
| InsZone | | | | | | | |
| **Total** | **1,975** | | | **2,548** | | **260,970** | |

| Manure Source Summary | *Units* | Value |
|---|---|---|
| **Manure** | ***Pounds / Day*** | **260,970** |
| **Manure** | ***Pounds / Year*** | **95,254,118** |
| **Manure** | ***US Tons / Year*** | **47,627** |

| Flush Water | *Units* | Value | Notes |
|---|---|---|---|
| **Flush Water remaining after some thickening** | | | |
| Tons / Year | *Tons / Year* | 43,963 | flushed manure thickened from 1.5% to 6.5% TS (volume calculated from excreted |

| Totals | *Units* | Value | Notes |
|---|---|---|---|
| Manure | *US Tons / Year* | 47,627 | |
| Bedding (Composted Manure Solids) - Calculation | *US Tons / Year* | - | |
| Flush water | *US Tons / Year* | 43,963 | |
| InsZone | | | |
| **Total** | ***US Tons / Year*** | **91,590** | Value is used on the **Feedstock** tab<br>Value is rounded to the nearest ten |

## Feedstock Matrix

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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| | Units | Totals | Notes | Flushed/Thickened Manure<br>Feedstock 1 | Notes | Dilution Water<br>Feedstock 2 | Notes | Annual Rye Grass Straw<br>Feedstock 3 | Notes | FOG / GTW<br>Feedstock 4 | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Characteristics** | | | | | | | | | | | |
| Feedstock Comments | | | | | | | Assumes - recycled digester effluent | | | | |
| N *(as is basis)* | Percent | | | 0.26% | From lab 11/20/2008 | 0.00% | | 1.42% | | 0.00% | |
| P *(as is basis)* | Percent | | | 0.00% | Unknown | 0.00% | | 1.07% | | 0.00% | |
| Total Solids *(as is basis)* | Percent | | | 6.5% | thickened to increase HRT | 4.5% | per AAT (DV 6/4/2009) | 90.0% | average of BOKU and A&L lab analysis | 30.0% | Food Quality Lab results |
| Volatile Solids of Total Solids | Percent | | | 68.6% | assumes 5.6% loss (exprapolate 5% TS = no loss and 13% TS = 30% loss) | 0.0% | | 94.0% | average of BOKU and WoodsEnd analysis | 90.0% | Food Quality Lab results |
| Methane Yield | $m^3$ $CH_4$ / kg VS | | | 0.180 | Average from lit values and lab results | - | | 0.286 | BOKU lab results 2007 sample | 0.572 | WoodsEnd Lab results |
| **Availability** | | | | | | | | | | | |
| Feedstock Available | US Tons / Year | 100,890 | | 91,590 | Value comes from the **Manure** tab | - | Note Value needs to be less than centrate or need to add additional water | 7,300 | Estimate available from Jensen - Willamette Valley Storage (DV 6/4/200) | 2,000 | FOG at less than 5% of total VS basis and keep digester at less than 100% |
| AD ***Volatile Solids*** Capacity | ***US Tons / Day*** | **29.59** | | **11.19** | | **-** | | **16.92** | | **1.48** | |
| AD ***Volatile Solids*** Capacity | ***US Tons / Year*** | **10,801** | | **4,085** | | **-** | | **6,176** | | **540** | |
| **Utilization** | | | | | | | | | | | |
| Digester ***Volatile Solids*** Capacity | *US Tons / Day* | **30.86** | Value is calculated on the **AD** tab | | | | | | | | |
| Feedstock ***Volatile Solids*** Utilization | ***US Tons / Day*** | **29.59** | | **11.19** | | **-** | | **16.92** | | **1.48** | |
| ***Volatile Solids*** Variance | *US Tons* | *(1.27)* | | | | | | | | | |
| *Digester Operating Capacity on a **Volatile Solids** Basis* | *Percent* | ***95.9%*** | Value is used on the **AD** tab | *36.3%* | | *0.0%* | | *54.8%* | | *4.8%* | |
| *Feedstock Utilized on a **Volatile Solids** Basis* | *Percent* | ***100.0%*** | | *37.8%* | | *0.0%* | | *57.2%* | | *5.0%* | |
| **Feedstock Utilization** | ***US Tons / Day*** | **276.4** | | **250.9** | | **-** | | **20.0** | | **5.5** | |
| **Feedstock Utilization** | ***US Tons / Year*** | **100,890** | | **91,590** | | **-** | | **7,300** | | **2,000** | |
| Utilized Feedstock's on a US Ton Basis | *Percent* | ***100.0%*** | | *90.8%* | | *0.0%* | | *7.2%* | | *2.0%* | |
| Total Solids *(as is basis)* | *Percent* | ***13.0%*** | Weighted average | *6.5%* | | *4.5%* | | *90.0%* | | *30.0%* | |
| Volatile Solids of Total Solids | *Percent* | ***82.3%*** | Weighted average | *68.6%* | | *0.0%* | | *94.0%* | | *90.0%* | |
| **Methane Yield** | | | | | | | | | | | |
| Weighted Average Methane Yield | *$m^3$ $CH_4$ / kg VS* | **0.260** | Weighted average | 0.180 | | - | | 0.286 | | 0.572 | |
| Methane per ***Volatile Solids*** | *MCF / US Ton* | | | 5.77 | | - | | 9.16 | | 18.33 | |
| Methane Production | ***MCF / Day*** | **246.7** | Value is used on the **AD** tab | **64.53** | | **-** | | **155.03** | | **27.12** | |
| Methane Production | *MCF / Hour* | **10.3** | Value is used on the **AD** tab | 2.69 | | - | | 6.46 | | 1.13 | |
| *Methane Production* | *Percent* | ***100.0%*** | | *26.2%* | | *0.0%* | | *62.8%* | | *11.0%* | |
| **Closed-Loop Biomass** | | | | | | | | | | | |
| Closed-Loop Biomass (PTC) | *Yes / No* | | | No | | No | | No | | No | |
| Methane Yield from Closed-Loop Biomass | *Percent* | **0.0%** | | 0.0% | | 0.0% | | 0.0% | | 0.0% | |
| **Digestate Volume** | | | | | | | | | | | |
| Destruction Rate of Volatile Solids | *Percent* | | | 40% | Burke 2001 | 0% | | 70% | Industry Average | 90% | Industry Average |
| Biogas | *US Tons / Day* | **17.7** | | 4.5 | Methane and CO2 | - | Methane and CO2 | 11.8 | Methane and CO2 | 1.3 | Methane and CO2 |
| **Digestate** | ***US Tons / Day*** | **258.7** | Value is used on the **Nutrients** tab | **246.4** | | **-** | | **8.2** | | **4.1** | |
| Total Solids in Digestate | *Percent* | **7.1%** | Weighted average | 4.80% | | 0.00% | | 75.48% | | 7.53% | |
| **Digestate Dry Solids** | ***US Tons / Day*** | **18.3** | Value is used on the **Nutrients** tab | **11.83** | | **-** | | **6.16** | | **0.31** | |
| **Digestate Liquid** | ***US Tons / Day*** | **240.4** | Value is used on the **Nutrients** tab | **234.59** | | **-** | | **2.00** | | **3.84** | |
| **Nitrogen & Phosphorus Volumes** | | | | | | | | | | | |
| N | ***US Tons / Day*** | **0.9** | Value is used on the **Nutrients** tab | **0.65** | | **-** | | **0.28** | | **-** | |
| N | ***US Tons / Year*** | **341.8** | Value is used on the **Nutrients** tab | **238.13** | | **-** | | **103.66** | | **-** | |
| P | ***US Tons / Day*** | **0.2** | Value is used on the **Nutrients** tab | **-** | | **-** | | **0.21** | | **-** | |
| P | ***US Tons / Year*** | **78.1** | Value is used on the **Nutrients** tab | **-** | | **-** | | **78.11** | | **-** | |
| **Methane Equivalent Value** *(FYI Purposes Only)* | | | | | | | | | | | |
| Clients Cost of Natural Gas | *US $ / Million BTU* | $ 10.31 | Value is set on the **Client** tab. | | | | | | | | |
| Value of Methane | *US $ / Day* | **$ 2,544** | | $ 665 | | $ - | | $ 1,599 | | $ 280 | |
| Value of Methane | *US $ / US Ton* | **$ 134** | | $ 2.65 | | $ - | | $ 79.93 | | $ 51.02 | |

Client

| | Units | Totals | Notes | Flushed/Thickened Manure<br>Feedstock 1 | Notes | Dilution Water<br>Feedstock 2 | Notes | Annual Rye Grass Straw<br>Feedstock 3 | Notes | FOG / GTW<br>Feedstock 4 | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Feedstock Revenue** | *Units* | **Totals** | **Notes** | | | | | | | | |
| | *US $ / US Ton* | | | $ - | | $ - | | $ - | | $ - | |
| InsZone | | | | | | | | | | | |
| **Feedstock Revenue** | ***US $ / US Ton*** | $ - | Weighted average | **$ -** | | **$ -** | | **$ -** | | **$ -** | |
| **Feedstock Revenue** | ***US $ / Day*** | $ - | | $ - | | $ - | | $ - | | $ - | |
| **Feedstock Revenue** | ***US $ / Year*** | $ - | Value is used on the **Op Sum** tab | $ - | | $ - | | $ - | | $ - | |
| **Direct Expenses** | *Units* | **Totals** | **Notes** | | | | | | | | |
| Purchase Price | *US $ / US Ton* | | | $ - | | $ - | | $ 35.00 | | $ - | |
| InsZone | | | | | | | | | | | |
| **Feedstock Direct Expense** | ***US $ / US Ton*** | $ 2.53 | Weighted average | **$ -** | | **$ -** | | **$ 35.00** | | **$ -** | |
| **Feedstock Direct Expense** | ***US $ / Day*** | $ 700 | | $ - | | $ - | | $ 700 | | $ - | |
| **Feedstock Direct Expense** | ***US $ / Year*** | $ 255,500 | Value is used on the **Op Sum** tab | $ - | | $ - | | $ 255,500 | | $ - | |
| **Opportunity Costs** | *Units* | **Totals** | **Notes** | | | | | | | | |
| | *US $ / US Ton* | | | $ - | | $ - | | $ - | | $ - | |
| InsZone | | | | | | | | | | | |
| **Feedstock Opportunity Cost** | ***US $ / US Ton*** | $ - | Weighted average | **$ -** | | **$ -** | | **$ -** | | **$ -** | |
| **Feedstock Opportunity Cost** | ***US $ / Day*** | $ - | | $ - | | $ - | | $ - | | $ - | |
| **Feedstock Opportunity Cost** | ***US $ / Year*** | $ - | Value is used on the **Op Sum** tab | $ - | | $ - | | $ - | | $ - | |
| **Avoided Expenses** | *Units* | **Totals** | **Notes** | | | | | | | | |
| | *US $ / US Ton* | | | $ - | | $ - | | $ - | | $ - | |
| InsZone | | | | | | | | | | | |
| **Feedstock Avoided Expense** | ***US $ / US Ton*** | $ - | Weighted average | **$ -** | | **$ -** | | **$ -** | | **$ -** | |
| **Feedstock Avoided Expense** | ***US $ / Day*** | $ - | | $ - | | $ - | | $ - | | $ - | |
| **Feedstock Avoided Expense** | ***US $ / Year*** | $ - | Value is used on the **Op Sum** tab | $ - | | $ - | | $ - | | $ - | |
| **Oregon Biomass Tax Credits** | *Units* | **Totals** | **Notes** | | | | | | | | |
| **Oregon Biomass Tax Credit Effective Dates**<br>2007 to 2012 | | | Value set on **Parameters** tab | | | | | | | | |
| OR Biomass Tax Credit ***Ag Crops*** | *US $ / US Ton* | | $10 / Wet Ton | $ - | | $ - | | $ - | | $ - | |
| OR Biomass Tax Credit ***Manure*** | *US $ / US Ton* | | $5 / Wet Ton | $ 5.00 | | $ - | | $ - | | $ - | |
| OR Biomass Tax Credit ***Waste Oil & Grease*** | *US $ / US Ton* | | $0.10 / Gallon | $ - | | $ - | | $ - | | $ - | |
| InsZone | | | | | | | | | | | |
| **Feedstock Tax Credit** | ***US $ / US Ton*** | $ 4.54 | Weighted average | **$ 5.00** | | **$ -** | | **$ -** | | **$ -** | |
| **Feedstock Tax Credit** | ***US $ / Day*** | $ 1,255 | | $ 1,255 | | $ - | | $ - | | $ - | |
| **Feedstock Tax Credit** | ***US $ / Year*** | $ 457,950 | Value is used on the **Tax Sum** tab | $ 457,950 | | $ - | | $ - | | $ - | |
| **Feedstock Net Expenses** *(FYI Purposes Only)* | *Units* | **Totals** | **Notes** | | | | | | | | |
| **Feedstock Net Expense** | ***US $ / US Ton*** | $ 2.01 | Weighted average | $ 5.00 | | $ - | | $ (35.00) | | $ - | |
| **Feedstock Net Expense** | ***US $ / Day*** | $ 555 | | $ 1,255 | | $ - | | $ (700) | | $ - | |
| **Feedstock Net Expense** | ***US $ / Year*** | $ 202,450 | | $ 457,950 | | $ - | | $ (255,500) | | $ - | |

## Feedstock Evaluation

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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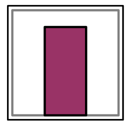

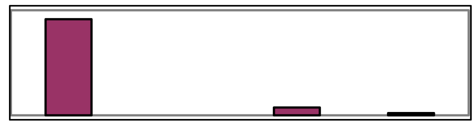

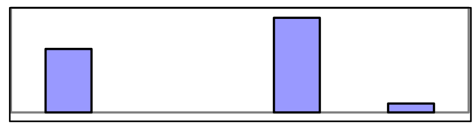

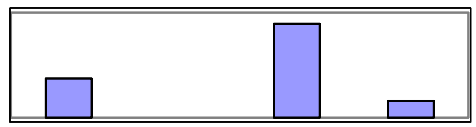

| Metric | Units | Totals | Flushed/Thickened Manure | Dilution Water | Annual Rye Grass Straw | FOG / GTW |
|---|---|---|---|---|---|---|
| Feedstock Utilization | US Tons / Year | **100,890** | **91,590** | **-** | **7,300** | **2,000** |
| *Utilized Feedstock on a AD Operating Capacity Basis* | *Percent* | 95.9% | **36.3%** | **0.0%** | **54.8%** | **4.8%** |
| *Methane Yield* | *Percent* | **100.0%** | **26.2%** | **0.0%** | **62.8%** | **11.0%** |
| Value as Methane (FYI) | *US $ / US Ton* | | **$ 2.65** | **$ -** | **$ 79.93** | **$ 51.02** |
| **Feedstock Net Income / US Wet Ton** | | | | | | |
| Feedstock Net Expense | *US $ / US Ton* | | **$ 5.00** | **$ -** | **$ (35.00)** | **$ -** |
| Electric Revenue<br>Electric Revenue is calculated on the **PPA Income** tab and is allocated to each feedstock by the percentage of methane generated | *US $ / US Ton* | $ 4.90 | $ 1.41 | $ - | $ 42.56 | $ 27.18 |
| RNG Revenue<br>RNG Revenue is calculated on the **RNG** tab and is allocated to each feedstock by the percentage of methane generated | *US $ / US Ton* | $ - | $ - | $ - | $ - | $ - |
| Baseline Year 1 CRT Value<br>Baseline Year 1 CRT Value is calculated on the **Carbon Income** tab and is only allocated to the livestock manure. Also note that the CRT's are only available for 10 years. | *US $ / US Ton* | $ - | $ - | | | |
| Baseline Year 1 Green Tag Value<br>Baseline Year 1 Green Tag Value is calculated on the **Tag Income** tab and is allocated to each feedstock by the percentage of methane generated | *US $ / US Ton* | $ 0.75 | $ 0.21 | $ - | $ 6.48 | $ 4.14 |

# Anaerobic Digester

## EC Oregon - AD Financial Feasibility Model v2.3

### Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush

**Confidential and Proprietary!**

Scenario:
**AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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| Capital Expenditures | Units | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| Design | US $ | $ 203,973 | per vendor |
| Construction | US $ | $ 2,772,964 | per vendor |
| Equipment | US $ | $ 450,440 | per vendor |
| InsZone | | | |
| **sub-total** | **US $** | **$ 3,427,377** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | Percent | 30.0% | |
| Contingency | US $ | $ 1,028,213 | |
| **Anaerobic Digester CapEx** | **US $** | **$ 4,455,590** | Value is used on the **Invest Sum** and **CapEx Sum** tabs. |
| **Depreciation Parameters** | | | |
| Life Span | Years | 7 | |
| Salvage Value | Percent | 2.5% | |
| **Salvage Value** | **US $** | **$ 111,390** | Value is used on the **CapEx Sum** tab. |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | Percent | 98% | |
| **ITC Eligible Value** | **US $** | **$ 4,366,479** | Value is used on the **ITC** tab. |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | Percent | 100% | |
| **BETC Eligible Value** | **US $** | **$ 4,455,590** | Value is used on the **BETC** tab. |

| Operations & Maintenance | Units | Value | Notes |
|---|---|---|---|
| **Operation & Maintenance** | | | |
| Operations & Maintenance | Percent of CapEx | 3.00% | |
| **Anaerobic Digester O&M Expense** | **US $ / Year** | **$ 102,821** | Value is used on the **Op Sum** tab. |

| Performance | Units | Value | Notes |
|---|---|---|---|
| **Operating** | | | |
| | *Hours / Day* | 24 | |
| | *Days / Year* | 365 | |
| | ***Hours / Year*** | **8,760** | |
| **Digester Specifications** | | | |
| Digester Tank 1 Capacity | *$m^3$* | 3,500 | |
| Digester Tank 2 Capacity | *$m^3$* | 3,500 | |
| InsZone | | | |
| **Total Digester Capacity** | ***$m^3$*** | **7,000** | |
| Organic Loading Rate | *kg / $m^3$ / Day* | 4.00 | per vendor |
| Capacity of ***Volatile Solids*** | *Metric Tons / Day* | 28.00 | |
| Conversion Factor | *US Tons / Metric Ton* | 1.102 | Unit conversion. |
| **Digester *Volatile Solids*** | ***US Tons / Day*** | **30.9** | Value is used on the **Feedstock** tab. |
| **Digester *Volatile Solids*** | ***US Tons / Year*** | **11,262** | |
| Digester Operating Capacity on a ***Volatile Solids*** Basis | *Percent* | 95.9% | Value is calculated on the **Feedstock** tab. |
| feedstock | *gpd* | 66,279 | |
| retention time | *days* | 28 | |
| **Feedstock Utilization Summary** | | | |
| Feedstock Utilization | *US Tons / Day* | 276.4 | Value is calculated on the **Feedstock** tab. |
| Total Solids in Feedstock | *Percent* | 13.0% | Value is calculated on the **Feedstock** tab. |
| Total Solids in Digestate | *Percent* | 7.1% | Value is calculated on the **Feedstock** tab. |
| **Methane Yield** | | | |
| Methane Yield | *MCF / Day* | 246.7 | Value is calculated on the **Feedstock** tab. |
| **Methane Yield** | ***MCF / Hour*** | **10.3** | Value is calculated on the **Feedstock** tab. |
| **Digester Methane Parasitic Load** *(If No CHP is Utilized)* | | | Value can be set to represent methane utilized in a boiler when no CHP is available for digester heating. |
| Digester Methane Parasitic Load | *Percent* | 0% | |
| Digester Methane Parasitic Load | *MCF / Hour* | - | |
| **Net Methane Yield** | ***MCF / Hour*** | **10.3** | |
| **Digester Electric Parasitic Load** | | | |
| Digester Electric Parasitic Load | *kW* | 5 | |
| Client — Grid Electric Cost | *US $ / kWh* | $ 0.0624 | Value is set on the **Client** tab. |
| **AD Electric Expense** | ***US $ / Year*** | **$ 2,733** | Value is used on the **Op Sum** tab. |
| **Methane Utilization** | | | |
| CHP — Methane forwarded to CHP | *Percent* | 100% | |
| RNG — Methane forwarded to RNG | *Percent* | 0% | |
| InsZone | | | |
| **Total** | ***Percent*** | 100% | |
| Methane forwarded to CHP | *MCF / Hour* | 10.3 | Value is used on the **CHP** tab |
| Methane forwarded to RNG | *MCF / Hour* | - | Value is used on the **RNG** tab |
| InsZone | | | |
| **Total** | ***MCF / Hour*** | **10.3** | |

## Combined Heat and Power

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

| Capital Expenditures | *Units* | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| **CHP Choice:** | | | |
| Caterpillar - G3520C - 1,600 kW | | | |
| Number of CHP Engines | *Count* | 1 | |
| Caterpillar - G3520C - 1,600 kW | *US $* | $ 832,000 | Proposal for SIFI from Peterson Pow er Systems 1-21-2008<br>Values are driven by the CHP selected. |
| Construction | *US $* | $ 50,000 | Container CHP |
| | *US $* | | |
| InsZone | | | |
| **sub-total** | ***US $*** | **$ 882,000** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | *Percent* | 30.0% | |
| Contingency | *US $* | $ 264,600 | |
| **Combined Heat and Power CapEx** | ***US $*** | **$ 1,146,600** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab.<br>Value is used on the **CapEx Sum** and **Invest Sum** tabs. |
| **Depreciation Parameters** | | | |
| Life Span | *Years* | 7 | |
| Salvage Value | *Percent* | 2.5% | |
| **Salvage Value** | ***US $*** | **$ 28,665** | Value is used on the **CapEx Sum** tab. |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | *Percent* | 100% | |
| **Eligible ITC Value** | ***US $*** | **$ 1,146,600** | Value is used on the **ITC** tab. |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | *Percent* | 100% | |
| **Eligible BETC Value** | ***US $*** | **$ 1,146,600** | Value is used on the **BETC** tab. |

| Operations & Maintenance | *Units* | Value | Notes |
|---|---|---|---|
| **Operation & Maintenance** | | | |
| Operations & Maintenance - Low | *US $ / kWh* | 0.012 | Values are driven by the CHP selected. |
| Operations & Maintenance - High | *US $ / kWh* | 0.012 | Values are driven by the CHP selected. |
| **Operations & Maintenance - Average** | ***US $ / kWh*** | **0.012** | |
| Operations & Maintenance | *US $ / kWh* | $ 0.012 | |
| Annual Gross Estimated Generation | *kWh* | 10,008,161 | |
| **Combined Heat and Power O&M Expense** | ***US $ / Year*** | **$ 120,098** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab.<br>Value is used on the **Op Sum** tab. |

| | Performance | Units | Value | Notes |
|---|---|---|---|---|
| | **Operating** | | | |
| | Operating | Hours / Day | 24 | |
| | Operating | Days / Year | 355 | As per EC Oregon |
| | **Operating** | ***Hours / Year*** | **8,520** | |
| | **CHP Downtime** | ***Days / Year*** | **10** | Value is used on the **PPA Income** tab. |
| | **AD Methane Available** | | | |
| | AD Methane for CHP | MCF / Hour | 10.3 | Value is calculated on the **AD** tab. |
| | Go to **Methane Utilization** on AD tab | | Utilize Methane | |
| | **CHP Engine Specifications** | | | |
| | Consuming | MCF / Hour | 14.0000 | As per vendor |
| | Producing | kW | 1,600 | As per vendor |
| | **Generating** | ***kWh / MCF / Hour*** | **114.29** | Values are driven by the CHP selected. |
| | **Electric - Generation** | | | |
| | Estimated Generation | kW | 1,175 | |
| | Station Service Requirements as a Percent | Percent | 3.0% | |
| | Station Service Requirements | kW | 35 | |
| | - Or - | | - Or - | The Station Service Requirements may be entered as a percent or in kWh. To use the kWh basis be sure to enter the percent basis as 0%. |
| | Station Service Requirements as kW | kW | - | |
| | **Adjusted Estimated Generation** | ***kW*** | **1,139** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab. Value is used on the **PPA Income** tab. |
| | Estimated Annual Generation | kWh | 9,707,916 | |
| | CHP Operating Capacity | Percent | 73.4% | |
| | **Electric - Consumption** *(Net Metering)* For modeling a Net Metering scenario be sure to select "None" as the Power Purchase Agreement on the **PPA Rates** tab. | | | |
| | Average Annual Electric Consumption | kWh | - | |
| Client | Clients Cost of Electricity | US $ / kWh | $ 0.0624 | Value is set on the **Client** tab. |
| | **Electric Avoided Expense** | ***US $ / Year*** | **$ -** | Value is used on the **Op Sum** tab. |
| | Generation Remaining after Consumption | kWh | 1,139 | Value is zeroed out if methane is not sent to the CHP from the **AD** tab. |
| | **CHP Jacket Heat - Not Dynamic!** | | | |
| Client | Raw Fuel Cost | US $ / Million BTU | $ 10.31 | Value is set on the **Client** tab. |
| | Operations and Maintenance | Factor | 1.3 | |
| | Enthalpy of Hot Water at 230 F | BTU / Lb | 196 | |
| | Enthalpy of Feedwater | BTU / Lb | 18 | |
| | Overall Boiler Efficiency | Factor | 0.825 | |
| | | US $ / 1,000 Lbs | $ 2.89 | |
| | Extracted from Jacket Heat | Million BTU / Hour | 1.23 | Based on Cat C3520C 1600kW model at partial capacity (full = 1.7248 MMBtu/hour) |
| | | Therms / Hour | 12.28 | |
| | Available at 230 F | Lb / Hour | 6,265 | |
| | | US $ / Hour | $ 18.12 | |
| | **CHP Jacket Heat - Revenue** | | | |
| | Amount Utilized | Percent | 0.0% | |
| | Utilized Jacket Heat | Therms / Year | - | |
| | Loaded Fuel Cost | US $ / Therm | $ 1.48 | |
| | **CHP Jacket Heat Revenue** | ***US $ / Year*** | **$ -** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab. Value is used on the **Op Sum** tab. |
| | **CHP Jacket Heat - Avoided Expense** | | | |
| | Amount Utilized | Percent | 0.0% | |
| | Utilized Jacket Heat | Therms / Year | - | |
| | Loaded Fuel Cost | US $ / Therm | $ 1.48 | |
| | **CHP Jacket Heat Avoided Expense** | ***US $ / Year*** | **$ -** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab. Value is used on the **Op Sum** tab. |
| | **CHP Exhaust Heat - Not Dynamic!** | | | |
| Client | Raw Fuel Cost | US $ / Million BTU | $ 10.31 | Value is set on the **Client** tab. |
| | Operations and Maintenance | Factor | 1.3 | |
| | Enthalpy of Steam | BTU / Lb | 1,190 | |
| | Enthalpy of Feedwater | BTU / Lb | 18 | Value is set above. |
| | Overall Boiler Efficiency | Factor | 0.825 | Value is set above. |
| | | US $ / 1,000 Lbs | $ 19.04 | |
| | Extracted from Jacket Heat | Million BTU / Hour | 2.46 | Based on Cat C3520C 1600kW model at partial capacity (full = 3.4544 MMBtu/hour) |
| | | Therms / Hour | 24.60 | |
| | Available at 125 psig using Enthalpy of Steam | Lb / Hour | 2,067 | |
| | | US $ / Hour | $ 39.37 | |
| | **CHP Exhaust Heat - Revenue** | | | |
| | Amount Utilized | Percent | 0% | |
| | Utilized Exhaust Heat | Therms / Year | - | |
| | Loaded Fuel Cost | US $ / Therm | $ 1.60 | |
| | **CHP Exhaust Heat Revenue** | ***US $ / Year*** | **$ -** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab. Value is used on the **Op Sum** tab. |
| | **CHP Exhaust Heat - Avoided Expense** | | | |
| | Amount Utilized | Percent | 0.0% | |
| | Utilized Jacket Heat | Therms / Year | - | |
| | Loaded Fuel Cost | US $ / Therm | $ 1.60 | |
| | **CHP Exhaust Heat Avoided Expense** | ***US $ / Year*** | **$ -** | Value is zeroed out if methane is not sent to the CHP from the **AD** tab. Value is used on the **Op Sum** tab. |

## Power Purchase Agreement Pricing

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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### Power Purchase Agreement Selection

**PPA Choice:**

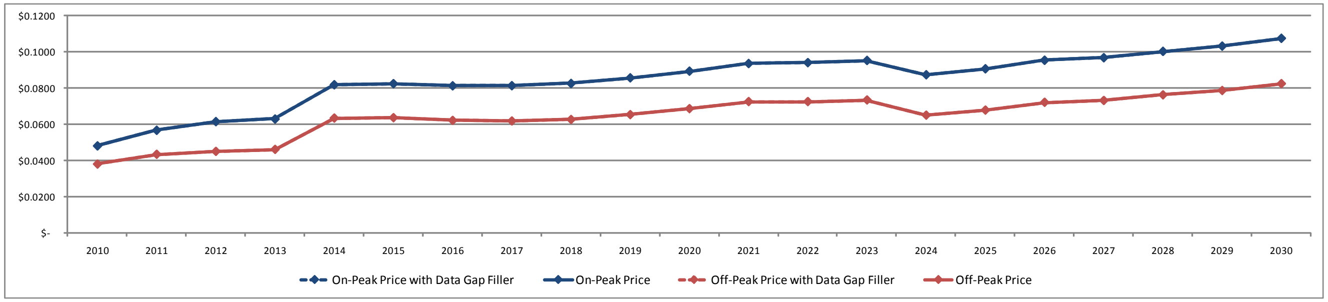
- PacifiCorp - Oregon Schedule 37 (Oct 20, 2008)
- PGE - Schedule 201 (Nov 1, 2007)
- PacifiCorp - Oregon Schedule 37 (September 9, 2009)
- None

### Power Purchase Agreement Selected

| | *Units* | 0<br>**2010** | 1<br>**2011** | 2<br>**2012** | 3<br>**2013** | 4<br>**2014** | 5<br>**2015** | 6<br>**2016** | 7<br>**2017** | 8<br>**2018** | 9<br>**2019** | 10<br>**2020** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PacifiCorp - Oregon Schedule 37 (September 9, 2009)** | | | | | | | | | | | | |
| On-Peak Price | *US $ / kWh* | $ 0.0482 | $ 0.0568 | $ 0.0616 | $ 0.0630 | $ 0.0819 | $ 0.0825 | $ 0.0813 | $ 0.0814 | $ 0.0826 | $ 0.0857 | $ 0.0894 |
| Off-Peak Price | *US $ / kWh* | $ 0.0380 | $ 0.0434 | $ 0.0450 | $ 0.0461 | $ 0.0634 | $ 0.0636 | $ 0.0621 | $ 0.0618 | $ 0.0626 | $ 0.0653 | $ 0.0686 |
| On-Peak Price with Data Gap Filler | *US $ / kWh* | $ 0.0482 | $ 0.0568 | $ 0.0616 | $ 0.0630 | $ 0.0819 | $ 0.0825 | $ 0.0813 | $ 0.0814 | $ 0.0826 | $ 0.0857 | $ 0.0894 |
| Off-Peak Price with Data Gap Filler | *US $ / kWh* | $ 0.0380 | $ 0.0434 | $ 0.0450 | $ 0.0461 | $ 0.0634 | $ 0.0636 | $ 0.0621 | $ 0.0618 | $ 0.0626 | $ 0.0653 | $ 0.0686 |

| | *Units* | 11<br>**2021** | 12<br>**2022** | 13<br>**2023** | 14<br>**2024** | 15<br>**2025** | 16<br>**2026** | 17<br>**2027** | 18<br>**2028** | 19<br>**2029** | 20<br>**2030** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PacifiCorp - Oregon Schedule 37 (September 9, 2009)** | | | | | | | | | | | |
| On-Peak Price | *US $ / kWh* | $ 0.0936 | $ 0.0941 | $ 0.0953 | $ 0.0874 | $ 0.0907 | $ 0.0954 | $ 0.0968 | $ 0.1003 | $ 0.1032 | $ 0.1075 |
| Off-Peak Price | *US $ / kWh* | $ 0.0725 | $ 0.0725 | $ 0.0734 | $ 0.0650 | $ 0.0678 | $ 0.0721 | $ 0.0731 | $ 0.0762 | $ 0.0786 | $ 0.0824 |
| On-Peak Price with Data Gap Filler | *US $ / kWh* | $ 0.0936 | $ 0.0941 | $ 0.0953 | $ 0.0874 | $ 0.0907 | $ 0.0954 | $ 0.0968 | $ 0.1003 | $ 0.1032 | $ 0.1075 |
| Off-Peak Price with Data Gap Filler | *US $ / kWh* | $ 0.0725 | $ 0.0725 | $ 0.0734 | $ 0.0650 | $ 0.0678 | $ 0.0721 | $ 0.0731 | $ 0.0762 | $ 0.0786 | $ 0.0824 |

**Note:** Years with no PPA rate available, indicated by "#N/A", above are forecasted by calculating the average price increase for the prior three years.



## Power Purchase Agreement Income

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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| | Units | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 9<br>2019 | 10<br>2020 | 11<br>2021 | 12<br>2022 | 13<br>2023 | 14<br>2024 | 15<br>2025 | 16<br>2026 | 17<br>2027 | 18<br>2028 | 19<br>2029 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Available On-Peak and Off-Peak Hours** | | | | | | | | | | | | | | | | | | | | | | |
| **Available On-Peak and Off-Peak Days** | | | | | | | | | | | | | | | | | | | | | | |
| Available | Days / Year | | 365 | 366 | 365 | 365 | 365 | 366 | 365 | 365 | 365 | 366 | 365 | 365 | 365 | 366 | 365 | 365 | 365 | 366 | 365 | 365 |
| Number of Sundays | Sundays / Year | | 52 | 53 | 52 | 52 | 52 | 52 | 53 | 52 | 52 | 52 | 52 | 52 | 53 | 52 | 52 | 52 | 52 | 53 | 52 | 52 |
| Number of NERC Holidays | Holidays / Year | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| CHP (link) CHP Downtime = 10<br>Value is calculated on the **CHP** tab | Days / Year | | | | | | | | | | | | | | | | | | | | | |
| CHP Downtime On-Peak | Days / Year | | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| CHP Downtime Off-Peak | Days / Year | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **On-Peak** | ***Days / Year*** | | **299** | **299** | **299** | **299** | **299** | **300** | **298** | **299** | **299** | **300** | **299** | **299** | **298** | **300** | **299** | **299** | **299** | **299** | **299** | **299** |
| **Off-Peak** | ***Days / Year*** | | **56** | **57** | **56** | **56** | **56** | **56** | **57** | **56** | **56** | **56** | **56** | **56** | **57** | **56** | **56** | **56** | **56** | **57** | **56** | **56** |
| **On-Peak and Off-Peak** | ***Days / Year*** | | 355 | 356 | 355 | 355 | 355 | 356 | 355 | 355 | 355 | 356 | 355 | 355 | 355 | 356 | 355 | 355 | 355 | 356 | 355 | 355 |
| **Available On-Peak and Off-Peak Hours** | | | | | | | | | | | | | | | | | | | | | | |
| On-Peak Hours = 16 | Hours / Day | | | | | | | | | | | | | | | | | | | | | |
| Off-Peak Hours = 8<br>Values are set on **Parameters** tab | Hours / Day | | | | | | | | | | | | | | | | | | | | | |
| **On-Peak** | ***Hours / Year*** | | **4,784** | **4,784** | **4,784** | **4,784** | **4,784** | **4,800** | **4,768** | **4,784** | **4,784** | **4,800** | **4,784** | **4,784** | **4,768** | **4,800** | **4,784** | **4,784** | **4,784** | **4,784** | **4,784** | **4,784** |
| **Off-Peak** | ***Hours / Year*** | | **3,736** | **3,760** | **3,736** | **3,736** | **3,736** | **3,744** | **3,752** | **3,736** | **3,736** | **3,744** | **3,736** | **3,736** | **3,752** | **3,744** | **3,736** | **3,736** | **3,736** | **3,760** | **3,736** | **3,736** |
| **Estimated kWh Generation** | | | | | | | | | | | | | | | | | | | | | | |
| CHP (link) CHP Adjusted Estimated kWh = 1139<br>Value is calculated on the **CHP** tab | kWh | | | | | | | | | | | | | | | | | | | | | |
| **On-Peak** | ***kWh / Year*** | | **5,451,017** | **5,451,017** | **5,451,017** | **5,451,017** | **5,451,017** | **5,469,248** | **5,432,787** | **5,451,017** | **5,451,017** | **5,469,248** | **5,451,017** | **5,451,017** | **5,432,787** | **5,469,248** | **5,451,017** | **5,451,017** | **5,451,017** | **5,451,017** | **5,451,017** | **5,451,017** |
| **Off-Peak** | ***kWh / Year*** | | **4,256,898** | **4,284,245** | **4,256,898** | **4,256,898** | **4,256,898** | **4,266,014** | **4,275,129** | **4,256,898** | **4,256,898** | **4,266,014** | **4,256,898** | **4,256,898** | **4,275,129** | **4,266,014** | **4,256,898** | **4,256,898** | **4,256,898** | **4,284,245** | **4,256,898** | **4,256,898** |
| Total | kWh / Year | | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 |
| **Power Purchase Agreement Selected** | | | | | | | | | | | | | | | | | | | | | | |
| P Rate (link) **PacifiCorp - Oregon Schedule 37 (September 9, 2009)**<br>PPA Rate Schedule is selected on the **PPA Rates** tab | | | | | | | | | | | | | | | | | | | | | | |
| **On-Peak Price** | ***US $ / kWh*** | | $ 0.0568 | $ 0.0616 | $ 0.0630 | $ 0.0819 | $ 0.0825 | $ 0.0813 | $ 0.0814 | $ 0.0826 | $ 0.0857 | $ 0.0894 | $ 0.0936 | $ 0.0941 | $ 0.0953 | $ 0.0874 | $ 0.0907 | $ 0.0954 | $ 0.0968 | $ 0.1003 | $ 0.1032 | $ 0.1075 |
| **Off-Peak Price** | ***US $ / kWh*** | | $ 0.0434 | $ 0.0450 | $ 0.0461 | $ 0.0634 | $ 0.0636 | $ 0.0621 | $ 0.0618 | $ 0.0626 | $ 0.0653 | $ 0.0686 | $ 0.0725 | $ 0.0725 | $ 0.0734 | $ 0.0650 | $ 0.0678 | $ 0.0721 | $ 0.0731 | $ 0.0762 | $ 0.0786 | $ 0.0824 |
| **Power Purchase Agreement Income** | | | | | | | | | | | | | | | | | | | | | | |
| **On-Peak Income** | ***US $ / Year*** | | $ 309,618 | $ 335,783 | $ 343,414 | $ 446,438 | $ 449,709 | $ 444,650 | $ 442,229 | $ 450,254 | $ 467,152 | $ 488,951 | $ 510,215 | $ 512,941 | $ 517,745 | $ 478,012 | $ 494,407 | $ 520,027 | $ 527,658 | $ 546,737 | $ 562,545 | $ 585,984 |
| **Off-Peak Income** | ***US $ / Year*** | | $ 184,749 | $ 192,791 | $ 196,243 | $ 269,887 | $ 270,739 | $ 264,919 | $ 264,203 | $ 266,482 | $ 277,975 | $ 292,649 | $ 308,625 | $ 308,625 | $ 313,794 | $ 277,291 | $ 288,618 | $ 306,922 | $ 311,179 | $ 326,459 | $ 334,592 | $ 350,768 |
| **Electric Revenue**<br>Value for Year 1 is used on the **Op Sum** tab<br>All yearly values are used on the **Income Statement** | ***US $ / Year*** | | **$ 494,367** | **$ 528,574** | **$ 539,657** | **$ 716,326** | **$ 720,448** | **$ 709,569** | **$ 706,432** | **$ 716,736** | **$ 745,128** | **$ 781,599** | **$ 818,840** | **$ 821,566** | **$ 831,539** | **$ 755,303** | **$ 783,025** | **$ 826,949** | **$ 838,838** | **$ 873,196** | **$ 897,137** | **$ 936,753** |

## Federal Production Tax Credit

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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| PTC Parameters | Units | Value |
|---|---|---|
| **PTC Parameters** | | |
| Eligibility In-Service Deadline | *Date* | December 31, 2012 |
| In-Service Deadline Met? | *Yes / No* | Yes |
| Credit Amount Basis | *Year* | 2008 |
| Full Credit - Amount | *US $ / kWh* | $ 0.0210 |
| Half Credit - Amount | *US $ / kWh* | $ 0.0100 |
| Full Credit - Calculated PTC Rate of Inflation | *Percent* | 2.67% |
| Half Credit - Calculated PTC Rate of Inflation | *Percent* | 2.22% |

| PTC - Closed-Loop Biomass | Units | Value |
|---|---|---|
| Methane Yield from Closed-Loop Biomass | *Percent* | 0.0% |

| | Units | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 9<br>2019 | 10<br>2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net Generation | *kWh / Year* | | - | - | - | - | - | - | - | - | - | - |
| Full Credit Amount | *US $ / kWh* | | $ 0.0222 | $ 0.0226 | $ 0.0230 | $ 0.0234 | $ 0.0238 | $ 0.0242 | $ 0.0246 | $ 0.0250 | $ 0.0254 | $ 0.0258 |
| **Federal Production Tax Credit - Full Credit** | ***US $ / Year*** | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |

Values are used on the **ITC** tab

| PTC - Open-Loop Biomass | Units | Value |
|---|---|---|
| Methane Yield from Open-Loop Biomass | *Percent* | 100.0% |

| | Units | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 9<br>2019 | 10<br>2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net Generation | *kWh / Year* | | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 |
| Half Credit Amount | *US $ / kWh* | | $ 0.0105 | $ 0.0107 | $ 0.0108 | $ 0.0110 | $ 0.0112 | $ 0.0113 | $ 0.0115 | $ 0.0117 | $ 0.0118 | $ 0.0120 |
| **Federal Production Tax Credit - Half Credit** | ***US $ / Year*** | | **$ 101,933** | **$ 103,843** | **$ 105,169** | **$ 106,787** | **$ 108,405** | **$ 110,333** | **$ 111,641** | **$ 113,259** | **$ 114,877** | **$ 116,823** |

Values are used on the **ITC** tab

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

# Digestate Dewatering

| Capital Expenditures | Units | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| Construction | US $ | $ 30,000 | in AD cost estimate |
| Equipment | US $ | | Equipment already on site |
| | US $ | | |
| InsZone | | | |
| **sub-total** | **US $** | **$ 30,000** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | Percent | 30.0% | |
| Contingency | US $ | $ 9,000 | |
| **Digestate Dewatering CapEx** | **US $** | **$ 39,000** | Value is used on the **CapEx Sum** and **Invest Sum** tabs |
| **Depreciation Parameters** | | | |
| Life Span | Years | 7 | |
| Salvage Value | Percent | 2.5% | |
| **Salvage Value** | **US $** | **$ 975** | Value is used on the **CapEx Sum** tab |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | Percent | 100% | |
| **Eligible ITC Value** | **US $** | **$ 39,000** | Value is used on the **ITC** tab |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | Percent | 100% | |
| **Eligible BETC Value** | **US $** | **$ 39,000** | Value is used on the **BETC** tab |

| Operations & Maintenance | Units | Value | Notes |
|---|---|---|---|
| **Operation & Maintenance** | | | |
| Operations & Maintenance | Percent of CapEx | 3.00% | |
| **Digestate Dewatering O&M Expense** | **US $ / Year** | **$ 900** | Value is used on the **Op Sum** tab |

| Performance | Units | Value | Notes |
|---|---|---|---|
| **Operating** | | | |
| | *Days / Year* | 365 | |
| **Digestate Available** | | | |
| Dry Solids in Digestate | *US Tons / Day* | 18.3 | Value is calculated on the **Feedstock** tab |
| Liquid in Digestate | *US Tons / Day* | 240.4 | Value is calculated on the **Feedstock** tab |
| **Digestate** | ***US Tons / Day*** | **258.7** | Value is calculated on the **Feedstock** tab |
| TS% | | 7.1% | |
| **Nutrient Values** | | | |
| N in Digestate | *US Tons / Day* | 0.94 | Value is calculated on the **Feedstock** tab |
| N in Digestate | *US Tons / Year* | 341.8 | Value is calculated on the **Feedstock** tab |
| P in Digestate | *US Tons / Day* | 0.21 | Value is calculated on the **Feedstock** tab |
| P in Digestate | *US Tons / Year* | 78.1 | Value is calculated on the **Feedstock** tab |
| N Soluble ($NH_4$) | *Percent* | 75.0% | |
| N Insoluble (Organic) | *Percent* | 25.0% | |
| N Value | *US $ / Pound* | $ 1.10 | Based on Organic N |
| P Value | *US $ / Pound* | $ 1.25 | Based on $1,050 / Ton P205 |
| **Digestate Fiber Fraction Available** | | | |
| Solids Capture Rate | *Percent* | 60% | variable based on equipment |
| Total Solids in Fiber | *Percent* | 30% | Estimate post dew atering |
| **Fiber** | ***US Tons / Day*** | **36.6** | |
| **Fiber** | ***US Tons / Year*** | **13,360** | |
| **$NH_4$ Available in Fiber** | | | |
| Water in Fiber | *US Tons / Day* | 25.62 | |
| Liquid in Digestate | *US Tons / Day* | 240.43 | Value is calculated on the **Feedstock** tab |
| N in Digestate | *US Tons / Day* | 0.94 | Value is calculated on the **Feedstock** tab |
| N Soluble ($NH_4$) | *Percent* | 75.0% | |
| **N Fiber Nutrients - $NH_4$** | ***US Tons / Day*** | **0.07** | |
| **Organic N Available in Fiber** | | | |
| Solids Capture Rate | *Percent* | 60% | |
| N in Digestate | *US Tons / Day* | 0.94 | Value is calculated on the **Feedstock** tab |
| N Insoluble (Organic) | *Percent* | 25.0% | |
| **N Fiber Nutrients - Organic N** | ***US Tons / Day*** | **0.14** | |
| **Total N Available in Fiber** | | | |
| **N in Fiber** | ***US Tons / Day*** | **0.22** | |
| **N in Fiber** | ***US Tons / Year*** | **78.6** | |
| **Total P Available in Fiber** | | | |
| P in Digestate | *US Tons / Day* | 0.21 | |
| Solids Capture Rate | *Percent* | 60% | |
| **P in Fiber** | ***US Tons / Day*** | **0.13** | |
| **P in Fiber** | ***US Tons / Year*** | **46.9** | |
| **Calculated Fiber Nutrient Value** | | | |
| Calculated Fiber Nutrient Value from N | *US $ / Year* | $ 172,876 | |
| Calculated Fiber Nutrient Value from P | *US $ / Year* | $ 117,165 | |
| **Calculated Fiber Nutrient Value** | ***US $ / US Ton*** | **$ 21.71** | N=0.59% and P as P205=0.8% |
| **US Tons to Yards Conversion** | | | |
| Fiber Conversion Factor | *US Tons / Yards $^3$* | 0.45 | From lab results in Terra Source Report |
| **Fiber Revenue** | | | |
| Fiber to Sell | *Percent* | 60% | |
| Fiber to Sell | *US Tons / Year* | 8,016 | |
| Fiber to Sell | *Yards $^3$ / Year* | 17,813 | |
| Use Calculated Fiber Value Price? | *Yes / No* | No | Enter "**Yes**" to use calculated value, enter "**No**" to use override value |
| Override Fiber Value | *US $ / US Ton* | $ 10.00 | |
| **Fiber Nutrient Revenue** | ***US $ / Year*** | **$ 80,158** | Value is used on the **Op Sum** tab |
| Value in Yards | *US $ / Yards $^3$* | $ 4.50 | |
| **Fiber Avoided Expense** | | | |
| Fiber to Retain | *Percent* | 40% | |
| Fiber to Retain | *US Tons / Year* | 5,344 | 29,282 |
| Fiber to Retain | *Yards $^3$ / Year* | 11,875 | |
| Use Calculated Fiber Value Price? | *Yes / No* | No | Enter "**Yes**" to use calculated value, enter "**No**" to use override value |
| Override Fiber Value | *US $ / US Ton* | $ - | |
| **Fiber Nutrient Avoided Expense** | ***US $ / Year*** | **$ -** | Value is used on the **Op Sum** tab |
| Value in Yards | *US $ / Yards $^3$* | $ - | |
| **Digestate Liquid Fraction Remaining** | | | |
| Digestate | *US Tons / Day* | 258.7 | Value is calculated on the **Feedstock** tab |
| Fiber | *US Tons / Day* | 36.6 | |
| Digestate Liquid Fraction Remaining | ***US Tons / Day*** | **222.1** | |

## Digestate Liquid Handling

| Capital Expenditures | *Units* | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| | *US $* | $ - | |
| | *US $* | $ - | |
| | *US $* | $ - | |
| InsZone | | | |
| **sub-total** | ***US $*** | **$ -** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | *Percent* | 0.0% | |
| Contingency | *US $* | $ - | |
| **Digestate Liquid Handling CapEx** | ***US $*** | **$ -** | Value is zeroed out if 0% Digestate Liquid Fraction is utilized<br>Value is used on the **CapEx Sum** and **Invest Sum** tabs |
| **Depreciation Parameters** | | | |
| Life Span | *Years* | 7 | |
| Salvage Value | *Percent* | 2.5% | |
| **Salvage Value** | ***US $*** | **$ -** | Value is used on the **CapEx Sum** tab |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | *Percent* | 0% | |
| **Eligible ITC Value** | ***US $*** | **$ -** | Value is used on the **ITC** tab |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | *Percent* | 0% | |
| **Eligible BETC Value** | ***US $*** | **$ -** | Value is used on the **BETC** tab |

| Operations & Maintenance | *Units* | Value | Notes |
|---|---|---|---|
| **Operation & Maintenance** | | | |
| Operations & Maintenance | *Percent of CapEx* | 3.00% | |
| **Digestate Liquid Handling O&M Expense** | ***US $ / Year*** | **$ -** | Value is zeroed out if 0% Digestate Liquid Fraction is utilized<br>Value is used on the **Op Sum** tab |

| Performance | Units | Value | Notes |
|---|---|---|---|
| **Operating** | | | |
| | *Days / Year* | 365 | |
| **Digestate Liquid Fraction Available** | | | |
| Digestate Liquid Fraction | *US Tons / Day* | 222.1 | Value is calculated above |
| Total Solids in Digestate Liquid Fraction | *Percent* | 3.3% | Estimate post dewatering |
| Concentrate Digestate Liquid Fraction? | *Yes / No* | No | "Yes" or "No" |
| Total Solids in Concentrated Liquid Nutrients | *Percent* | 2.0% | Estimate post evaporator |
| Total Solids in Concentrated Liquid Nutrients to Use | *Percent* | 3.3% | |
| **Liquid Fraction** | ***US Tons / Day*** | **222.1** | |
| **$NH_4$ Available in Liquid Fraction** | | | |
| Water in Digestate Liquid Fraction | *US Tons / Day* | 214.81 | |
| Liquid in Digestate | *US Tons / Day* | 240.43 | Value is calculated on the **Feedstock** tab |
| N in Digestate | *US Tons / Day* | 0.94 | Value is calculated on the **Feedstock** tab |
| Percent N Soluble ($NH_4$) | *Percent* | 75.0% | |
| **N Liquid Fraction - $NH_4$** | ***US Tons / Day*** | **0.63** | |
| **Organic N Available in Liquid Fraction** | | | |
| Solids Escape Rate | *Percent* | 40% | |
| N in Digestate | *US Tons / Day* | 0.94 | Value is calculated on the **Feedstock** tab |
| N Insoluble (Organic) | *Percent* | 25.0% | |
| **N Liquid Fraction - Organic N** | ***US Tons / Day*** | **0.09** | |
| **Total N Available in Liquid Fraction** | | | |
| **N in Liquid Fraction** | ***US Tons / Day*** | **0.72** | |
| **N in Liquid Fraction** | ***US Tons / Year*** | **263.19** | |
| **Total P Available in Liquid Fraction** | | | |
| P in Digestate | *US Tons / Day* | 0.21 | |
| Solids Escape Rate | *Percent* | 40% | |
| **P in Liquid Fraction** | ***US Tons / Day*** | **0.09** | |
| **P in Liquid Fraction** | ***US Tons / Year*** | **31.2** | |
| **Calculated Liquid Fraction Nutrient Value** | | | |
| Calculated Liquid Nutrient Value | *US $ / US Ton* | $ 8.10 | N=0.32% and P as P205=0.09% |
| **Liquid Nutrients Revenue** | | | |
| Liquid Nutrients to Sell | *Percent* | 0% | |
| Liquid Nutrients to Sell | *US Tons / Year* | - | |
| Use Calculated Liquid Nutrient Value Price? | *Yes / No* | Yes | Enter "**Yes**" to use calculated value, enter "**No**" to use override value |
| Override Liquid Nutrient Value | *US $ / US Ton* | $ - | |
| **Liquid Nutrient Revenue** | ***US $ / Year*** | **$ -** | Value is used on the **Op Sum** tab |
| **Liquid Nutrients Avoided Expense** | | | |
| Liquid Nutrients to Retain | *Percent* | 0% | |
| Liquid Nutrients to Retain | *US Tons / Year* | - | |
| Use Calculated Liquid Nutrient Value Price? | *Yes / No* | Yes | Enter "**Yes**" to use calculated value, enter "**No**" to use override value |
| Override Liquid Nutrient Value | *US $ / US Ton* | $ - | |
| **Liquid Nutrient Avoided Expense** | ***US $ / Year*** | **$ -** | Value is used on the **Op Sum** tab |
| **Process Water Remaining** | | | |
| | *US Tons / Day* | - | |
| | *US Tons / Year* | - | |
| | *Gallons / Day* | - | |
| | *Gallons / Year* | - | |
| | *Gallons / Minute* | - | |
| Process Water Value | *US $ / US Ton* | $ - | |
| **Process Water Nutrient Avoided Expense** | ***US $ / Year*** | **$ -** | Value is used on the **Op Sum** tab |
| - Or - | | - Or - | The Process Water Remaining may have an Avoided Expense value or be an Expense. Enter as appropriate. |
| Process Water Expense | *US $ / US Ton* | $ - | |
| **Process Water Handling Expense** | ***US $ / Year*** | **$ -** | Value is used on the **Op Sum** tab |

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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## Feed Handling Equipment

| Capital Expenditures | Units | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| **Reception and feeding equipment** | US $ | | |
| Dry solid feeder | US $ | $ 176,777 | per vendor |
| Extruder for cell disruption | US $ | $ 205,787 | per vendor |
| Dry material pump | US $ | $ 33,996 | per vendor |
| | US $ | | |
| | US $ | | |
| InsZone | | | |
| **sub-total** | **US $** | **$ 416,559** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | Percent | 30.0% | |
| Contingency | US $ | $ 124,968 | |
| **Feed Handling Equipment CapEx** | **US $** | **$ 541,527** | Value is used on the **CapEx Sum** and **Invest Sum** tabs |
| **Depreciation Parameters** | | | |
| Life Span | Years | 7 | |
| Salvage Value | Percent | 2.5% | |
| **Salvage Value** | **US $** | **$ 13,538** | Value is used on the **CapEx Sum** tab |
| **ITC Parameters** | | | |
| Percent of Capital Expenditure ITC Eligible | Percent | 100% | |
| **Eligible ITC Value** | **US $** | **$ 541,527** | Value is used on the **ITC** tab |
| **BETC Parameters** | | | |
| Percent of Capital Expenditure BETC Eligible | Percent | 100% | |
| **Eligible BETC Value** | **US $** | **$ 541,527** | Value is used on the **BETC** tab |

| Operations & Maintenance | Units | Value | Notes |
|---|---|---|---|
| **Operation & Maintenance** | | | |
| Operations & Maintenance Percent of Capital Expenditure | Percent of CapEx | 3.00% | |
| **Feed Handling Equipment O&M Expense** | **US $ / Year** | **$ 12,497** | Value is used on the **Op Sum** tab |

# Feedstock & Fiber Storage

| Capital Expenditures | Units | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| Design | US $ | $ 15,000 | |
| Equipment | US $ | $ 30,000 | |
| Construction | US $ | $ 70,000 | |
| InsZone | | | |
| **sub-total** | **US $** | **$ 115,000** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | *Percent* | 30.0% | |
| Contingency | US $ | $ 34,500 | |
| **Feedstock & Fiber Storage CapEx** | **US $** | **$ 149,500** | Value is used on the **CapEx Sum** and **Invest Sum** tabs |
| **Depreciation Parameters** | | | |
| Life Span | *Years* | 7 | |
| Salvage Value | *Percent* | 2.5% | |
| **Salvage Value** | **US $** | **$ 3,738** | Value is used on the **CapEx Sum** tab |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | *Percent* | 0% | |
| **Eligible ITC Value** | **US $** | **$ -** | Value is used on the **ITC** tab |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | *Percent* | 100% | |
| **Eligible BETC Value** | **US $** | **$ 149,500** | Value is used on the **BETC** tab |

| Operations & Maintenance | Units | Value | Notes |
|---|---|---|---|
| **Operation & Maintenance** | | | |
| Operations & Maintenance Percent of Capital Expenditure | *Percent of CapEx* | 2.00% | |
| **Feedstock & Fiber Storage O&M Expense** | ***US $ / Year*** | **$ 2,300** | Value is used on the **Op Sum** tab |

# Green Tags

## EC Oregon - AD Financial Feasibility Model v2.3

### Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush

**Confidential and Proprietary!**

Scenario:
**AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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| Initial Certification | Units | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| Green Tag Initial Certification | US $ | $ - | |
| | US $ | | |
| InsZone | | | |
| **sub-total** | **US $** | **$ -** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | Percent | 0.0% | |
| Contingency | US $ | $ - | |
| **Green Tags Initial Certificiation** | **US $** | **$ -** | Value is used on the **CapEx Sum** and **Invest Sum** tabs |
| **Depreciation Parameters** | | | |
| Life Span | Years | - | |
| Salvage Value | Percent | 0.0% | |
| **Salvage Value** | **US $** | **$ -** | Value is used on the **CapEx Sum** tab |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | Percent | 0% | |
| **Eligible ITC Value** | **US $** | **$ -** | Value is used on the **ITC** tab |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | Percent | 0% | |
| **Eligible BETC Value** | **US $** | **$ -** | Value is used on the **BETC** tab |

| Annual Fees | Units | Value | Notes |
|---|---|---|---|
| **Annual Fees** | | | |
| Green Tag Annual Certification and Audit Fees | US $ / Year | $ - | |
| InsZone | | | |
| **Green Tags Annual Fees** | **US $ / Year** | **$ -** | Value is used on the **Op Sum** tab<br>Annual fees begin in year 2 for the Income Statement |

## Green Tag Income (REC's)

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario:
**AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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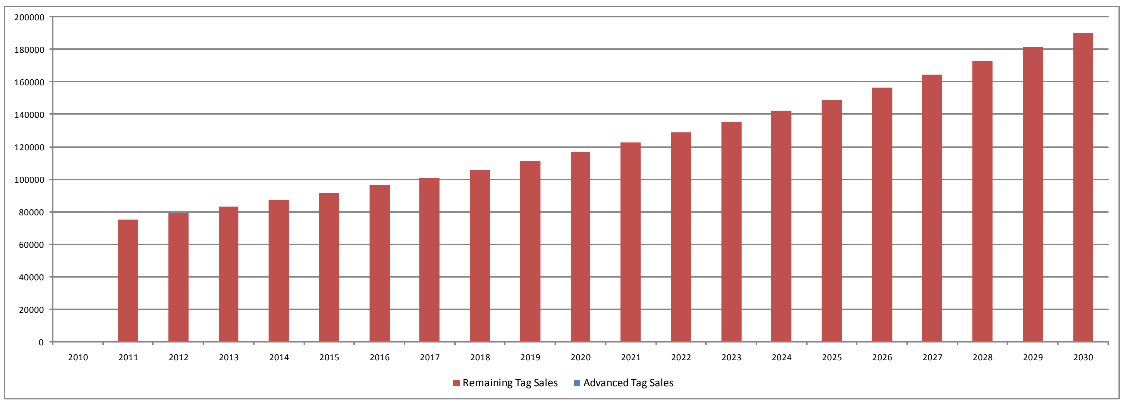
| Green Tag Income | *Units* | Value | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 9<br>2019 | 10<br>2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tags Available** | | | | | | | | | | | | | |
| Total kWh per Year | *kWh / Year* | | | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 |
| **Available** | ***Tags / Year*** | | | **9,708** | **9,735** | **9,708** | **9,708** | **9,708** | **9,735** | **9,708** | **9,708** | **9,708** | **9,735** |
| **Advanced Tag Sales** | | | | | | | | | | | | | |
| Sold in Advance | *Years* | | | | | | | | | | | | |
| Sold in Advance | *Tags* | | | | | | | | | | | | |
| | ***Tags / Year*** | | | - | - | - | - | - | - | - | - | - | - |
| Starting Selling Price | *US $ / Tag* | | | | | | | | | | | | |
| Annual Increase | *Percent* | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | ***US $ / Year*** | | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| Discount Rate | *Percent* | 0.00% | | | | | | | | | | | |
| **Advanced Tag Sales** | ***US $*** | | | **$ -** | | | | | | | | | |
| Simple Tag Value | *US $* | $ - | | | | | | | | | | | |
| **Remaining Tag Sales** | | | | | | | | | | | | | |
| Tags Remaining | *Tags / Year* | | | 9,708 | 9,735 | 9,708 | 9,708 | 9,708 | 9,735 | 9,708 | 9,708 | 9,708 | 9,735 |
| Starting Selling Price | *US $ / Tag* | $ 7.75 | | | | | | | | | | | |
| Annual Increase | *Percent* | 5.00% | | $ 7.75 | $ 8.14 | $ 8.54 | $ 8.97 | $ 9.42 | $ 9.89 | $ 10.39 | $ 10.91 | $ 11.45 | $ 12.02 |
| **Remaining Tag Sales** | ***US $ / Year*** | | | **$ 75,236** | **$ 79,221** | **$ 82,948** | **$ 87,095** | **$ 91,450** | **$ 96,293** | **$ 100,824** | **$ 105,865** | **$ 111,158** | **$ 117,045** |

| Green Tag Income | 11<br>2021 | 12<br>2022 | 13<br>2023 | 14<br>2024 | 15<br>2025 | 16<br>2026 | 17<br>2027 | 18<br>2028 | 19<br>2029 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tags Available** | | | | | | | | | | |
| Total kWh per Year | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 | 9,707,916 | 9,735,262 | 9,707,916 | 9,707,916 |
| **Available** | **9,708** | **9,708** | **9,708** | **9,735** | **9,708** | **9,708** | **9,708** | **9,735** | **9,708** | **9,708** |
| **Advanced Tag Sales** | | | | | | | | | | |
| Sold in Advance | | | | | | | | | | |
| Sold in Advance | | | | | | | | | | |
| | - | - | - | - | - | - | - | - | - | - |
| Starting Selling Price | | | | | | | | | | |
| Annual Increase | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| Discount Rate | | | | | | | | | | |
| **Advanced Tag Sales** | | | | | | | | | | |
| Simple Tag Value | | | | | | | | | | |
| **Remaining Tag Sales** | | | | | | | | | | |
| Tags Remaining | 9,708 | 9,708 | 9,708 | 9,735 | 9,708 | 9,708 | 9,708 | 9,735 | 9,708 | 9,708 |
| Starting Selling Price | | | | | | | | | | |
| Annual Increase | $ 12.62 | $ 13.26 | $ 13.92 | $ 14.61 | $ 15.34 | $ 16.11 | $ 16.92 | $ 17.76 | $ 18.65 | $ 19.58 |
| **Remaining Tag Sales** | **$ 122,552** | **$ 128,680** | **$ 135,114** | **$ 142,269** | **$ 148,963** | **$ 156,411** | **$ 164,232** | **$ 172,929** | **$ 181,065** | **$ 190,119** |



# Other Project Costs

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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| Capital Expenditures | Units | Value | Notes |
|---|---|---|---|
| **Capital Expenditure Items** | | | |
| Permits | US $ | $ 5,000 | |
| Electric Interconnection | US $ | $ 125,000 | |
| Feasibility Study | US $ | $ - | Paid for by CREF and ETO |
| Project Management | US $ | $ 210,000 | |
| InsZone | | | |
| **sub-total** | **US $** | **$ 340,000** | |
| **Capital Expenditure Contingency** | | | |
| Contingency Factor | Percent | 30.0% | |
| Contingency | US $ | $ 102,000 | |
| **Other Project Costs CapEx** | **US $** | **$ 442,000** | Value is used on the **CapEx Sum** and **Invest Sum** tabs |
| **Depreciation Parameters** | | | |
| Life Span | Years | 7 | |
| Salvage Value | Percent | 2.5% | |
| **Salvage Value** | **US $** | **$ 11,050** | Value is used on the **CapEx Sum** tab |
| **ITC Parameters** | | | |
| Capital Expenditure ITC Eligible | Percent | 0% | |
| **Eligible ITC Value** | **US $** | **$ -** | Value is used on the **ITC** tab |
| **BETC Parameters** | | | |
| Capital Expenditure BETC Eligible | Percent | 100% | |
| **Eligible BETC Value** | **US $** | **$ 442,000** | Value is used on the **BETC** tab |

## Investment Summary

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

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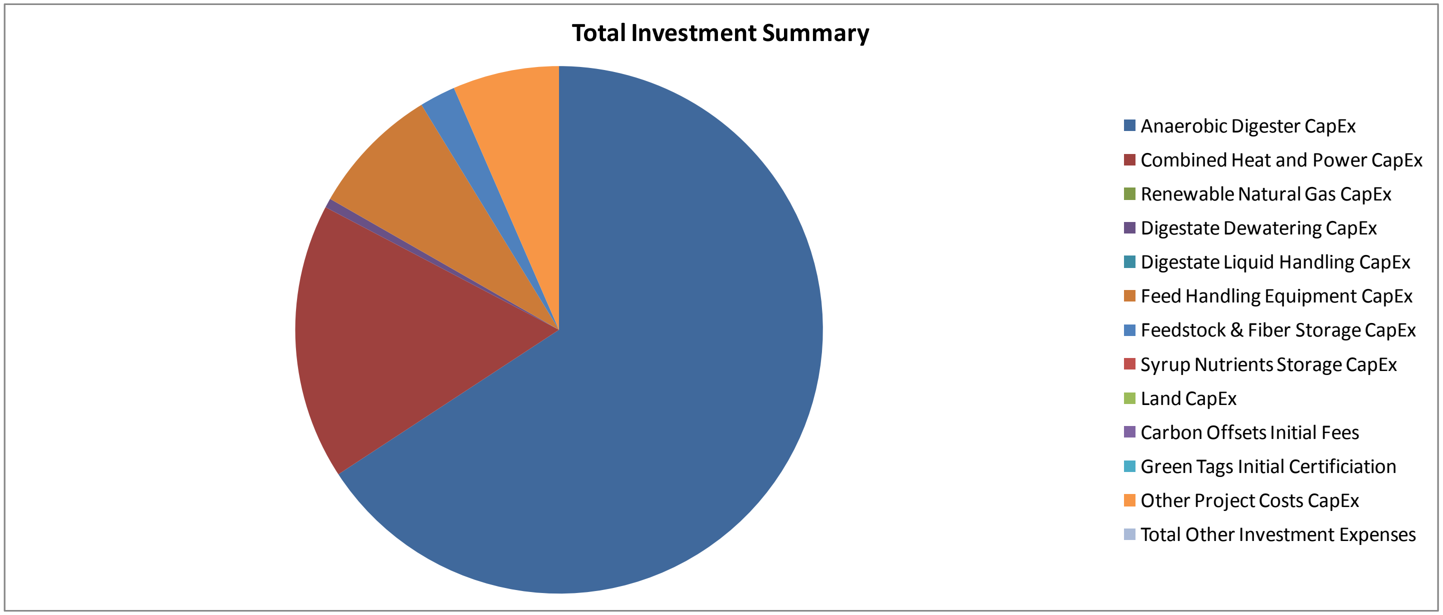
CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity
RNG: 0 MCF/Hour
Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%
*Version: 10/4/2009*

Nav

### Total Investment Summary

Notes

| | Investment Item | Cost | Percent of Total | Percent ITC Eligible | ITC Eligible Value | Percent BETC Eligible | BETC Eligible Value | |
|---|---|---|---|---|---|---|---|---|
| GoTo | Anaerobic Digester CapEx | $ 4,455,590 | 65.8% | 98% | $ 4,366,479 | 100% | $ 4,455,590 | These values are used on the **Funding** tab |
| GoTo | Combined Heat and Power CapEx | $ 1,146,600 | 16.9% | 100% | $ 1,146,600 | 100% | $ 1,146,600 | |
| GoTo | Renewable Natural Gas CapEx | $ - | 0.0% | 0% | $ - | 0% | $ - | |
| GoTo | Digestate Dewatering CapEx | $ 39,000 | 0.6% | 100% | $ 39,000 | 100% | $ 39,000 | |
| GoTo | Digestate Liquid Handling CapEx | $ - | 0.0% | 0% | $ - | 0% | $ - | |
| GoTo | Feed Handling Equipment CapEx | $ 541,527 | 8.0% | 100% | $ 541,527 | 100% | $ 541,527 | |
| GoTo | Feedstock & Fiber Storage CapEx | $ 149,500 | 2.2% | 0% | $ - | 100% | $ 149,500 | |
| GoTo | Syrup Nutrients Storage CapEx | $ - | 0.0% | 100% | $ - | 0% | $ - | |
| GoTo | Land CapEx | $ - | 0.0% | N/A | N/A | N/A | N/A | |
| GoTo | Carbon Offsets Initial Fees | $ - | 0.0% | 0% | $ - | 0% | $ - | |
| GoTo | Green Tags Initial Certification | $ - | 0.0% | 0% | $ - | 0% | $ - | |
| GoTo | Other Project Costs CapEx | $ 442,000 | 6.5% | 0% | $ - | 100% | $ 442,000 | |
| GoTo | Total Other Investment Expenses | $ - | 0.0% | 0% | $ - | 0% | $ - | |
| | InsZone | | | | | | | |
| | **Total Investment** | **$ 6,774,218** | **100.0%** | | **$ 6,093,606** | | **$ 6,774,218** | |



## Capital Expenditure Summary

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

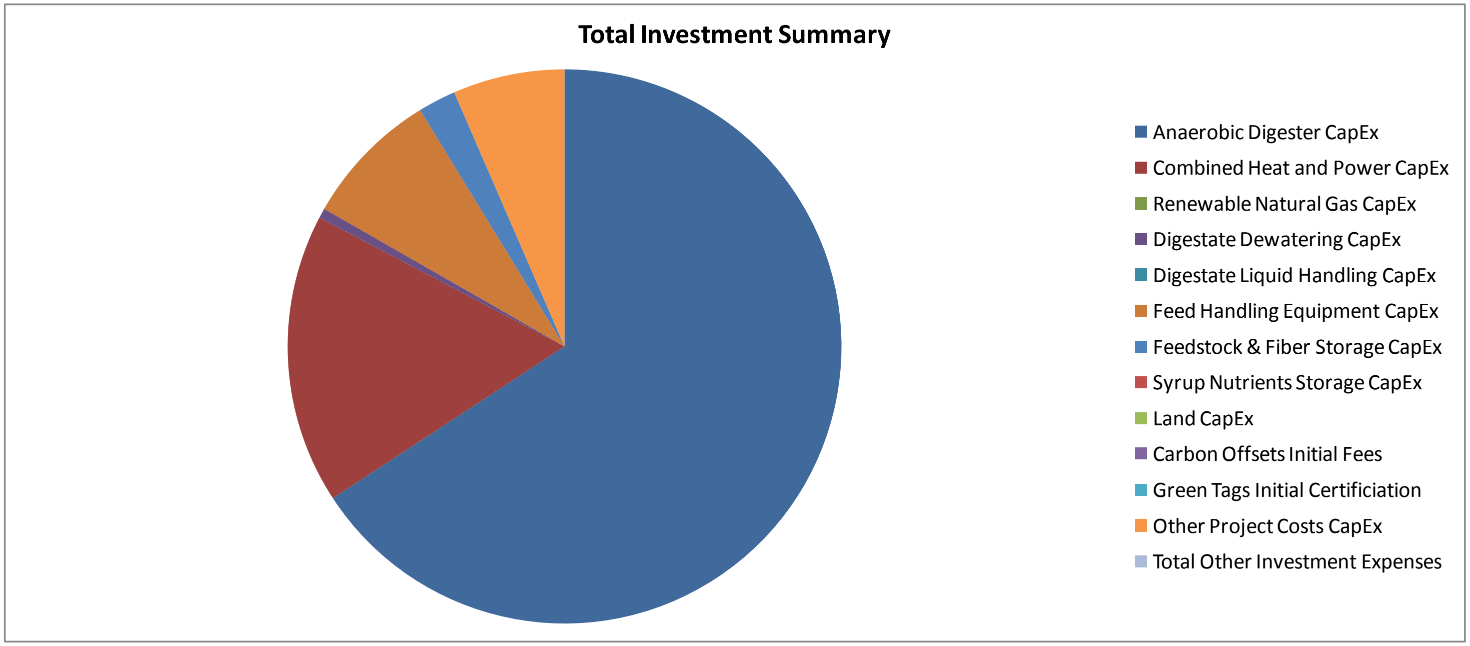
Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

### Capital Expenditures Summary

Notes

| | Capital Expenditure Item | Capital Expenditure | Percent of Total | Life Span in Years | Salvage Value Percent | Salvage Value | Notes |
|---|---|---|---|---|---|---|---|
| GoTo | Anaerobic Digester CapEx | $ 4,455,590 | 65.8% | 7 | 2.5% | $ 111,390 | These values are used on the **Depreciation** tab |
| GoTo | Combined Heat and Power CapEx | $ 1,146,600 | 16.9% | 7 | 2.5% | $ 28,665 | |
| GoTo | Renewable Natural Gas CapEx | $ - | 0.0% | - | 0.0% | $ - | |
| GoTo | Digestate Dewatering CapEx | $ 39,000 | 0.6% | 7 | 2.5% | $ 975 | |
| GoTo | Digestate Liquid Handling CapEx | $ - | 0.0% | 7 | 2.5% | $ - | |
| GoTo | Feed Handling Equipment CapEx | $ 541,527 | 8.0% | 7 | 2.5% | $ 13,538 | |
| GoTo | Feedstock & Fiber Storage CapEx | $ 149,500 | 2.2% | 7 | 2.5% | $ 3,738 | |
| GoTo | Syrup Nutrients Storage CapEx | $ - | 0.0% | - | 0.0% | $ - | |
| GoTo | Carbon Offsets Initial Fees | $ - | 0.0% | - | 0.0% | $ - | |
| GoTo | Green Tags Initial Certificiation | $ - | 0.0% | - | 0.0% | $ - | |
| GoTo | Other Project Costs CapEx | $ 442,000 | 6.5% | 7 | 2.5% | $ 11,050 | |
| | InsZone | | | | | | |
| | **Total Capital Expenditures** | **$ 6,774,218** | **100.0%** | | | **$ 169,355** | |



## Year 1 Baseline Operations Summary

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

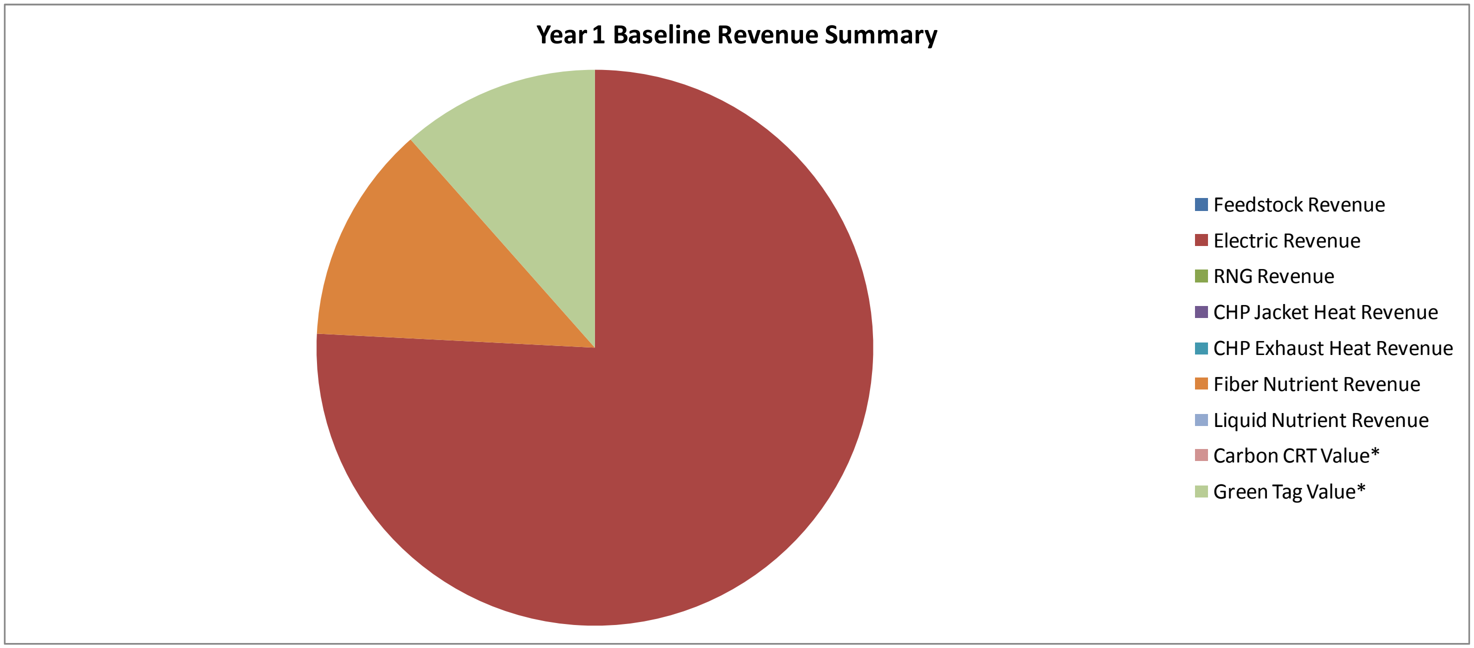
**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

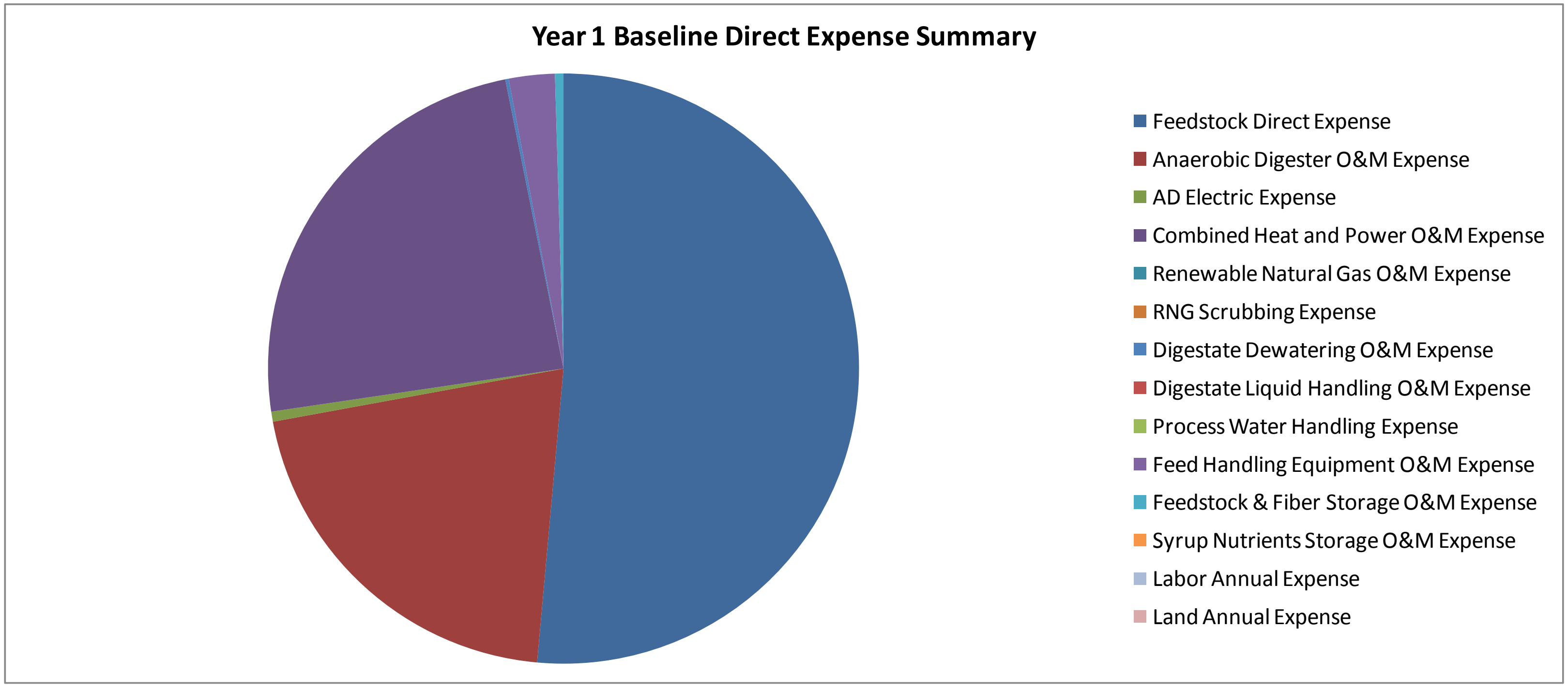
Nav

### Year 1 Baseline Revenue Summary

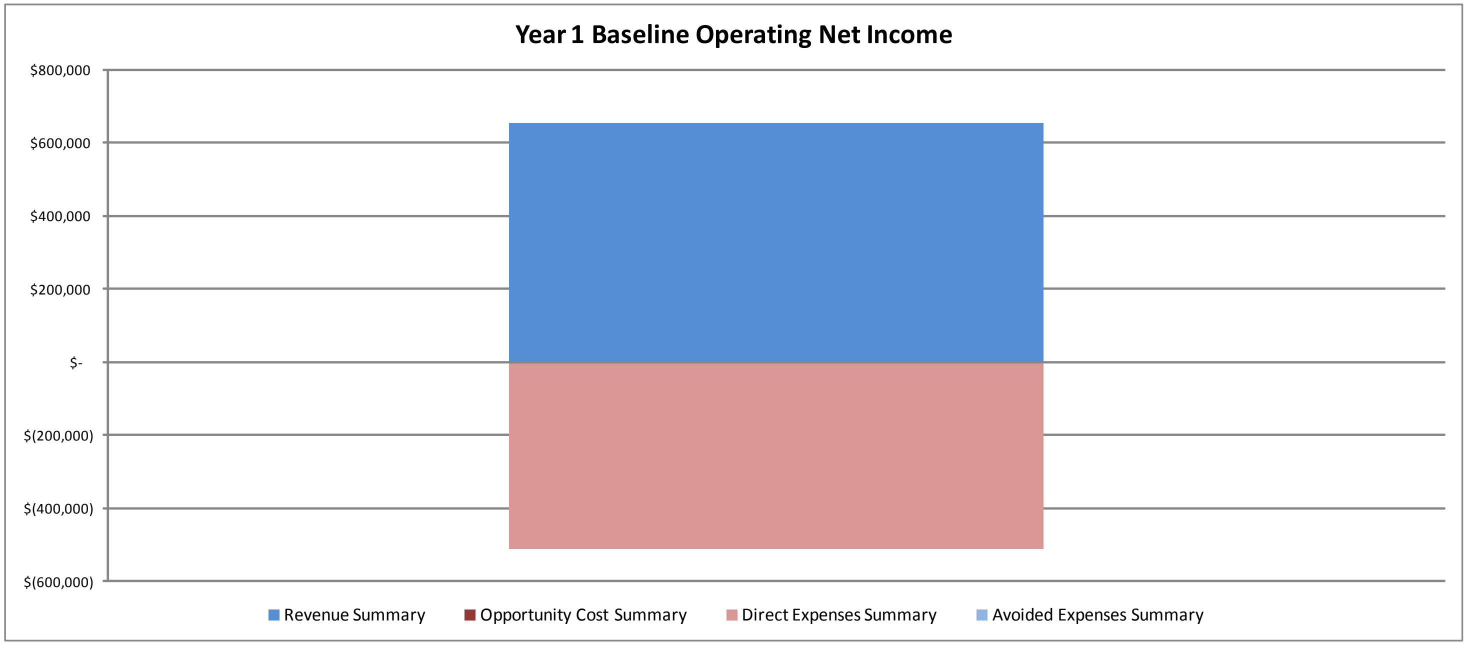
| | Revenue Item | | Revenue | Percent of Total | Inflation Rate | Notes |
|---|---|---|---|---|---|---|
| GoTo | Feedstock Revenue | $ | - | 0.0% | 3.0% | These values are used on the **Income Statement** |
| GoTo | Electric Revenue | $ | 494,367 | 75.8% | Projected | |
| GoTo | RNG Revenue | $ | - | 0.0% | 3.0% | |
| GoTo | CHP Jacket Heat Revenue | $ | - | 0.0% | 3.0% | |
| GoTo | CHP Exhaust Heat Revenue | $ | - | 0.0% | 3.0% | |
| GoTo | Fiber Nutrient Revenue | $ | 82,563 | 12.7% | 3.0% | |
| GoTo | Liquid Nutrient Revenue | $ | - | 0.0% | 3.0% | |
| GoTo | Carbon CRT Value* | $ | - | 0.0% | Projected | *Does not reflect advanced sales. Fewer CRT's are available in year 1. CRT's are only credited for 10 years. |
| GoTo | Green Tag Value* | $ | 75,236 | 11.5% | Projected | *Does not reflect advanced sales |
| | InsZone | | | | | |
| | **Total Revenue Summary** | **$** | **652,167** | **100.0%** | | |



| | Year 1 Baseline Direct Expense Summary | | | | | Notes |
|---|---|---|---|---|---|---|
| | Direct Expense Item | | Direct Expense | Percent of Total | Inflation Rate | |
| GoTo | Feedstock Direct Expense | $ | (263,165) | 51.4% | 3.0% | These values are used on the **Income Statement** |
| GoTo | Anaerobic Digester O&M Expense | $ | (105,906) | 20.7% | 3.0% | |
| GoTo | AD Electric Expense | $ | (2,815) | 0.6% | 3.0% | |
| GoTo | Combined Heat and Power O&M Expense | $ | (123,701) | 24.2% | 3.0% | |
| GoTo | Renewable Natural Gas O&M Expense | $ | - | 0.0% | 3.0% | |
| GoTo | RNG Scrubbing Expense | $ | - | 0.0% | 3.0% | |
| GoTo | Digestate Dewatering O&M Expense | $ | (927) | 0.2% | 3.0% | |
| GoTo | Digestate Liquid Handling O&M Expense | $ | - | 0.0% | 3.0% | |
| GoTo | Process Water Handling Expense | $ | - | 0.0% | 3.0% | |
| GoTo | Feed Handling Equipment O&M Expense | $ | (12,872) | 2.5% | 3.0% | |
| GoTo | Feedstock & Fiber Storage O&M Expense | $ | (2,369) | 0.5% | 3.0% | |
| GoTo | Syrup Nutrients Storage O&M Expense | $ | - | 0.0% | 3.0% | |
| GoTo | Labor Annual Expense | $ | - | 0.0% | 3.0% | |
| GoTo | Land Annual Expense | $ | - | 0.0% | 3.0% | |
| GoTo | Carbon Offsets Annual Fees | $ | - | 0.0% | 3.0% | CRT's are only available for 10 years |
| GoTo | Green Tags Annual Fees | $ | - | 0.0% | 3.0% | |
| | InsZone | | | | | |
| | **Total Direct Expense Summary** | **$** | **(511,755)** | **100.0%** | | |



| Year 1 Baseline Net Income Summary | | | Notes |
|---|---|---|---|
| **Revenue** | | | |
| Revenue Summary | $ | 652,167 | |
| Opportunity Cost Summary | $ | - | |
| InsZone | | | |
| **Total Revenue** | **$** | **652,167** | |
| **Expenses** | | | |
| Direct Expenses Summary | $ | (511,755) | |
| Avoided Expenses Summary | $ | - | |
| InsZone | | | |
| **Total Expenses** | **$** | **(511,755)** | |
| **Baseline Operating Net Income** *(EBITDA)* | **$** | **140,412** | |




| Baseline Simple Payback | | |
|---|---|---|
| Total Investment | $ | 6,774,218 |
| Revenue Summary | $ | 652,167 |
| Avoided Expenses Summary | $ | - |
| | **$** | **652,167** |
| **Simple Payback Period** | | **10.4** |

## Operations and Maintenance Summary

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**

**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**

**RNG: 0 MCF/Hour**

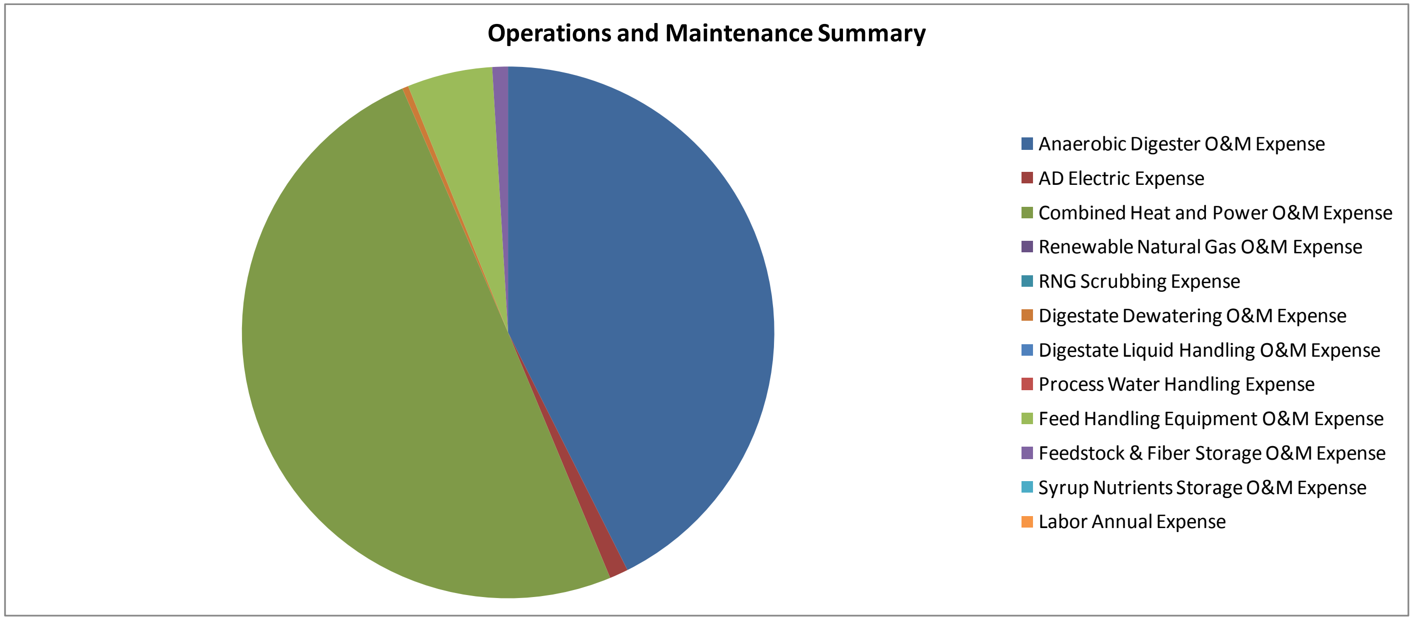
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**

***Version: 10/4/2009***

Nav

**Operations and Maintenance Summary** Notes

| | Capital Expenditure Item | | Operations and Maintenance Expense | Percent of Total |
|---|---|---|---|---|
| GoTo | Anaerobic Digester O&M Expense | $ | (105,906) | 42.6% |
| GoTo | AD Electric Expense | $ | (2,815) | 1.1% |
| GoTo | Combined Heat and Power O&M Expense | $ | (123,701) | 49.8% |
| GoTo | Renewable Natural Gas O&M Expense | $ | - | 0.0% |
| GoTo | RNG Scrubbing Expense | $ | - | 0.0% |
| GoTo | Digestate Dewatering O&M Expense | $ | (927) | 0.4% |
| GoTo | Digestate Liquid Handling O&M Expense | $ | - | 0.0% |
| GoTo | Process Water Handling Expense | $ | - | 0.0% |
| GoTo | Feed Handling Equipment O&M Expense | $ | (12,872) | 5.2% |
| GoTo | Feedstock & Fiber Storage O&M Expense | $ | (2,369) | 1.0% |
| GoTo | Syrup Nutrients Storage O&M Expense | $ | - | 0.0% |
| GoTo | Labor Annual Expense | $ | - | 0.0% |
| | InsZone | | | |
| | **Total Operations and Maintenance Summary** | **$** | **(248,590)** | **100.0%** |



# Federal Production Tax Credit or Investment Tax Credit (*PTC or ITC*)

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

## Tax Credit to Use

**Tax Credit Choice:**

- PTC
- ITC
- ITC Grant
- None

Tax Credit Selected: ITC Grant

## Value of the PTC

| | 0<br>**2010** | 1<br>**2011** | 2<br>**2012** | 3<br>**2013** | 4<br>**2014** | 5<br>**2015** | 6<br>**2016** | 7<br>**2017** | 8<br>**2018** | 9<br>**2019** | 10<br>**2020** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Full Federal Production Tax Credit** | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| **Half Federal Production Tax Credit** | $ - | $ 101,933 | $ 103,843 | $ 105,169 | $ 106,787 | $ 108,405 | $ 110,333 | $ 111,641 | $ 113,259 | $ 114,877 | $ 116,823 |
| **Federal Production Tax Credit** | **$ -** | **$ 101,933** | **$ 103,843** | **$ 105,169** | **$ 106,787** | **$ 108,405** | **$ 110,333** | **$ 111,641** | **$ 113,259** | **$ 114,877** | **$ 116,823** |

PTC Net Present Value: **$ 663,915**

*Discount Rate*: 10.0%

## Value of the ITC

ITC Discount Factor: 30%

| | **Investment Item** | **Capital Expenditure** | **Percent ITC Eligible** | **ITC Eligible Value** | **ITC Value** |
|---|---|---|---|---|---|
| GoTo | Anaerobic Digester CapEx | $ 4,455,590 | 98% | $ 4,366,479 | $ 1,309,944 |
| GoTo | Combined Heat and Power CapEx | $ 1,146,600 | 100% | $ 1,146,600 | $ 343,980 |
| GoTo | Renewable Natural Gas CapEx | $ - | 0% | $ - | $ - |
| GoTo | Digestate Dewatering CapEx | $ 39,000 | 100% | $ 39,000 | $ 11,700 |
| GoTo | Digestate Liquid Handling CapEx | $ - | 0% | $ - | $ - |
| GoTo | Feed Handling Equipment CapEx | $ 541,527 | 100% | $ 541,527 | $ 162,458 |
| GoTo | Feedstock & Fiber Storage CapEx | $ 149,500 | 0% | $ - | $ - |
| GoTo | Syrup Nutrients Storage CapEx | $ - | 100% | $ - | $ - |
| GoTo | Land CapEx | N/A | N/A | N/A | N/A |
| GoTo | Carbon Offsets Initial Fees | $ - | 0% | $ - | $ - |
| GoTo | Green Tags Initial Certificiation | $ - | 0% | $ - | $ - |
| GoTo | Other Project Costs CapEx | $ 442,000 | 0% | $ - | $ - |
| | InsZone | | | | |
| | **Total Investment** | **$ 6,774,218** | | **$ 6,093,606** | **$ 1,828,082** |

## Value of the ITC Grant

**Value of the ITC Grant**: **$ 1,828,082**

# Oregon Business Energy Tax Credit (*BETC*)

## EC Oregon - AD Financial Feasibility Model v2.3

### Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**

**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**

**RNG: 0 MCF/Hour**

**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**

***Version: 10/4/2009***

Nav

## BETC Eligible Costs

| | Investment Item | Percent BETC Eligible | | BETC Value |
|---|---|---|---|---|
| GoTo | Anaerobic Digester CapEx | 100% | $ | 4,455,590 |
| GoTo | Combined Heat and Power CapEx | 100% | $ | 1,146,600 |
| GoTo | Renewable Natural Gas CapEx | 0% | $ | - |
| GoTo | Digestate Dewatering CapEx | 100% | $ | 39,000 |
| GoTo | Digestate Liquid Handling CapEx | 0% | $ | - |
| GoTo | Feed Handling Equipment CapEx | 100% | $ | 541,527 |
| GoTo | Feedstock & Fiber Storage CapEx | 100% | $ | 149,500 |
| GoTo | Syrup Nutrients Storage CapEx | 0% | $ | - |
| GoTo | Land CapEx | N/A | | N/A |
| GoTo | Carbon Offsets Initial Fees | 0% | $ | - |
| GoTo | Green Tags Initial Certificiation | 0% | $ | - |
| GoTo | Other Project Costs CapEx | 100% | $ | 442,000 |
| GoTo | Total Other Investment Expenses | 0% | $ | - |
| | InsZone | | | |
| | **Total Investment** | | **$** | **6,774,218** |

## Federal Grant Reductions

| | | |
|---|---|---|
| Federal Grant Reductions | $ | 2,328,082 |
| **Total BETC Eligible Costs** | **$** | **4,446,136** |

## BETC Review Fee

**BETC Parameters**

| | |
|---|---|
| Review Fee Rate | 0.0060 |
| Review Fee Cap | $ 35,000 |
| Tax Credit Percent | 50% |
| Tax Credit Duration in Years | 5 |
| Pass-through Percent | 33.5% |

**BETC Review Fee**

| | | |
|---|---|---|
| Eligible Costs | $ 4,446,136 | |
| **BETC Review Fee** | **$ 26,677** | Value is used on the **Income Statement** |

## Retain Vs. Pass-Through Decision

Client

**Tax Rate Parameters**

| | | |
|---|---|---|
| Federal Effective Tax Rate | 32.0% | Value is set on the **Client** tab. |
| Oregon Effective Tax Rate | 9.0% | Value is set on **Parameters** tab |
| **Combined Effective Tax Rate** | **41.0%** | |

**Percent of BETC to Retain Suggestions**

These suggested percentages are provided if the goal is to retain enough of the BETC to offset the tax implications for selling the BETC. Choose the appropriate percent depending on your offset goals.

| | |
|---|---|
| Offset Federal Tax Only | 17.6548% |
| Offset Oregon Tax Only | 5.6871% |
| **Offset Federal and Oregon Tax** | **21.5502%** |

**Percent of BETC to Retain**

To complete retain the tax credit use 100%, to completely sell it use 0%, otherwise enter what percent of the credit to retain.

| | |
|---|---|
| Percent of BETC to Retain | 0.0000% |

## Value of BETC Retained

| | 0<br>**2010** | 1<br>**2011** | 2<br>**2012** | 3<br>**2013** | 4<br>**2014** | 5<br>**2015** |
|---|---|---|---|---|---|---|
| Percent | | 10% | 10% | 10% | 10% | 10% |
| Full Value of BETC | | $ 444,614 | $ 444,614 | $ 444,614 | $ 444,614 | $ 444,614 |
| **Amount of BETC to Retain** | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |

Values are used on the **Tax Summary** tab

## Value of BETC Pass-through

| | 0<br>**2010** | 1<br>**2011** | 2<br>**2012** | 3<br>**2013** | 4<br>**2014** | 5<br>**2015** |
|---|---|---|---|---|---|---|
| Pass-through Percent | | 33.5% | | | | |
| Pass-through Value | | $ 1,489,456 | | | | |
| **Amount of BETC to Pass-through** | | **$ 1,489,456** | | | | |

Value is used on the **Income Statement**

## Depreciation Schedule

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**

**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**

**RNG: 0 MCF/Hour**

**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**

***Version: 10/4/2009***

Nav

### CapEx Depreciable Basis Adjustment

ITC Credit Selected: ITC Grant — Selection is made on the **ITC** tab

Use Adjusted Depreciable Basis: Yes

| | Capital Expenditure | Original Capital Expenditure | ITC Value | Adjusted Capital Expenditure | Capital Expenditure Value to Use |
|---|---|---|---|---|---|
| GoTo | Anaerobic Digester CapEx | $ 4,455,590 | $ 1,309,944 | $ 3,800,619 | $ 3,800,619 |
| GoTo | Combined Heat and Power CapEx | $ 1,146,600 | $ 343,980 | $ 974,610 | $ 974,610 |
| GoTo | Renewable Natural Gas CapEx | $ - | $ - | $ - | $ - |
| GoTo | Digestate Dewatering CapEx | $ 39,000 | $ 11,700 | $ 33,150 | $ 33,150 |
| GoTo | Digestate Liquid Handling CapEx | $ - | $ - | $ - | $ - |
| GoTo | Feed Handling Equipment CapEx | $ 541,527 | $ 162,458 | $ 460,298 | $ 460,298 |
| GoTo | Feedstock & Fiber Storage CapEx | $ 149,500 | $ - | $ 149,500 | $ 149,500 |
| GoTo | Syrup Nutrients Storage CapEx | $ - | $ - | $ - | $ - |
| GoTo | Land CapEx | N/A | N/A | N/A | N/A |
| GoTo | Carbon Offsets Initial Fees | $ - | $ - | $ - | $ - |
| GoTo | Green Tags Initial Certificiation | $ - | $ - | $ - | $ - |
| GoTo | Other Project Costs CapEx | $ 442,000 | $ - | $ 442,000 | $ 442,000 |
| | InsZone | | | | |
| | **Total Capital Expenditures** | **$ 6,774,218** | **$ 1,828,082** | **$ 5,860,177** | **$ 5,860,177** |

### Depreciation Method Selection

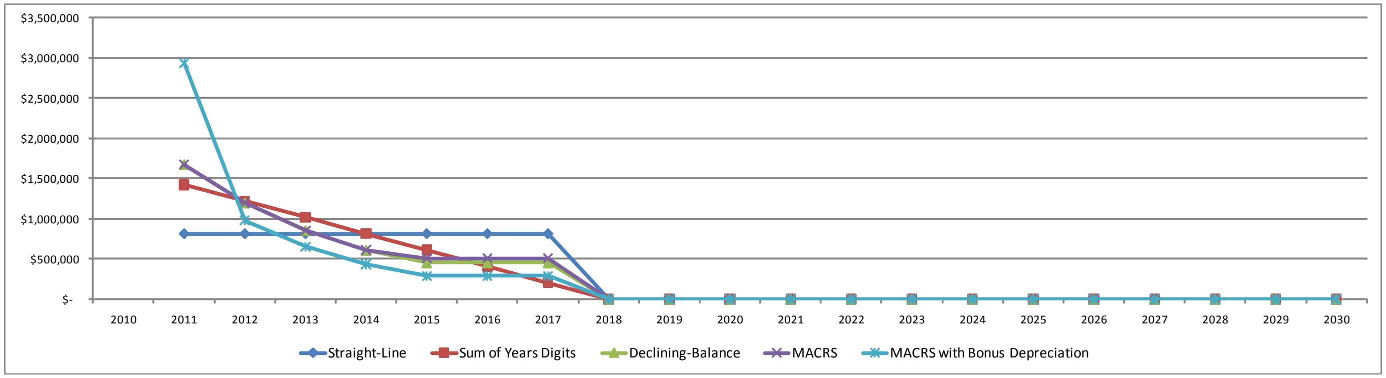
Straight-Line
Sum of Years Digits
Declining-Balance
MACRS

### Depreciation Method Selected

| | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 |
|---|---|---|---|---|---|---|---|---|
| **MACRS Depreciation** | | **$ 2,930,088** | **$ 1,195,954** | **$ 854,253** | **$ 610,181** | **$ 508,484** | **$ 508,484** | **$ 508,484** |

These values are used on the **Income** and **Cash Flow** tabs

### Depreciation Comparisons



## Depreciation Choices

### Straight-Line

| Capital Expenditure | Capital Expenditure | Life Span Years | Salvage Value Percent | Salvage Value | 0 2010 | 1 2011 | 2 2012 | 3 2013 | 4 2014 | 5 2015 | 6 2016 | 7 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaerobic Digester CapEx | $ 3,800,619 | 7 | 2.5% | $ 111,390 | | $ 527,033 | $ 527,033 | $ 527,033 | $ 527,033 | $ 527,033 | $ 527,033 | $ 527,033 |
| Combined Heat and Power CapEx | $ 974,610 | 7 | 2.5% | $ 28,665 | | $ 135,135 | $ 135,135 | $ 135,135 | $ 135,135 | $ 135,135 | $ 135,135 | $ 135,135 |
| Renewable Natural Gas CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Digestate Dewatering CapEx | $ 33,150 | 7 | 2.5% | $ 975 | | $ 4,596 | $ 4,596 | $ 4,596 | $ 4,596 | $ 4,596 | $ 4,596 | $ 4,596 |
| Digestate Liquid Handling CapEx | $ - | 7 | 2.5% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Feed Handling Equipment CapEx | $ 460,298 | 7 | 2.5% | $ 13,538 | | $ 63,823 | $ 63,823 | $ 63,823 | $ 63,823 | $ 63,823 | $ 63,823 | $ 63,823 |
| Feedstock & Fiber Storage CapEx | $ 149,500 | 7 | 2.5% | $ 3,738 | | $ 20,823 | $ 20,823 | $ 20,823 | $ 20,823 | $ 20,823 | $ 20,823 | $ 20,823 |
| Syrup Nutrients Storage CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Land CapEx | N/A | N/A | N/A | N/A | | | | | | | | |
| Carbon Offsets Initial Fees | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Green Tags Initial Certificiation | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Other Project Costs CapEx | $ 442,000 | 7 | 2.5% | $ 11,050 | | $ 61,564 | $ 61,564 | $ 61,564 | $ 61,564 | $ 61,564 | $ 61,564 | $ 61,564 |
| InsZone | | | | | | | | | | | | |
| **Total Capital Expenditures** | **$ 5,860,177** | | | **$ 169,355** | | **$ 812,974** | **$ 812,974** | **$ 812,974** | **$ 812,974** | **$ 812,974** | **$ 812,974** | **$ 812,974** |

### Sum of Years Digits

| Capital Expenditure | Capital Expenditure | Life Span Years | Salvage Value Percent | Salvage Value | 0 2010 | 1 2011 | 2 2012 | 3 2013 | 4 2014 | 5 2015 | 6 2016 | 7 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaerobic Digester CapEx | $ 3,800,619 | 7 | 2.5% | $ 111,390 | | $ 922,307 | $ 790,549 | $ 658,791 | $ 527,033 | $ 395,275 | $ 263,516 | $ 131,758 |
| Combined Heat and Power CapEx | $ 974,610 | 7 | 2.5% | $ 28,665 | | $ 236,486 | $ 202,703 | $ 168,919 | $ 135,135 | $ 101,351 | $ 67,568 | $ 33,784 |
| Renewable Natural Gas CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Digestate Dewatering CapEx | $ 33,150 | 7 | 2.5% | $ 975 | | $ 8,044 | $ 6,895 | $ 5,746 | $ 4,596 | $ 3,447 | $ 2,298 | $ 1,149 |
| Digestate Liquid Handling CapEx | $ - | 7 | 2.5% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Feed Handling Equipment CapEx | $ 460,298 | 7 | 2.5% | $ 13,538 | | $ 111,690 | $ 95,734 | $ 79,779 | $ 63,823 | $ 47,867 | $ 31,911 | $ 15,956 |
| Feedstock & Fiber Storage CapEx | $ 149,500 | 7 | 2.5% | $ 3,738 | | $ 36,441 | $ 31,235 | $ 26,029 | $ 20,823 | $ 15,617 | $ 10,412 | $ 5,206 |
| Syrup Nutrients Storage CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Land CapEx | N/A | N/A | N/A | N/A | | | | | | | | |
| Carbon Offsets Initial Fees | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Green Tags Initial Certificiation | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Other Project Costs CapEx | $ 442,000 | 7 | 2.5% | $ 11,050 | | $ 107,738 | $ 92,346 | $ 76,955 | $ 61,564 | $ 46,173 | $ 30,782 | $ 15,391 |
| InsZone | | | | | | | | | | | | |
| **Total Capital Expenditures** | **$ 5,860,177** | | | **$ 169,355** | | **$ 1,422,705** | **$ 1,219,462** | **$ 1,016,218** | **$ 812,974** | **$ 609,731** | **$ 406,487** | **$ 203,244** |

### Declining-Balance

Factor: 2.0

A **Factor** of **2** is used for the double-declining method.

Switch to Straight-Line Depreciation?: Yes

A value of "**Yes**" causes the calculation to switch to the straight-line method when depreciation is greater than the declining balance method.

**Note**: *A "**No**" value may not fully depreciate an asset by the end of its life.*

| Capital Expenditure | Capital Expenditure | Life Span Years | Salvage Value Percent | Salvage Value | 0 2010 | 1 2011 | 2 2012 | 3 2013 | 4 2014 | 5 2015 | 6 2016 | 7 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaerobic Digester CapEx | $ 3,800,619 | 7 | 2.5% | $ 111,390 | | $ 1,085,891 | $ 775,636 | $ 554,026 | $ 395,733 | $ 292,647 | $ 292,647 | $ 292,647 |
| Combined Heat and Power CapEx | $ 974,610 | 7 | 2.5% | $ 28,665 | | $ 278,460 | $ 198,900 | $ 142,071 | $ 101,480 | $ 75,011 | $ 75,011 | $ 75,011 |
| Renewable Natural Gas CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Digestate Dewatering CapEx | $ 33,150 | 7 | 2.5% | $ 975 | | $ 9,471 | $ 6,765 | $ 4,832 | $ 3,452 | $ 2,551 | $ 2,551 | $ 2,551 |
| Digestate Liquid Handling CapEx | $ - | 7 | 2.5% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Feed Handling Equipment CapEx | $ 460,298 | 7 | 2.5% | $ 13,538 | | $ 131,514 | $ 93,938 | $ 67,099 | $ 47,928 | $ 35,427 | $ 35,427 | $ 35,427 |
| Feedstock & Fiber Storage CapEx | $ 149,500 | 7 | 2.5% | $ 3,738 | | $ 42,714 | $ 30,510 | $ 21,793 | $ 15,566 | $ 11,726 | $ 11,726 | $ 11,726 |
| Syrup Nutrients Storage CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Land CapEx | N/A | N/A | N/A | N/A | | | | | | | | |
| Carbon Offsets Initial Fees | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Green Tags Initial Certificiation | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Other Project Costs CapEx | $ 442,000 | 7 | 2.5% | $ 11,050 | | $ 126,286 | $ 90,204 | $ 64,431 | $ 46,022 | $ 34,669 | $ 34,669 | $ 34,669 |
| InsZone | | | | | | | | | | | | |
| **Total Capital Expenditures** | **$ 5,860,177** | | | **$ 169,355** | | **$ 1,674,336** | **$ 1,195,954** | **$ 854,253** | **$ 610,181** | **$ 452,032** | **$ 452,032** | **$ 452,032** |

## MACRS

Use Bonus Depreciation? Yes
Bonus Depreciation Factor 50%

| Capital Expenditure | Capital Expenditure | Life Span Years | Salvage Value Percent | Salvage Value | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaerobic Digester CapEx | $ 3,800,619 | 7 | 0.0% | $ - | | $ 1,085,891 | $ 775,636 | $ 554,026 | $ 395,733 | $ 329,777 | $ 329,777 | $ 329,777 |
| Combined Heat and Power CapEx | $ 974,610 | 7 | 0.0% | $ - | | $ 278,460 | $ 198,900 | $ 142,071 | $ 101,480 | $ 84,566 | $ 84,566 | $ 84,566 |
| Renewable Natural Gas CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Digestate Dewatering CapEx | $ 33,150 | 7 | 0.0% | $ - | | $ 9,471 | $ 6,765 | $ 4,832 | $ 3,452 | $ 2,876 | $ 2,876 | $ 2,876 |
| Digestate Liquid Handling CapEx | $ - | 7 | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Feed Handling Equipment CapEx | $ 460,298 | 7 | 0.0% | $ - | | $ 131,514 | $ 93,938 | $ 67,099 | $ 47,928 | $ 39,940 | $ 39,940 | $ 39,940 |
| Feedstock & Fiber Storage CapEx | $ 149,500 | 7 | 0.0% | $ - | | $ 42,714 | $ 30,510 | $ 21,793 | $ 15,566 | $ 12,972 | $ 12,972 | $ 12,972 |
| Syrup Nutrients Storage CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Land CapEx | N/A | N/A | N/A | N/A | | | | | | | | |
| Carbon Offsets Initial Fees | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Green Tags Initial Certificiation | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Other Project Costs CapEx | $ 442,000 | 7 | 0.0% | $ - | | $ 126,286 | $ 90,204 | $ 64,431 | $ 46,022 | $ 38,352 | $ 38,352 | $ 38,352 |
| InsZone | | | | | | | | | | | | |
| **Total Capital Expenditures** | **$ 5,860,177** | | | **$ -** | | **$ 1,674,336** | **$ 1,195,954** | **$ 854,253** | **$ 610,181** | **$ 508,484** | **$ 508,484** | **$ 508,484** |

## MACRS with Bonus Depreciation

| Capital Expenditure | Capital Expenditure | Life Span Years | Salvage Value Percent | Salvage Value | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Anaerobic Digester CapEx | $ 3,800,619 | 7 | 0.0% | $ - | | $ 1,900,309 | $ 633,436 | $ 422,291 | $ 281,527 | $ 187,685 | $ 187,685 | $ 187,685 |
| Combined Heat and Power CapEx | $ 974,610 | 7 | 0.0% | $ - | | $ 487,305 | $ 162,435 | $ 108,290 | $ 72,193 | $ 48,129 | $ 48,129 | $ 48,129 |
| Renewable Natural Gas CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Digestate Dewatering CapEx | $ 33,150 | 7 | 0.0% | $ - | | $ 16,575 | $ 5,525 | $ 3,683 | $ 2,456 | $ 1,637 | $ 1,637 | $ 1,637 |
| Digestate Liquid Handling CapEx | $ - | 7 | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Feed Handling Equipment CapEx | $ 460,298 | 7 | 0.0% | $ - | | $ 230,149 | $ 76,716 | $ 51,144 | $ 34,096 | $ 22,731 | $ 22,731 | $ 22,731 |
| Feedstock & Fiber Storage CapEx | $ 149,500 | 7 | 0.0% | $ - | | $ 74,750 | $ 24,917 | $ 16,611 | $ 11,074 | $ 7,383 | $ 7,383 | $ 7,383 |
| Syrup Nutrients Storage CapEx | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Land CapEx | N/A | N/A | N/A | N/A | | | | | | | | |
| Carbon Offsets Initial Fees | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Green Tags Initial Certificiation | $ - | - | 0.0% | $ - | | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Other Project Costs CapEx | $ 442,000 | 7 | 0.0% | $ - | | $ 221,000 | $ 73,667 | $ 49,111 | $ 32,741 | $ 21,827 | $ 21,827 | $ 21,827 |
| InsZone | | | | | | | | | | | | |
| **Total Capital Expenditures** | **$ 5,860,177** | | | **$ -** | | **$ 2,930,088** | **$ 976,696** | **$ 651,131** | **$ 434,087** | **$ 289,391** | **$ 289,391** | **$ 289,391** |

## Tax Credit Summary

**EC Oregon - AD Financial Feasibility Model v2.3**

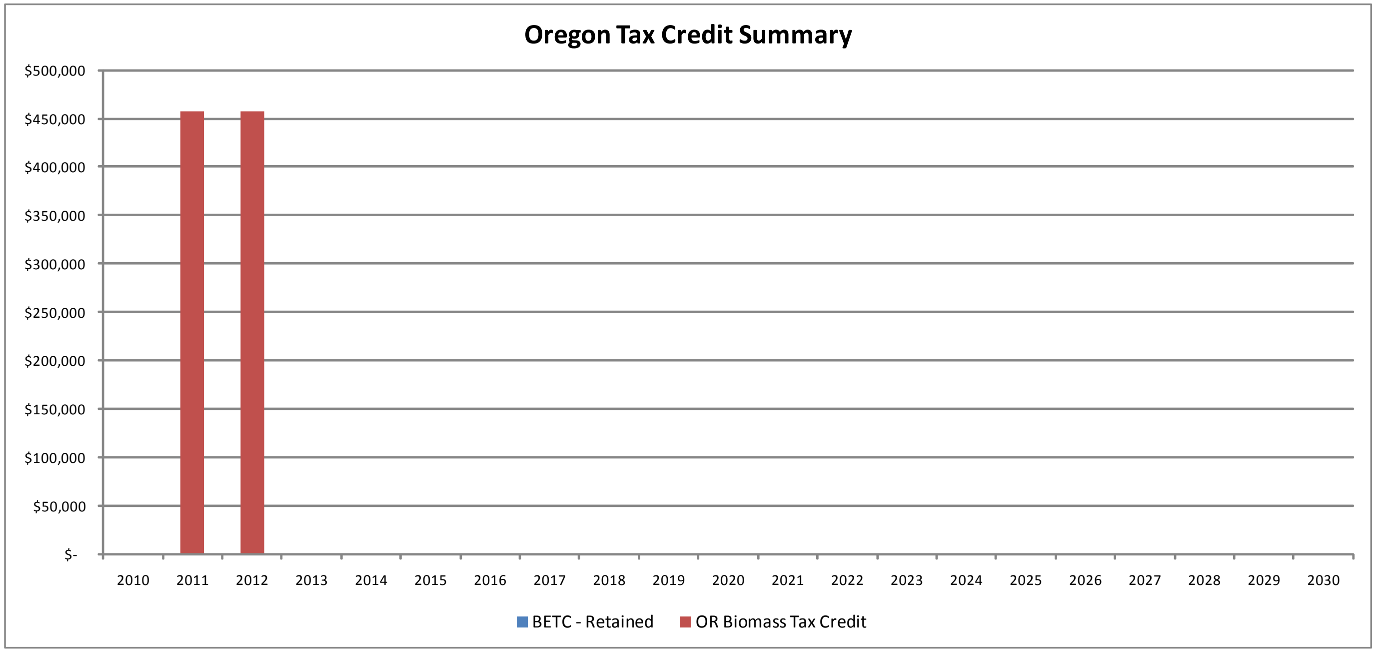
**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

Nav

| Oregon Tax Credit Summary | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 9<br>2019 | 10<br>2020 | 11<br>2021 | 12<br>2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GoTo BETC - Retained | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo OR Biomass Tax Credit | | $ 457,950 | $ 457,950 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| InsZone | | | | | | | | | | | | | |
| **Total Oregon Tax Credits** | **$ -** | **$ 457,950** | **$ 457,950** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |



## Funding

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

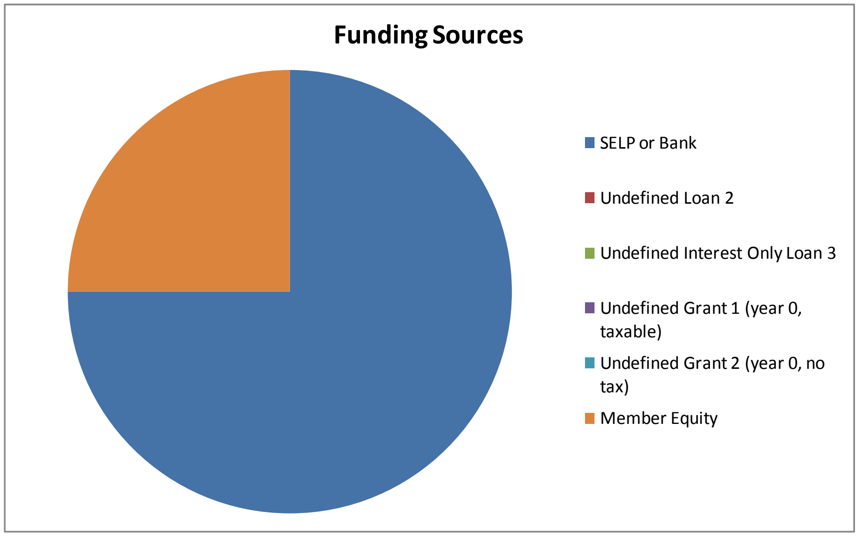
Nav

### Total Investment

| | Investment Item | | Cost |
|---|---|---|---|
| GoTo | Anaerobic Digester CapEx | $ | 4,455,590 |
| GoTo | Combined Heat and Power CapEx | $ | 1,146,600 |
| GoTo | Renewable Natural Gas CapEx | $ | - |
| GoTo | Digestate Dewatering CapEx | $ | 39,000 |
| GoTo | Digestate Liquid Handling CapEx | $ | - |
| GoTo | Feed Handling Equipment CapEx | $ | 541,527 |
| GoTo | Feedstock & Fiber Storage CapEx | $ | 149,500 |
| GoTo | Syrup Nutrients Storage CapEx | $ | - |
| GoTo | Land CapEx | $ | - |
| GoTo | Carbon Offsets Initial Fees | $ | - |
| GoTo | Green Tags Initial Certificiation | $ | - |
| GoTo | Other Project Costs CapEx | $ | 442,000 |
| GoTo | Total Other Investment Expenses | $ | - |
| | InsZone | | |
| | **Total Investment** | **$** | **6,774,218** |

### Funding Sources

| Funding Parameters | | | | |
|---|---|---|---|---|
| Percent Debt Financing via Loan 1 | 75% | $ | 5,080,663 | SELP or Bank |
| Percent Debt Financing via Loan 2 | 0% | $ | - | Undefined Loan 2 |
| Percent Debt Financing via Interest Only Loan 3 | 0% | $ | - | Undefined Interest Only Loan 3 |
| Percent Grant 1 (year 0, taxable) | 0% | $ | - | Undefined Grant 1 (year 0, taxable) |
| Percent Grant 2 (year 0, non-taxable) | 0% | $ | - | Undefined Grant 2 (year 0, no tax) |
| Percent Equity | 25% | $ | 1,693,554 | Member Equity |
| InsZone | | | | |
| **Total Funding** | **100%** | **$** | **6,774,218** | |
| **Debt to Equity Ratio** | | | **4.00** | |



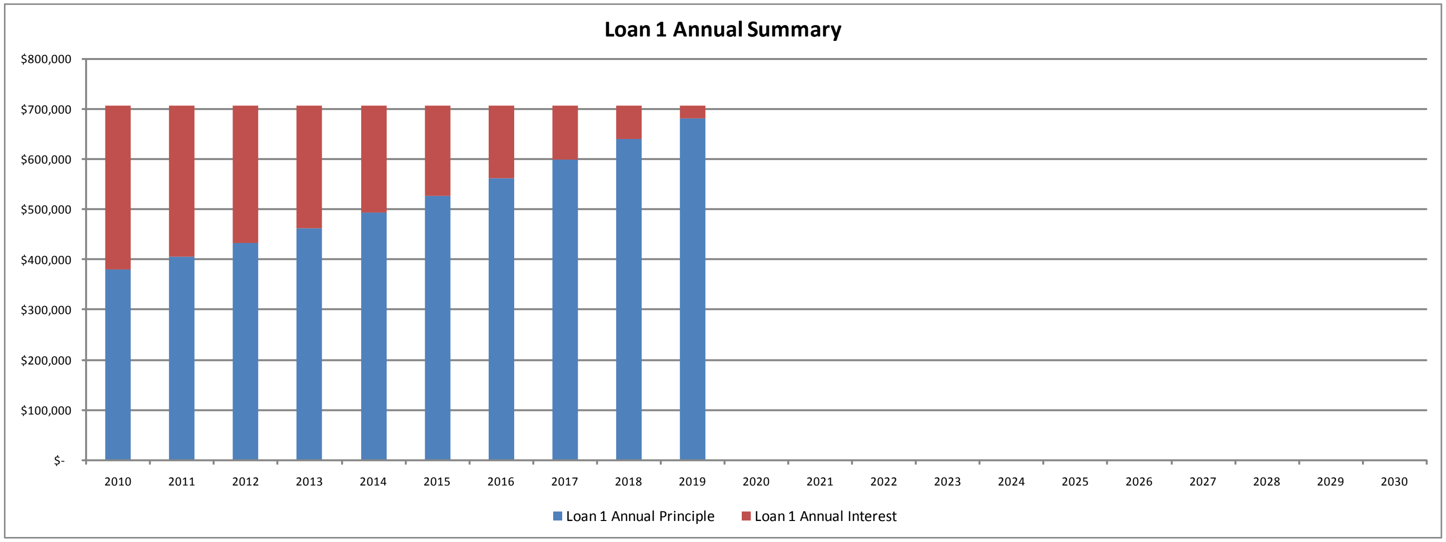
**Debt Financing - SELP or Bank**

**Loan 1 Parameters**

| | |
|---|---|
| Loan Type | **Amortization Loan** |
| Loan Amount | $ 5,080,663 |
| Annual Interest Rate | 6.50% |
| Loan Points | 2.00% |
| Number of Years | 10 |
| Loan Start Year | 2010 |
| Points | $ 101,613 |
| Loan Amount with Points | **$ 5,182,276** |

**SELP or Bank Annual Summary**

| | 0<br>**2010** | 1<br>**2011** | 2<br>**2012** | 3<br>**2013** | 4<br>**2014** | 5<br>**2015** | 6<br>**2016** | 7<br>**2017** | 8<br>**2018** | 9<br>**2019** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Loan 1 Starting Balance** | **$ 5,182,276** | | | | | | | | | |
| **Loan 1 Annual Principle** | $ 380,479 | $ 405,960 | $ 433,148 | $ 462,157 | $ 493,108 | $ 526,133 | $ 561,369 | $ 598,965 | $ 639,079 | $ 681,879 |
| **Loan 1 Annual Interest** | $ 325,646 | $ 300,164 | $ 272,976 | $ 243,968 | $ 213,016 | $ 179,992 | $ 144,756 | $ 107,160 | $ 67,046 | $ 24,246 |
| **Loan 1 Annual Payment** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** | **$ 706,124** |
| **Loan 1 End of Year Balance** | **$ 4,801,798** | **$ 4,395,837** | **$ 3,962,689** | **$ 3,500,532** | **$ 3,007,424** | **$ 2,481,291** | **$ 1,919,922** | **$ 1,320,957** | **$ 681,879** | **$ (0)** |



# Round 2 Funding *(Delayed)*

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**

**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**

**RNG: 0 MCF/Hour**

**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**

***Version: 10/4/2009***

Nav

## Additional Funding Sources

| Funding Source Type | Amount | Funding Source Name | Reduces BETC? | BETC Reduction |
|---|---|---|---|---|
| | *US $* | | *Yes / No* | *US $* |
| Grant 3 (year 1, taxable) | $ 500,000 | USDA REAP Grant (year 1, taxable) | Yes | $ 500,000 |
| Grant 4 (year 1, non-taxable) | $ - | Undefined Grant 4 (year 1, no tax) | No | $ - |
| ITC Grant (year 1, non-taxable) | $ 1,828,082 | ITC Grant (year 1, no tax) | Yes | $ 1,828,082 |
| InsZone | | | | |
| **Total Additional Funding** | **$ 2,328,082** | | | **$ 2,328,082** |

## Projected Income Statement

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD:** 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis
**CHP:** Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity
**RNG:** 0 MCF/Hour
**Financial:** Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%
*Version: 10/4/2009*

Nav

| | | Inflation Rate | What If? | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Operating Revenue** | | | | | | | | | | | | |
| GoTo | Feedstock Revenue | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Electric Revenue | Projected | 100% | | $ 494,367 | $ 528,574 | $ 539,657 | $ 716,326 | $ 720,448 | $ 709,569 | $ 706,432 | $ 716,736 | $ 936,753 |
| GoTo | RNG Revenue | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | CHP Jacket Heat Revenue | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | CHP Exhaust Heat Revenue | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Fiber Nutrient Revenue | 3.0% | 100% | | $ 82,563 | $ 85,040 | $ 87,591 | $ 90,219 | $ 92,926 | $ 95,713 | $ 98,585 | $ 101,542 | $ 144,775 |
| GoTo | Liquid Nutrient Revenue | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Carbon CRT Advanced Sales | Projected | 100% | | $ - | | | | | | | | |
| GoTo | Carbon CRT Revenue | Projected | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Green Tag Advanced Sales | Projected | 100% | | $ - | | | | | | | | |
| GoTo | Green Tag Revenue | Projected | 100% | | $ 75,236 | $ 79,221 | $ 82,948 | $ 87,095 | $ 91,450 | $ 96,293 | $ 100,824 | $ 105,865 | $ 190,119 |
| GoTo | Feedstock Opportunity Cost | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Operating Revenue** | | | **$ -** | **$ 652,167** | **$ 692,834** | **$ 710,196** | **$ 893,640** | **$ 904,823** | **$ 901,576** | **$ 905,840** | **$ 924,143** | **$ 1,271,646** |
| | **Operating Expenses** | | | | | | | | | | | | |
| | **Direct Operating Expenses** | | | | | | | | | | | | |
| GoTo | Feedstock Direct Expense | 3.0% | 100% | | $ (131,583) | $ (135,530) | $ (279,192) | $ (287,568) | $ (296,195) | $ (305,080) | $ (314,233) | $ (323,660) | $ (461,461) |
| GoTo | Anaerobic Digester O&M Expense | 3.0% | 100% | | $ (105,906) | $ (109,083) | $ (112,356) | $ (115,726) | $ (119,198) | $ (122,774) | $ (126,457) | $ (130,251) | $ (185,707) |
| GoTo | AD Electric Expense | 3.0% | 100% | | $ (2,815) | $ (2,900) | $ (2,987) | $ (3,076) | $ (3,168) | $ (3,263) | $ (3,361) | $ (3,462) | $ (4,936) |
| GoTo | Combined Heat and Power O&M Expense | 3.0% | 100% | | $ (123,701) | $ (127,412) | $ (131,234) | $ (135,171) | $ (139,226) | $ (143,403) | $ (147,705) | $ (152,136) | $ (216,910) |
| GoTo | Renewable Natural Gas O&M Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | RNG Scrubbing Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Digestate Dewatering O&M Expense | 3.0% | 100% | | $ (927) | $ (955) | $ (983) | $ (1,013) | $ (1,043) | $ (1,075) | $ (1,107) | $ (1,140) | $ (1,626) |
| GoTo | Digestate Liquid Handling O&M Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Process Water Handling Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Feed Handling Equipment O&M Expense | 3.0% | 100% | | $ (12,872) | $ (13,258) | $ (13,656) | $ (14,065) | $ (14,487) | $ (14,922) | $ (15,369) | $ (15,831) | $ (22,571) |
| GoTo | Feedstock & Fiber Storage O&M Expense | 3.0% | 100% | | $ (2,369) | $ (2,440) | $ (2,513) | $ (2,589) | $ (2,666) | $ (2,746) | $ (2,829) | $ (2,914) | $ (4,154) |
| GoTo | Syrup Nutrients Storage O&M Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Labor Annual Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Land Annual Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Carbon Offsets Annual Fees | 3.0% | 100% | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | |
| GoTo | Green Tags Annual Fees | 3.0% | 100% | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Direct Operating Expenses** | | | **$ -** | **$ (380,172)** | **$ (391,577)** | **$ (542,920)** | **$ (559,208)** | **$ (575,984)** | **$ (593,264)** | **$ (611,062)** | **$ (629,394)** | **$ (897,365)** |
| | **Avoided Operating Expenses** | | | | | | | | | | | | |
| GoTo | Feedstock Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Electric Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | CHP Jacket Heat Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | CHP Exhaust Heat Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Fiber Nutrient Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Liquid Nutrient Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Process Water Nutrient Avoided Expense | 3.0% | 100% | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Avoided Operating Expenses** | | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | InsZone | | | | | | | | | | | | |
| | **Total Operating Expenses** | | | **$ -** | **$ (380,172)** | **$ (391,577)** | **$ (542,920)** | **$ (559,208)** | **$ (575,984)** | **$ (593,264)** | **$ (611,062)** | **$ (629,394)** | **$ (897,365)** |
| | InsZone | | | | | | | | | | | | |
| | **Gross Profit from Operations** | | | **$ -** | **$ 271,995** | **$ 301,257** | **$ 167,276** | **$ 334,432** | **$ 328,839** | **$ 308,312** | **$ 294,779** | **$ 294,750** | **$ 374,281** |
| | **Gross Profit Margin**<br>Gross Profit / Revenue | | | **0.0%** | **41.7%** | **43.5%** | **23.6%** | **37.4%** | **36.3%** | **34.2%** | **32.5%** | **31.9%** | **29.4%** |

| | | Inflation Rate | What If? | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Non-Operating Income / (Expenses)** | | | | | | | | | | | | |
| GoTo | Total Other Investment Expenses | N/A | 100% | $ - | | | | | | | | | |
| GoTo | BETC Review Fee | N/A | 100% | $ (26,677) | | | | | | | | | |
| GoTo | BETC Pass-through | N/A | 100% | | $ 1,489,456 | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Undefined Grant 1 (year 0, taxable) | N/A | 100% | $ - | | | | | | | | | |
| GoTo | USDA REAP Grant (year 1, taxable) | N/A | 100% | | $ 500,000 | | | | | | | | |
| GoTo | SELP or Bank Interest Expense | N/A | N/A | $ (325,646) | $ (300,164) | $ (272,976) | $ (243,968) | $ (213,016) | $ (179,992) | $ (144,756) | $ (107,160) | $ (67,046) | $ - |
| GoTo | Undefined Loan 2 Interest Expense | N/A | N/A | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Undefined Interest Only Loan 3 Interest Expense | N/A | N/A | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Non-Operating Income / (Expense)** | | | **$ (352,322)** | **$ 1,689,291** | **$ (272,976)** | **$ (243,968)** | **$ (213,016)** | **$ (179,992)** | **$ (144,756)** | **$ (107,160)** | **$ (67,046)** | **$ -** |
| | **Non-Taxable Non-Operating Income / (Expense)** | | | | | | | | | | | | |
| GoTo | Undefined Grant 2 (year 0, no tax) | N/A | 100% | $ - | | | | | | | | | |
| GoTo | Undefined Grant 4 (year 1, no tax) | N/A | 100% | | $ - | | | | | | | | |
| GoTo | ITC Grant (year 1, no tax) | N/A | 100% | | $ 1,828,082 | | | | | | | | |
| | InsZone | | | | | | | | | | | | |
| | **Total Non-Taxable Non-Operating Income / (Expense)** | | | **$ -** | **$ 1,828,082** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | **Depreciation** | | | | | | | | | | | | |
| GoTo | MACRS Depreciation | N/A | N/A | $ - | $ (2,930,088) | $ (1,195,954) | $ (854,253) | $ (610,181) | $ (508,484) | $ (508,484) | $ (508,484) | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Depreciation** | | | **$ -** | **$ (2,930,088)** | **$ (1,195,954)** | **$ (854,253)** | **$ (610,181)** | **$ (508,484)** | **$ (508,484)** | **$ (508,484)** | **$ -** | **$ -** |
| | InsZone | | | | | | | | | | | | |
| | **Pre-Tax Income / (Loss)** | | | **$ (352,322)** | **$ 859,279** | **$(1,167,674)** | **$ (930,945)** | **$ (488,765)** | **$ (359,636)** | **$ (344,928)** | **$ (320,865)** | **$ 227,704** | **$ 374,281** |
| | **Pre-Tax Return on Investment** *(ROI)* | | | **16.90** | | | | | | | | | |
| | **Pre-Tax Return on Investment Percent** | | | **-5.2%** | **55.9%** | **0.4%** | **-1.1%** | **1.8%** | **2.2%** | **2.4%** | **2.8%** | **3.4%** | **5.5%** |
| | **Pre-Tax Return on Equity** *(ROE)* | | | **1.54** | | | | | | | | | |
| | **Pre-Tax Return on Equity Percent** | | | **-20.8%** | **223.8%** | **1.7%** | **-4.5%** | **7.2%** | **8.8%** | **9.7%** | **11.1%** | **13.4%** | **22.1%** |
| | **Debt Service Coverage Ratio** *(DSCR)* | **(0.10)** | | **(0.04)** | **1.64** | **(1.27)** | **(0.97)** | **(0.39)** | **(0.25)** | **(0.28)** | **(0.30)** | **0.42** | **-** |
| | **Beginning Members Equity** | | | **$ -** | **$ 1,341,232** | **$ 2,200,511** | **$ 1,032,838** | **$ 101,893** | **$ (386,872)** | **$ (746,508)** | **$ (1,091,436)** | **$ (1,412,301)** | **$ 2,381,265** |
| | Contributed Equity | | | $ 1,693,554 | | | | | | | | | |
| | Plus Pre-Tax Income / (Loss) | | | $ (352,322) | $ 859,279 | $ (1,167,674) | $ (930,945) | $ (488,765) | $ (359,636) | $ (344,928) | $ (320,865) | $ 227,704 | $ 374,281 |
| | Less Minimum Distribution for Tax Liability | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | Less Profit Distribution | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Ending Members Equity** | | | **$ 1,341,232** | **$ 2,200,511** | **$ 1,032,838** | **$ 101,893** | **$ (386,872)** | **$ (746,508)** | **$ (1,091,436)** | **$ (1,412,301)** | **$ (1,184,597)** | **$ 2,755,547** |

| | | Inflation Rate | What If? | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Tax Credits Available** | | | | | | | | | | | | |
| | **Federal Tax Credits Available** | | | | | | | | | | | | |
| GoTo | Full Federal Production Tax Credit | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Half Federal Production Tax Credit | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Investment Tax Credit | | | | $ - | | | | | | | | |
| | InsZone | | | | | | | | | | | | |
| | **Total Federal Tax Credits Available** | | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | **Oregon Tax Credits Available** | | | | | | | | | | | | |
| GoTo | BETC - Retained | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | OR Biomass Tax Credit | | | | $ 457,950 | $ 457,950 | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Oregon Tax Credits Available** | | | **$ -** | **$ 457,950** | **$ 457,950** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | InsZone | | | | | | | | | | | | |
| | **Total Tax Credits Available** | | | **$ -** | **$ 457,950** | **$ 457,950** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | **Projected Pass-Through LLC Income Tax Liability** *(FYI Purposes Only)* | | | | | | | | | | | | |
| | **Taxable Pre-Tax Income / (Loss)** | | | **$ (352,322)** | **$ (968,802)** | **$ (1,167,674)** | **$ (930,945)** | **$ (488,765)** | **$ (359,636)** | **$ (344,928)** | **$ (320,865)** | **$ 227,704** | **$ 374,281** |
| | **Projected Federal Tax** | | | | | | | | | | | | |
| Client | Effective Federal Tax Rate | | 32.0% | | | | | | | | | | |
| | Federal Tax | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ (72,865) | $ (119,770) |
| | If income is less than zero then the Federal Tax is set to zero | | | | | | | | | | | | |
| | Federal Tax Credits Available | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Projected Federal Tax** | | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ (72,865)** | **$ (119,770)** |
| | If there is no tax liability, any positive balance is zeroed out | | | | | | | | | | | | |
| | **Projected Oregon Tax** | | | | | | | | | | | | |
| Client | Effective Oregon Tax Rate | | 9.0% | | | | | | | | | | |
| | Oregon Tax | | | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ (20,493) | $ (33,685) |
| | If income is less than zero then the Oregon Tax is set to zero | | | | | | | | | | | | |
| | Oregon Tax Credits Available | | | $ - | $ 457,950 | $ 457,950 | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | | |
| | **Total Projected Oregon Tax** | | | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ (20,493)** | **$ (33,685)** |
| | If there is no tax liability, any positive balance is zeroed out | | | | | | | | | | | | |
| | InsZone | | | | | | | | | | | | |
| | **Post-Tax Income / (Loss)** | | | **$ (352,322)** | **$ 859,279** | **$(1,167,674)** | **$ (930,945)** | **$ (488,765)** | **$ (359,636)** | **$ (344,928)** | **$ (320,865)** | **$ 134,345** | **$ 220,826** |
| | **Post-Tax Return on Investment** *(ROI)* | | | **21+** | | | | | | | | | |
| | **Post-Tax Return on Investment Percent** | | | **-5.2%** | **55.9%** | **0.4%** | **-1.1%** | **1.8%** | **2.2%** | **2.4%** | **2.8%** | **2.0%** | **3.3%** |
| | **Post-Tax Return on Equity** *(ROE)* | | | **1.54** | | | | | | | | | |
| | **Post-Tax Return on Equity Percent** | | | **-20.8%** | **223.8%** | **1.7%** | **-4.5%** | **7.2%** | **8.8%** | **9.7%** | **11.1%** | **7.9%** | **13.0%** |

## Projected Cash Flow Statement

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**
**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**
**RNG: 0 MCF/Hour**
**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**
***Version: 10/4/2009***

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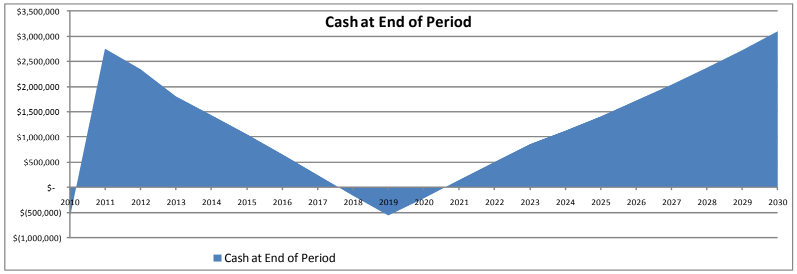
| | | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 9<br>2019 | 10<br>2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GoTo | **Pre-Tax Income / (Loss)** | **$ (352,322)** | **$ 859,279** | **$ (1,167,674)** | **$ (930,945)** | **$ (488,765)** | **$ (359,636)** | **$ (344,928)** | **$ (320,865)** | **$ 227,704** | **$ 288,354** | **$ 338,647** |
| | **Operating Activities** | | | | | | | | | | | |
| GoTo | MACRS Depreciation | $ - | $ 2,930,088 | $ 1,195,954 | $ 854,253 | $ 610,181 | $ 508,484 | $ 508,484 | $ 508,484 | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | |
| | **Net Cash Flow from Operations** | **$ (352,322)** | **$ 3,789,368** | **$ 28,281** | **$ (76,692)** | **$ 121,416** | **$ 148,848** | **$ 163,557** | **$ 187,619** | **$ 227,704** | **$ 288,354** | **$ 338,647** |
| | **Investing Activities** | | | | | | | | | | | |
| GoTo | Capital Expenditures | $ (6,774,218) | | | | | | | | | | |
| GoTo | Member Equity | $ 1,693,554 | | | | | | | | | | |
| | Member Minimum Distribution for Tax Liability | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | Member Profit Distribution | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | |
| | **Net Cash Flow from Investing** | **$ (5,080,663)** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | **Financing Activities** | | | | | | | | | | | |
| GoTo | SELP or Bank | $ 5,182,276 | | | | | | | | | | |
| GoTo | Undefined Loan 2 | $ - | | | | | | | | | | |
| GoTo | Undefined Interest Only Loan 3 | $ - | | | | | | | | | | |
| GoTo | SELP or Bank Principle Repayment | $ (380,479) | $ (405,960) | $ (433,148) | $ (462,157) | $ (493,108) | $ (526,133) | $ (561,369) | $ (598,965) | $ (639,079) | $ (681,879) | $ - |
| GoTo | Undefined Loan 2 Principle Repayment | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Undefined Interest Only Loan 3 Principle Repayment | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | | |
| | **Net Cash Flow from Financing** | **$ 4,801,798** | **$ (405,960)** | **$ (433,148)** | **$ (462,157)** | **$ (493,108)** | **$ (526,133)** | **$ (561,369)** | **$ (598,965)** | **$ (639,079)** | **$ (681,879)** | **$ -** |
| | **Net Increase / (Decrease) in Cash and Cash Equivalents** | **$ (631,188)** | **$ 3,383,407** | **$ (404,867)** | **$ (538,848)** | **$ (371,692)** | **$ (377,285)** | **$ (397,812)** | **$ (411,346)** | **$ (411,375)** | **$ (393,525)** | **$ 338,647** |
| | **Cash at Beginning of Period** | **$ -** | **$ (631,188)** | **$ 2,752,219** | **$ 2,347,352** | **$ 1,808,504** | **$ 1,436,811** | **$ 1,059,526** | **$ 661,714** | **$ 250,368** | **$ (161,007)** | **$ (554,532)** |
| | **Cash at End of Period** | **$ (631,188)** | **$ 2,752,219** | **$ 2,347,352** | **$ 1,808,504** | **$ 1,436,811** | **$ 1,059,526** | **$ 661,714** | **$ 250,368** | **$ (161,007)** | **$ (554,532)** | **$ (215,885)** |

| | | 11<br>2021 | 12<br>2022 | 13<br>2023 | 14<br>2024 | 15<br>2025 | 16<br>2026 | 17<br>2027 | 18<br>2028 | 19<br>2029 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GoTo | **Pre-Tax Income / (Loss)** | **$ 364,595** | **$ 356,144** | **$ 354,728** | **$ 267,290** | **$ 282,797** | **$ 314,694** | **$ 314,343** | **$ 336,737** | **$ 347,533** | **$ 374,281** |
| | **Operating Activities** | | | | | | | | | | |
| GoTo | MACRS Depreciation | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | |
| | **Net Cash Flow from Operations** | **$ 364,595** | **$ 356,144** | **$ 354,728** | **$ 267,290** | **$ 282,797** | **$ 314,694** | **$ 314,343** | **$ 336,737** | **$ 347,533** | **$ 374,281** |
| | **Investing Activities** | | | | | | | | | | |
| GoTo | Capital Expenditures | | | | | | | | | | |
| GoTo | Member Equity | | | | | | | | | | |
| | Member Minimum Distribution for Tax Liability | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | Member Profit Distribution | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | |
| | **Net Cash Flow from Investing** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | **Financing Activities** | | | | | | | | | | |
| GoTo | SELP or Bank | | | | | | | | | | |
| GoTo | Undefined Loan 2 | | | | | | | | | | |
| GoTo | Undefined Interest Only Loan 3 | | | | | | | | | | |
| GoTo | SELP or Bank Principle Repayment | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Undefined Loan 2 Principle Repayment | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| GoTo | Undefined Interest Only Loan 3 Principle Repayment | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| | InsZone | | | | | | | | | | |
| | **Net Cash Flow from Financing** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** | **$ -** |
| | **Net Increase / (Decrease) in Cash and Cash Equivalents** | **$ 364,595** | **$ 356,144** | **$ 354,728** | **$ 267,290** | **$ 282,797** | **$ 314,694** | **$ 314,343** | **$ 336,737** | **$ 347,533** | **$ 374,281** |
| | **Cash at Beginning of Period** | **$ (215,885)** | **$ 148,710** | **$ 504,854** | **$ 859,582** | **$ 1,126,872** | **$ 1,409,670** | **$ 1,724,364** | **$ 2,038,707** | **$ 2,375,444** | **$ 2,722,977** |
| | **Cash at End of Period** | **$ 148,710** | **$ 504,854** | **$ 859,582** | **$ 1,126,872** | **$ 1,409,670** | **$ 1,724,364** | **$ 2,038,707** | **$ 2,375,444** | **$ 2,722,977** | **$ 3,097,258** |

| | |
|---|---|
| **Net Present Value** *(NPV)* | **$ 691,043** |
| *Discount Rate* | 5.0% |
| **Internal Rate of Return** *(IRR)* | **7.6%** |
| *Guess* | 10.00% If the result is #NUM!, then adjust the guess value |



## Projected Balance Sheet

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis
CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity
RNG: 0 MCF/Hour
Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%
*Version: 10/4/2009*

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| | 0<br>2010 | 1<br>2011 | 2<br>2012 | 3<br>2013 | 4<br>2014 | 5<br>2015 | 6<br>2016 | 7<br>2017 | 8<br>2018 | 20<br>2030 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Assets** | | | | | | | | | | |
| **Current Assets** | | | | | | | | | | |
| Cash and Cash Equivalents | $ (631,188) | $ 2,752,219 | $ 2,347,352 | $ 1,808,504 | $ 1,436,811 | $ 1,059,526 | $ 661,714 | $ 250,368 | $ (161,007) | $ 3,097,258 |
| InsZone | | | | | | | | | | |
| **Total Current Assets** | **$ (631,188)** | **$ 2,752,219** | **$ 2,347,352** | **$ 1,808,504** | **$ 1,436,811** | **$ 1,059,526** | **$ 661,714** | **$ 250,368** | **$ (161,007)** | **$ 3,097,258** |
| **Fixed Assets** | | | | | | | | | | |
| Original Capital Expenditure Value | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 | $ 6,774,218 |
| MACRS Depreciation | $ - | $ 2,930,088 | $ 1,195,954 | $ 854,253 | $ 610,181 | $ 508,484 | $ 508,484 | $ 508,484 | $ - | $ - |
| Accumulated Depreciation | $ - | $ 2,930,088 | $ 4,126,043 | $ 4,980,296 | $ 5,590,477 | $ 6,098,961 | $ 6,607,445 | $ 7,115,929 | $ 7,115,929 | $ 7,115,929 |
| InsZone | | | | | | | | | | |
| **Total Fixed Assets** | **$ 6,774,218** | **$ 3,844,129** | **$ 2,648,175** | **$ 1,793,922** | **$ 1,183,741** | **$ 675,257** | **$ 166,773** | **$ (341,711)** | **$ (341,711)** | **$ (341,711)** |
| InsZone | | | | | | | | | | |
| **Total Assets** | **$ 6,143,030** | **$ 6,596,349** | **$ 4,995,527** | **$ 3,602,425** | **$ 2,620,552** | **$ 1,734,783** | **$ 828,487** | **$ (91,343)** | **$ (502,718)** | **$ 2,755,547** |
| **Liabilities and Equity** | | | | | | | | | | |
| **Long Term Liabilities** | | | | | | | | | | |
| SELP or Bank Principle Balance | $ 4,801,798 | $ 4,395,837 | $ 3,962,689 | $ 3,500,532 | $ 3,007,424 | $ 2,481,291 | $ 1,919,922 | $ 1,320,957 | $ 681,879 | $ - |
| Undefined Loan 2 Principle Balance | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| Undefined Interest Only Loan 3 Principle Balance | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| InsZone | | | | | | | | | | |
| **Total Long Term Liabilities** | **$ 4,801,798** | **$ 4,395,837** | **$ 3,962,689** | **$ 3,500,532** | **$ 3,007,424** | **$ 2,481,291** | **$ 1,919,922** | **$ 1,320,957** | **$ 681,879** | **$ -** |
| **Equity** | | | | | | | | | | |
| Members Equity | $ 1,341,232 | $ 2,200,511 | $ 1,032,838 | $ 101,893 | $ (386,872) | $ (746,508) | $ (1,091,436) | $ (1,412,301) | $ (1,184,597) | $ 2,755,547 |
| InsZone | | | | | | | | | | |
| **Total Equity** | **$ 1,341,232** | **$ 2,200,511** | **$ 1,032,838** | **$ 101,893** | **$ (386,872)** | **$ (746,508)** | **$ (1,091,436)** | **$ (1,412,301)** | **$ (1,184,597)** | **$ 2,755,547** |
| InsZone | | | | | | | | | | |
| **Total Liabilities and Equity** | **$ 6,143,030** | **$ 6,596,349** | **$ 4,995,527** | **$ 3,602,425** | **$ 2,620,552** | **$ 1,734,783** | **$ 828,487** | **$ (91,343)** | **$ (502,718)** | **$ 2,755,547** |
| *Assets = Liabilities and Equity Checksum* | *$ -* | *$ -* | *$ -* | *$ -* | *$ -* | *$ -* | *$ 0* | *$ 0* | *$ 0* | *$ (0)* |

## Summary Stats

**EC Oregon - AD Financial Feasibility Model v2.3**

**Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush**

**Confidential and Proprietary!**

Scenario: **AD: 276.4 Wet Tons/Day, 29.6 VS Tons/Day, 10.3 MCF/Hour Methane at 95.9% Capacity VS Basis**

**CHP: Generating 1,139 kWh, 9,707,916 Annual kWh at 73.4% Capacity**

**RNG: 0 MCF/Hour**

**Financial: Pre-Tax ROI = 16.9, Pre-Tax ROE = 1.5, NPV = $691,043 at 5% disc, IRR = 7.6%**

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### Investment Dollars

| | | | | | |
|---|---|---|---|---|---|
| Total Investment Cost | $ | 6,774,218 | Total Investment Cost | $ | 6,774,218 |
| Estimated Net CHP Capacity | | 1,139 | Herd Size | | 1,975 |
| **Investment Dollars / kW** | **$** | **5,945** | **Investment Dollars / Animal** | **$** | **3,430** |

### Revenue, Expenses and Net Income

| | | | | | |
|---|---|---|---|---|---|
| Year 1 Baseline Revenue & Opportunity Costs | $ | 652,167 | Year 1 Baseline Revenue & Opportunity Costs | $ | 652,167 |
| Feedstock Wet Tons / Year Utilized | | 100,890 | CHP Operating Hours / Year | | 8,520 |
| **Revenue / Wet Ton** | **$** | **6.46** | **Revenue / Operating Hour** | **$** | **76.55** |
| Year 1 Baseline Expenses | $ | (511,755) | Year 1 Baseline Expenses | $ | (511,755) |
| Feedstock Wet Tons / Year Utilized | | 100,890 | CHP Operating Hours / Year | | 8,520 |
| **Expenses / Wet Ton** | **$** | **(5.07)** | **Expenses / Operating Hour** | **$** | **(60.07)** |
| Year 1 Baseline Net Income | $ | 140,412 | Year 1 Baseline Net Income | $ | 140,412 |
| Feedstock Wet Tons / Year Utilized | | 100,890 | CHP Operating Hours / Year | | 8,520 |
| **Net Income / Wet Ton** | **$** | **1.39** | **Net Income / Operating Hour** | **$** | **16.48** |

## SENSITIVITY ANALYSIS

The following table is provided as an estimate of the feedstock mixture if annual ryegrass straw is replaced with additional manure. Note that overall methane production decreases due to the lower relative energy value of manure versus straw. Also note that manure and straw methane yields have been reduced by 8% due to decreased residence time in the digesters.

**Table 18 Feedstock regime at permitted capacity**
**(EC Oregon, 2009)**

Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush - 10/4/2009

| Feedstock | Annual Used | Used Daily | Total Solids (TS) *(as is basis)* | Volatile Solids (VS) of Total Solids | Methane Yield | Methane Production |
|---|---|---|---|---|---|---|
| | *US Tons / Year* | *US Tons / Day* | | | *$m^3$ $CH_4$ / kg VS* | *Mcf / Day* |
| Manure | 141,210 | 387 | 6.5% | 68.6% | 0.166 | 91.52 |
| Dilution Water | - | - | 4.5% | - | - | - |
| Annual Rye Grass Straw | 4,600 | 13 | 90.0% | 94.0% | 0.263 | 89.86 |
| FOG / GTW | 2,000 | 5 | 30.0% | 90.0% | 0.572 | 27.12 |
| **Total** | **147,810** | **405** | **9.4%** | **77.1%** | **0.221** | **208.50** |

The following table shows what the feedstock mixture if annual ryegrass straw is replaced with additional food processor residue. It is assumed the amount sourced will not change so long as processing residue does not incur a cost. Therefore, the table shows the mixture for both food process residues for free and with a tipping fee.

**Table 19 Feedstock regime with increased food processor residue**
**(EC Oregon, 2009)**

Volbeda Dairy - Scenario = Complete Mix, Co-digestion and Flush - 10/4/2009

| Feedstock | Annual Used | Used Daily | Total Solids (TS) *(as is basis)* | Volatile Solids (VS) of Total Solids | Methane Yield | Methane Production |
|---|---|---|---|---|---|---|
| | *US Tons / Year* | *US Tons / Day* | | | *$m^3$ $CH_4$ / kg VS* | *Mcf / Day* |
| Flushed/Thickened Manure | 91,590 | 251 | 6.5% | 68.6% | 0.180 | 64.53 |
| Dilution Water | - | - | 4.5% | - | - | - |
| Annual Rye Grass Straw | 3,500 | 10 | 90.0% | 94.0% | 0.286 | 74.31 |
| FOG / GTW | 2,000 | 5 | 30.0% | 90.0% | 0.572 | 27.12 |
| Food Processor Residue | 12,500 | 34 | 30.0% | 85.0% | 0.355 | 99.29 |
| **Total** | **109,590** | **300** | **12.3%** | **80.1%** | **0.281** | **265.25** |

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## Glossary

| | | |
|---|---|---|
| ACDP | - | Air Contaminant Discharge Permit |
| ACP | - | Anaerobic Contact Process |
| AD | - | Anaerobic Digestion |
| AGF | - | Anoxic Gas Flotation |
| ARS | - | Annual Ryegrass Straw |
| AWM | - | Animal Waste Management (Oregon) |
| BETC | - | Oregon Business Energy Tax Credit |
| BMP | - | Biochemical Methane Potential |
| BOD | - | Biological Oxygen Demand |
| Btu | - | British Thermal Unit |
| C:N | - | Carbon to Nitrogen ratio |
| CBM | - | Compressed Biomethane |
| $CH_4$ | - | Methane |
| CHP | - | Combined Heat and Power |
| CNG | - | Compressed Natural Gas |
| $CO_2$ | - | Carbon Dioxide |
| COD | - | Chemical Oxygen Demand |
| CSTR | - | Continuous Stirred Tank Reactor |
| DEQ | - | Oregon Department of Environmental Quality |
| DWW | - | Water Scrubbing Under Pressure |
| ESCP | - | Erosion and Sediment Control Plan |
| EU | - | European Union |
| FOG | - | Fats, Oils and Grease |
| g | - | gram |
| g/kg | - | gram per kilogram |
| gpm | - | gallons per minute |
| GTW | - | Grease Trap Waste |
| $H_2O$ | - | Water |
| $H_2S$ | - | Hydrogen Sulfide |
| HRT | - | Hydraulic Retention Time |
| IBR | - | Induced Blanket Reactor |
| $IC_{50}$ | - | Inhibitory Concentrations equivalent to 50% decrease in methane production rate |
| IRR | - | Internal rate of return |
| kg | - | kilogram |
| kW | - | kilowatt |
| kWh | - | kilowatt hour |
| L | - | Liter |
| LBM | - | Liquefied Biomethane |
| LUCS | - | Land Use Compatibility Statement |
| MC | - | Moisture Content |
| Mcf | - | thousand cubic feet |
| MFW | - | Municipal Food Waste |
| mg/L | - | milligram per liter |
| MMbtu | - | Million Btu |
| MW | - | Mega Watt |

| | | |
|---|---|---|
| MWh | - | Mega Watt hour |
| NLCD | - | National Land Coverage Data |
| NPDES | - | National Pollution Discharge Elimination |
| O&M | - | Operations and Maintenance |
| OLR | - | Organic Loading Rate |
| pH | - | Measure of acidity or alkalinity |
| PL | - | Poultry Litter |
| ppm | - | parts per million |
| PSA | - | Pressure Swing Absorption |
| PTC | - | Renewable Electricity Production Tax Credit |
| REAP | - | Rural Energy for America Program |
| REC | - | Renewable Energy Certificates |
| RFI | - | Request for Information |
| RNG | - | Renewable Natural Gas |
| RO | - | Reverse Osmosis |
| ROE | - | Return on Equity |
| ROI | - | Return on Investment |
| SBR | - | Sequencing Batch Reactor |
| scf | - | standard cubic feet |
| SELP | - | Small Scale Energy Loan Program |
| SIC | - | Standard Industrial Classification |
| SRM | - | Specified Risk Material |
| SRT | - | Solids Residence Time |
| Ton | - | (U.S) 2,000 pounds |
| tonne | - | metric ton |
| tpd | - | tons/day |
| tpy | - | tons/year |
| TRCs | - | Tradable Renewable Certificates |
| TS | - | Total Solids |
| UASB | - | Upflow Anaerobic Sludge Blanket |
| UF | - | Ultrafiltration |
| USD | - | United States dollar |
| USDA | - | United States Department of Agriculture |
| USGS | - | U.S. Geological Survey |
| VAPG | - | Value Added Producer Grant |
| VER | - | Verifiable Emission Reductions |
| VS | - | Volatile Solids |
| WPCF | - | Water Pollution Control Facility |