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## APPENDICES

# 1 SUMMARY

The proposed Sandoval County Wholesale Water Treatment Plant requires a considerable amount of energy in the form of gas, heat, and electrical power. The water treatment plant has a 4.25 MW anticipated electricity requirement. Continuous plant operation requires that 4.25 MW as baseload. In addition to electricity, drying heat, steam, or adsorptive chilling are required in the treatment process.

1. Variable renewable energy sources like solar and wind are not well matched to the electricity demand.
2. Combustive energy generation is well matched to the plant's demand profile, as are other types of baseload renewable energy like hydropower and geothermal.
3. Reclaimed heat is useful in adsorptive chillers for dehydrating and other uses.
4. Assuming positive financial analyses, solar energy could be used to supplement combustive generation during daylight hours.

The County faces several choices in meeting these energy requirements:

- ***Option 1 – Existing Utility Services***: The County could obtain electric and natural gas service from the local utility (PNM) Public Services of New Mexico. The site is undeveloped and has no utility services. Utility services that could be extended to the site include:
    1. Public Service Company of New Mexico operates a regional 345 kV electrical transmission line in the general site vicinity. A 34.8 kV substation is located approximately 4.7 miles NNE of the site, and the plant has a no-cost easement along the access road. Preliminary cost estimates indicate that a 4.7-mile transmission line, a secondary substation, and other connecting equipment could be installed for about $0.75 to $1.0 million.
    2. New Mexico Gas Company has a 4"Ø, 750 $lb/in^2$ secondary pipeline passing near the site. A connection could be made at an existing blowdown approximately 5.5 miles NE of the site. Preliminary cost estimates indicate a 3" Ø, 150 $lb/in^2$ line to the site could be installed for between $330,000 and $400,000.
- ***Option 2 – Combined Heat & Power***: The County could acquire natural gas only from PNM and produce their own electrical power. The plant's combined energy requirements include electricity, heat, and adsorptive chilling suggests that a combined heat and power (CHP) system could be efficient. We evaluated the potential advantages of connecting only the gas utility and meeting all treatment plant demand with a 3.0 MW CHP system. The recovered heat, avoids other energy costs and cuts the plant-wide average energy cost by $800,000 when compared with grid electricity.
- ***Option 3 – Alternative Renewable Energy:*** The County could produce their own gas using an agricultural based energy crop anerobically digested to create biogas. This source of gas would then be utilized to operate a combined heat and power (CHP) energy plant.
- ***Option 4 – 250 MW Gas Fired Power Plant:*** The County has been approached by Native Energy Development, LLC, a Navajo tribal enterprise to co-locate a gas fired power plant with the proposed water plant. The County would purchase power directly from the power plant and benefit from free heat. The water plant would provide water for cooling and injection. It is assumed that softened high T.D.S. water may be used for this purpose using evaporative cooling systems. An algae production system would be included to benefit both facilities with the algae being gasified to supplement the power plant. Additionally, this co-located endeavor could lead to other synergies such as dual permitted wells that would produce both gas and water.

The following table summarizes the financial impact of each of these options on the water treatment plant project.

**Table 1-3**
**Financial Impact of Options on Water Treatment Project**

| Option | Equivalent Cost of Energy | |
|---|---|---|
| | Gas ($MMBTU) | Electricity ($/kW – Hr) |
| 1. Existing Utility | $5 | $0.06 |
| 2. CHP | $6 | N/A |
| 3. Biogas Renewable Energy | $5 | $0.06* |
| 4. Gas Fired Power Plant | N/A | $0.04 |

** Assuming $0.01 Renewable Energy Credit*

The following table illustrates the aggregate annual energy cost for each option.

**Table 1-4**
**Annual Cost of Energy Options**

| Option | Annual |
|---|---|
| 1. Existing Utility | $3,300,000 |
| 2. CHP | $2,500,000 |
| 3. Biogas Renewable Energy | $3,800,000 |
| 4. Gas Fired Power Plant | $1,500,000 |

Option No. 4 is the clear choice for an energy option for this project. It is, however, subject to the successful development and implementation of an aggressive permitting and construction schedule. As a result, alternative plans should be made to implement in the short-term Option No. 2 followed by the long-term plan to convert to the renewable Option No. 3.

If this power project failed to materialize in a timely manner the County could fall back to Option No. 2 CHP choosing to negotiate for the purchase of natural gas from either PNM or Native Energy Development, LLC. If Option No. 2 is activated as a result of the gas fired power plant not materializing, the County must be aware of the unpredictable nature of gas pricing. As a long-term plan any CHP energy alternative should include future use of renewable biogas production on-site.

Sandoval County, New Mexico recently authorized the completion of a “preliminary engineering report “ (PER). The purpose of this report is to provide a comprehensive evaluation of the County’s proposal to develop a wholesale water utility. This report includes an evaluation of various issues facing the County and presents a recommended action plan. The plan provides a review of previous groundwater supply development efforts, a description of the selected water treatment process, a summary of pilot testing confirming these processes, and a financial analysis of the recommended project.

The proposed wholesale water supply utility will extract brackish groundwater and treat it to drinking water standards using a desalination water treatment process. The design criteria to be used in implementing this effort is presented within this report. All of the design criteria has been developed to comply with the U.S. Safe Drinking Water Act administered by the U.S. Environmental Protection Agency (USEPA) together with the regulations and policy of the New Mexico Environmental Department (NMED).

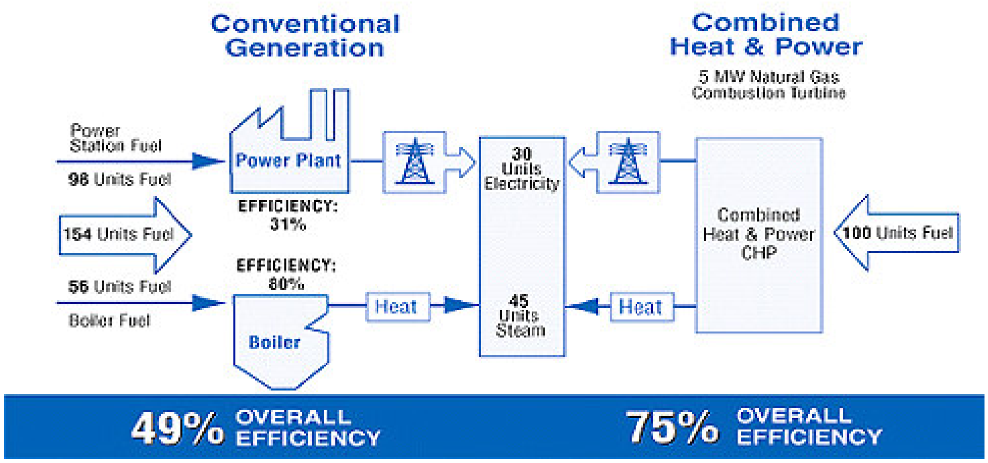
The primary motivation of the County in initiating this project is to foster the economic growth of the County. In pursuing the development of a new potable water supply within the County it is recognized that with the addition of new industrial and commercial enterprises there will also be an increase in housing. It should be noted, however, that the overriding focus is to create more employment opportunities within Sandoval County. To this end, this water project has been positioned not only as a support to future economic development; but, also as an economic development catalyst. Where possible this project seeks to reduce waste plant residuals by converting them into marketable products. In the course of this effort the water treatment process itself creates ancillary enterprises and additional employment opportunities.

# 2 COMBINED COOLING, HEATING, & POWER (CHP)

## 2.1 Overview

Tri-generation or Combined Cooling, Heat and Power is defined as *simultaneous* generation of electrical and thermal energy (heating and cooling) *on-site* from a single fuel source. The installation of a Tri-generation system designed to meet the *thermal* and *electrical* loads of a facility can greatly increase the facility's operational efficiency and decrease energy costs. Tri-generation also reduces the emission of greenhouse gases, which contribute to global climate change.

Source:
*US EPA CHP Partnership Program – Combined Heat & Power (CHP) Diagram:*




In this example of a typical CHP system, to produce 75 units of useful energy, the conventional generation or separate heat and power systems (SHP) use 154 units of energy - 98 for electricity production and 56 to produce heat - resulting in an overall efficiency of 49 percent. However, the CHP system needs only 100 units of energy to produce the 75 units of useful energy from a single fuel source, resulting in a total system efficiency of 75 percent.

A CHP system's efficiency depends on the technology used to generate the electricity and thermal energy, the system design, and how much of the thermal energy is used by the site. Therefore, every CHP system will have a different, site-specific efficiency once installed. However, the six most commonly installed CHP prime movers tend to offer fairly standard ranges of achievable efficiency as follows:

| | |
|---|---|
| Steam Turbine: | 80 percent |
| Diesel Engine: | 70 - 80 percent |
| Natural Gas Engine: | 70 - 80 percent |
| Gas Turbine: | 70 - 75 percent |
| Micro-turbine: | 65 - 75 percent |
| Fuel Cell: | 65 - 80 percent |

Essentially a combined heat and power scenario can be applied to any of the following energy alternatives:

***Option 4*** – A co-located power plant where electricity is provided to the water plant at low rates and waste heat is provided for free. This CHP method lowers the annual cost of electricity and eliminates the need for natural gas.

***Option 2*** – An on-site natural gas fired co-generation plant where only gas is purchased annually to produce electricity and heat for the use of the water plant. This plan increases annual gas cost but eliminates the need to purchase electricity.

***Option 3*** – An on-site biogas plant is a renewable option to that of a natural gas fired co-gen system. It is likely that a biogas plant would be a future project gradually replacing the water plant's reliance on natural gas.

All of the above CHP options yield the potential carbon offsets and future carbon credits. The value of these items have not been accounted for in the project pro forma.

It is recommended that the County proceed with Option 4 as the most cost effective. A back-up plan would be in the form of Option No. 2 with a long-range plan of implementing Option No. 4 as a renewable alternative.

It should be noted that all CHP alternatives allow for the provision of solar PV or contracted solar arrays to supplement electricity production. Because, however, since solar is considered an intermittent power source, it will only be considered as a component of a solar/CHP hybrid system. This provides a fully dispatchable high quality power source.

The exploitation of renewable power sources will focus on the implementation of a biogas system. The implementation of such a system is further described in this appendix.

# 3 BIOGAS ENERGY INTEGRATION

## *3.1 Biogas Energy*

The production of bio methane gas used to fuel electricity generation is a proven and significant renewable energy strategy that is used in Germany today. The bio methane gas generation is fueled by renewable energy derived from sweet sorghum forage silage crops. The fuel crops used are genetically selected but naturally occurring strains that are specifically grown for the purpose of optimizing bio methane gas production. These silage crops are then fermented in an anaerobic bio digestion process to create methane gas. The methane gas is then burned in an internal combustion engine to generate electricity.

In addition to the electric energy, this process generates several by-products consisting of waste heat, liquid containing weak fertilizer elements and fibrous “digestate” consisting of partially digested bio mass remnants of the silage crop. These residuals represent important potential revenue sources that may support the financial feasibility of the electricity generation model beyond what is currently known. Creating uses and markets for them represents an important opportunity supporting this renewable energy strategy.

This renewable energy strategy has been proven to be reliable through production in Germany over the past fifteen (15) years. There were more than 3,711 of these bio methane production plants in Germany at the end of 2007. These 3,711 biogas plants were delivering a combined total of approximately 1,300 megawatts (MW) of renewable electric energy. These 3,711 biogas plants are said to have been attributed with the creation of approximately 96,100 jobs in the renewable energy sector in Germany. It is projected that by the end of 2009, there will be as many as 5,000 of these bio methane production plants in use in Germany.

This renewable biogas electricity generation strategy is recommended to be used in conjunction with a natural gas driven electricity generator system referred to as a Combined Cooling, Heating and Power (CCHP) system. This system has an advantage over most renewable energy forms because it is capable of delivering a reliable and constant stream (not intermittent) of electricity because it can couple the use of the renewable biogas with pipeline delivered natural gas to generate electricity in order to meet the current base load operation energy demands of the Sandoval County Water Treatment Plant. One of the features of this strategy is the potential to capture and use the waste heat energy generated as a by-product of the electricity generation, for the heating and cooling of the Sandoval County water treatment facility. The efficient capture and use of this waste heat energy is unique to the Biogas renewable energy strategy.

With the adoption of renewable electric energy production, it will be necessary for Sandoval County to transmit (deliver) the electric energy into the Sandoval County Water Treatment Plant “behind the electric meter” that is supplied by the local electric utility (PNM). This can be achieved with the installation of a “paralleling switch gear” that sits between the utility company’s electric meter and the Sandoval County Water Treatment Plant electric system interface. Once this “paralleling switch gear” is installed and functioning, the adoption of other renewable electricity forms can be easily integrated as technology improvements are made and electricity rates increase thereby justifying the required investments.

**<u>Summary of Biogas Operations</u>**

Bio-methane gas production uses carefully selected, naturally occurring strains, of nonfood fuel crops as the gas generation fuel. This renewable energy strategy leverages and improves upon processes that have been successfully used in Germany for the past 15 years and it is considered a “second generation” biofuel.

The bio-methane gas produced with this renewable energy strategy is then combusted in an internal combustion engine which generates electricity. This innovative strategy can be deployed in plant sizes ranging from 500 kilowatts up to 100 megawatts of electrical energy output.

With this energy strategy, non-food fuel crops are grown specifically for the purpose of generating bio-methane gas. These fuel crops are harvested and stored as “silage” that is capable of being “banked” or stored for periods of up to two years.

With the bio-methane gas strategy, these “silaged” crops are later ingested into a huge tank called a “bio-digester” where a controlled process of anaerobic digestion occurs. The process of anaerobic digestion results in the creation of bio-methane gas, a large volume of nutrient rich liquid and a fibrous bio-digestate material left behind by the cellulosic fuel crop.

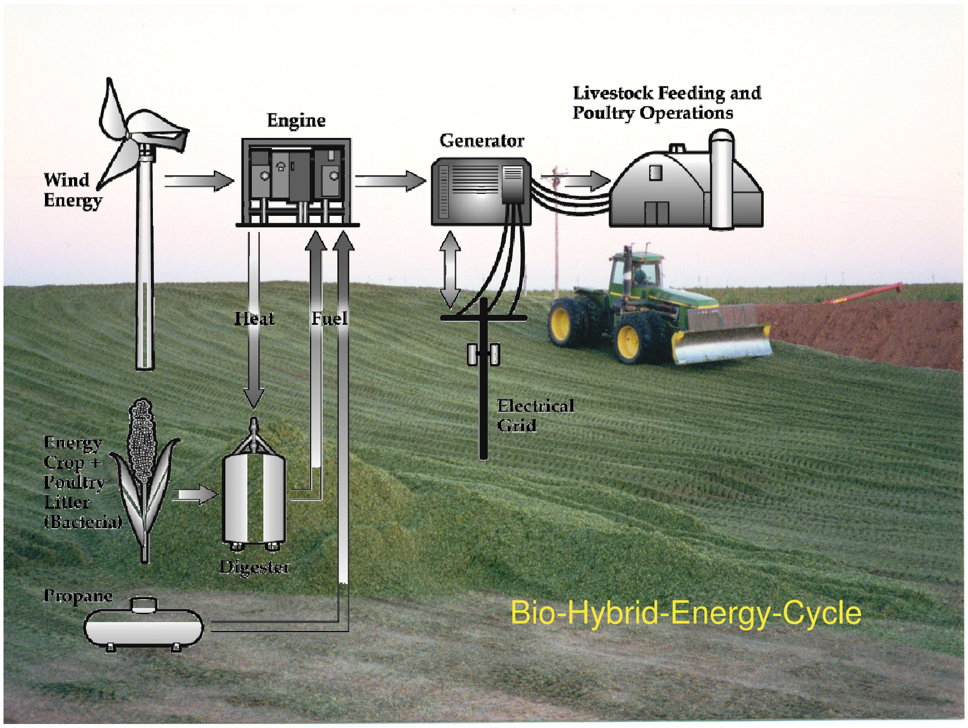
The bio-methane gas created by this energy strategy is captured, piped to an internal combustion engine and then burned as the fuel to generate electricity. A by-product of burning the bio-methane gas to generate electricity is the creation of waste heat. In an ideal application, this waste heat can be captured to use its energy for the fulfillment of other energy requirements, such as heating boilers for steam power, or for powering heaters or chilling equipment.

The large volume of liquid generated as a by-product of the bio-methane gas generation is rich in nitrogen (N), phosphorous (P), and potassium (K) and represents an important residual of the process that can be used as an organic fertilizer. As an organic fertilizer, this residual represents an asset rather than a waste stream and will generate important revenue thereby increasing the Return on Investment (ROI) for this energy strategy.

The bio-digestate material also represents an asset rather than a waste stream and can be dried to be sold as animal bedding such as that which is used in large poultry, or livestock operations. It can also be returned to the farm soil to help re-enrich the soil as a fertilizer supplement.

By locating the internal combustion engine electricity generator in close proximity to the Sandoval County Water Treatment Plant, it will be possible to efficiently capture and use the waste heat energy that is created with the electricity generation step of the process.

*Bio-Hybrid-Energy-Cycle (BHEC)*




Cellulose is the most common organic compound on Earth. Approximately thirty-three percent (33%) of all plant matter is cellulose. This abundant supply of renewable organic matter can be transformed into clean heat and electrical energy. The cultivation of specific, genetically engineered crops, that have been designed and tested to achieve and assure the consistent expression and performance of the fuel crop's required physical, structural, chemical, and yield characteristics represents the foundation of the BHEC process.

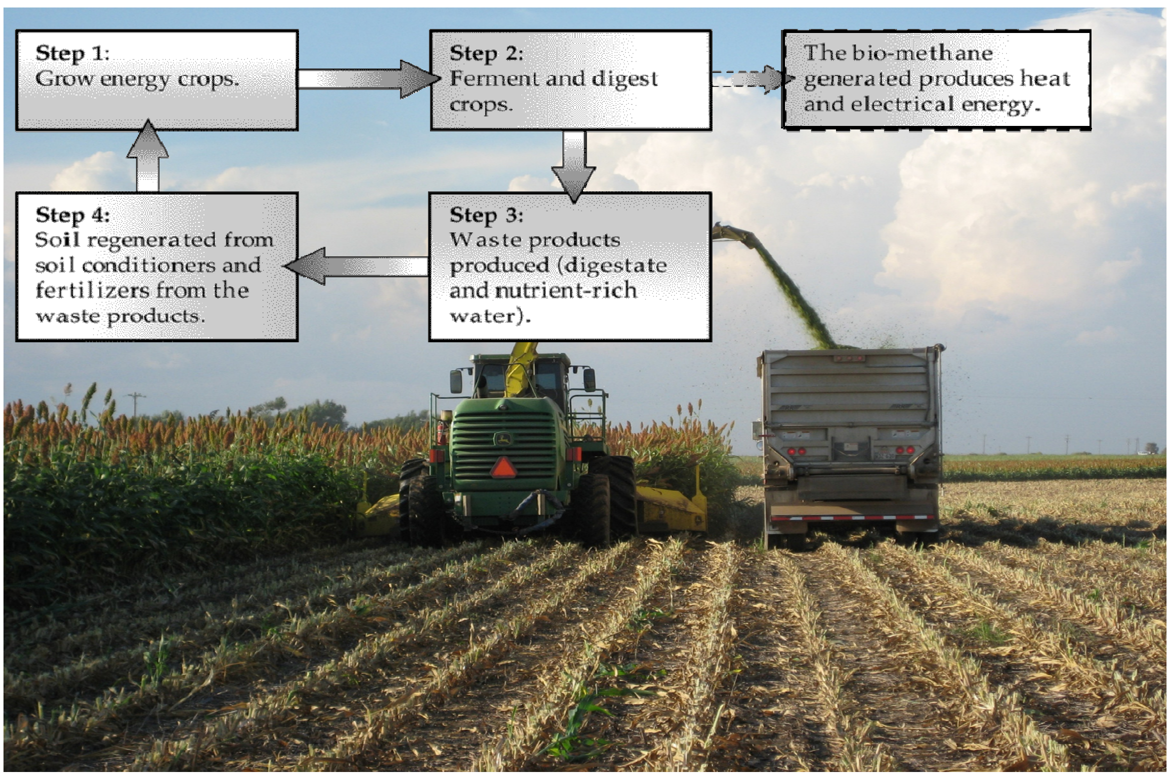
Bio-methane fuel production from dedicated energy crops has become a significant part of the overall global bio-energy production industry. Bio-methane (bio-gas) has the potential to yield more energy than any other current type of bio-fuel (e.g. bio-diesel, bio-ethanol) because a larger proportion of the biomass can be converted to energy. Bio-methane can be produced from a wide range of conventional biomass crops. Using maize, for example, typically yields between 1500 to 2000 m3 methane per hectare per year. With certain grass species yields as high as 5,000 m3 of methane per year per hectare have been reported. In the BHEC, the proven bio methane production processes have been refined to assure high yields of bio methane gas. This bio methane gas is then burned in an internal combustion engine to generate electricity.

Once the 4.25 MW plant is in full production, maintenance of the fermentation process in the biodigesters will require the ingestion of approximately ________tons of silage daily, on an ongoing basis. This will require large scale production of the forage crops. Large scale production of these special forage crops will be achieved at a scale calculated and sized to create a commercially viable, utility grade, production model. Supporting these utility grade economic models will be contractual relationships defining grower obligations that will initially be met by contractual relationships between the County and neighboring Indian Pueblos. The Jemez and Navajo Tribes have expressed an interest in providing these energy crops. The Jemez Pueblo has an area known as the Espirito Santa (Holy

Ghost) grant which is irrigated and would provide a good site for growing sorghum grass energy crop. This area is currently either non-productive or exhibits under production. The biogas production process is based upon the conversion of biomass (crops) and other organic waste streams to create clean bio methane gas used in a gaseous fuel mix for utility grade energy production systems. Optimizing the performance of the anaerobic digestion process is achieved by maintaining specific heat conditions of the biogas, digestate and water mixture in order to facilitate the digestion. The by-products of the process include organic fertilizers, soil conditioners, heat, and phosphate remediation for animal waste.

### *3.2 The "Bio-Hybrid Energy Cycle" (BHEC) - (4-Cycle Process)*

The BHEC production cycle has four stages. The four stages of the cycle are crop (fuel) growth, conversion, cogeneration, and soil regeneration. These four stages of the cycle work within the growers' normal agricultural practices. The following graphic illustrates the high level overview of the production process details.




### *3.3 The Growth Cycle*

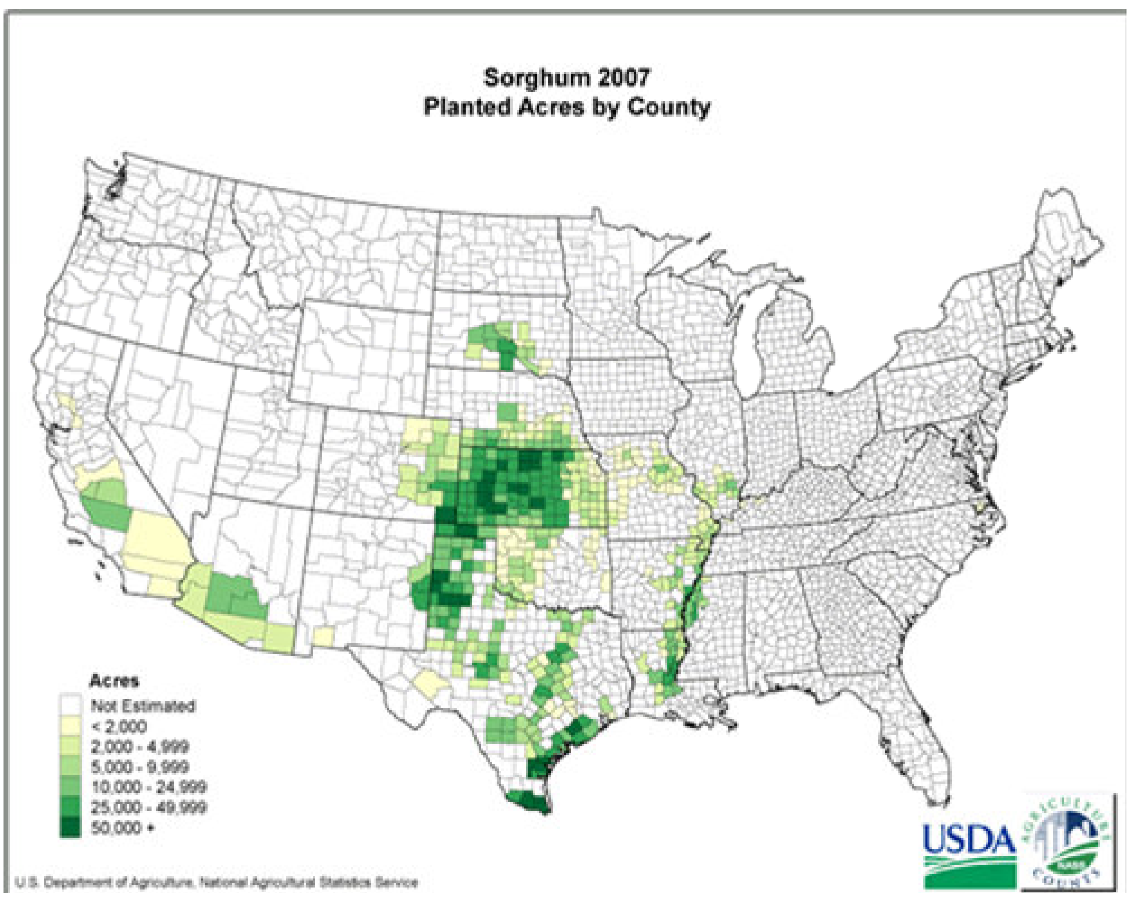
The cycle begins with the germination, planting, harvesting and conversion of carefully selected, naturally occurring genetic strains of plant structures that contain high levels of carbohydrates specifically grown for the production of biogas through cellulolysis derived from symbiotic anaerobic bacteria. The foundation of this cycle is the genetic screening and yield testing for drought hardiness and the specific soil and climate conditions of the specific plant seed that will be planted to create the crops used in the process.

The primary growing season for the sweet sorghum consists of a 75 day growing cycle that begins with planting in late April of the year.  The sorghum crop harvest is followed by a planting of a legume cover crop that is planted beginning the second or third week of September.  This cover crop is valuable for the aeration of the soil that it accomplishes as well as its potential to return high quantities of carbon and other important regenerative nutrients to the soil, thereby sustaining the viability of the soil for the continued viability of the production cycle.  This legume cover crop will also be harvested to create silage that can be “banked” or stored and later ingested by the anaerobic digester to create bio methane gas.

**Sandoval County’s BHEC Pre-Production Growth Cycle – Process Refinement Summary**

A total of 6,300 acres are planned for the support of this project.  This land will be cultivated in sweet sorghum in the spring and a possible legume cover crop can create a second planting in September for purposes of returning carbon to the soil as well as contributing to the aeration of the soil. This legume cover crop will also be harvested for silage fuel crops for the generation of bio methane.

Cultivation of the most productive fuel crops has been assured with the performance of extensive testing of genetically selected Forage Sorghum seed trials.  These trials have been conducted over the past two years and include the test planting of at least 36 specific genetic strains of seed in various soil plots across a target growing region in Texas that was considered to be a stressful growth environment.  These tests have enabled the identity of the most suitable seed variety that includes drought resistant strengths.  The results of the Texas seed trials are believed to be applicable to the growing results that



will be experienced in Sandoval County because the growing conditions in Sandoval County are believed to be more favorable due to higher soil fertility and higher average rainfall.

These seed trials have been conducted according to the recommended best practices of the seed producer, Richardson Seed Company in cooperation with MMR, the seed variety developer. The growing results and production yields have been verified by Agra-Life, an independent consultant. Adding an additional of layer of consulting expertise and acting in an advisory capacity for the full spectrum of agricultural economics have been the Sam Houston State University, School of Agriculture and the USDA in Texas.

The various crop varieties have also been tested to deliver the optimum levels of carbohydrates necessary to deliver a consistent supply of the critical ingredients needed to maintain a predictable and constant fermentation process in the bio digester.

The BHEC team has selected the five (5) top producing seed varieties that are expected to deliver the maximum quantity of cubic feet of bio methane gas per ton of raw silage ingested for fermentation.

Understanding the beginning chemistry of the seed crop, enabled the team to develop optimum fermentation processes that achieves a balance between Mesophilic (low temperature) fermentation and Thermophilic (high temperature) fermentation. To understand the underlying chemical attributes of the crop, the team has performed biological testing of the crop silage to determine the cellulose percentages, the dry matter percentages, and the carbohydrate chemistry. These ratios determine the heat loss or gain in the fermentation process. Heat loss or gain is the critical variable that must be managed in order to maximize the anaerobic digestion process reliability. With known input chemistries, achieving the optimum fermentation process can be quick and maintaining it can be reliable.

Managing these variables begins with the selection of the seed crop that delivers the desired chemistry capable of delivering the targeted fermentation process and temperature. This critical step then enabled the team to mitigate the risks associated with the loss of bacteria that can interrupt the bio methane gas production in the fermentation process as a result of undesirable temperature extremes.

The BHEC project team deems the seed selection and testing step of the process to be crucial to the reliability of the crop supply as well as the integrity of the fermentation process. It is the consensus of the team that the risks arising from the wide spectrum of potential weather and soil risks have been predicted, tested, and mitigated, thereby assuring that a viable long term supply of the fuel crop will be available and that the supply of the fuel crop will perform predictably regardless of the stress experienced in the growing cycle as a result of weather impacts.

### *3.4 The Conversion Cycle*

The second cycle in the "Bio-Hybrid Energy Cycle" (BHEC) has two steps, the first being the production of silage.

Feedstock for the facility will be shipped via trucks using the major roads serving the bio-digester site. Trucks will enter the site by a driveway access direct off the road into the plant site.

The ensiled organic product retains a larger percentage of its nutrients through preservation by anaerobic fermentation. This fermentation process allows for the long term storage of organic material with a maintained moisture content of 50% to 70%. This storage function allows the feed stock for future bio fuel production to be "banked" according to annual use rates.

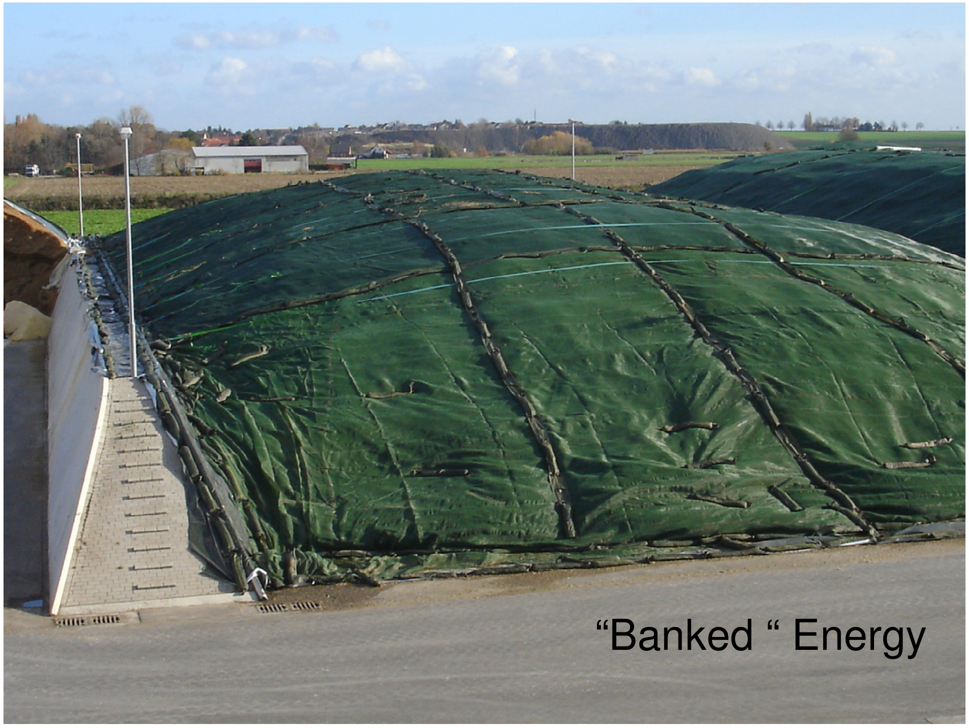
### *3.5 Feedstock Supplies and Storage*

Sandoval County will contract for the cultivation, harvest and delivery of specific genetic strains of sweet sorghum silage crops that will then be stored in silo bunkers or silo bags. The planned silos can accommodate quantities representing as much as two (2) full years' of feed stock supply for the generation of bio methane gas.

The silos can be permanently constructed structures consisting of concrete "T" Bunkers laid out in long runs on the ground. An alternative storage method involves the placement and storage of this silage feed stock, at the time of harvest, in large plastic bag tubes with dimensions of eight (8) feet in diameter and up to forty (40) feet in length. John Deere Corporation is currently working to perfect this harvest / storage process. These "silo bags" can then be stored on the ground and do not require silo "T" bunker structure facilities. Using these bags to store silage instead of bunkering the silage in permanently constructed facilities can eliminate significant facility costs. Unlike other renewable energy generating strategies, the Sandoval County BHEC project has the unique competitive advantage of delivering a constant and uninterrupted stream of electrical energy because of its ability to "bank" the fuel crop in quantities capable of supporting the ongoing operation of the process for more than one year. This differentiates the project from wind, solar and other intermittent renewable energy strategies and enables the developers to provide reliable power to its customers, achieve uninterrupted revenue streams, secure performance guarantees that will thereby support the financing of the project and provide guarantees to support the financing structure of the development.

"Banking" of the fuel crop also protects this energy strategy from the risks arising from weather related disasters that could cause the loss of a critical supply of the sorghum silage feedstock in any given year.

Silage storage facilities consisting of concrete "T" Bunker Silos are covered by plastic sheets once the silage crop has been trucked in for storage. The bio methane plant is designed for easy loading and unloading off the semi-trailer trucks directly into the silo bunkers for long term storage of the silage until ready for ingestion in the biodigester.


"Banked " Energy

### *3.6 Bio Digestion Reactor & Process*

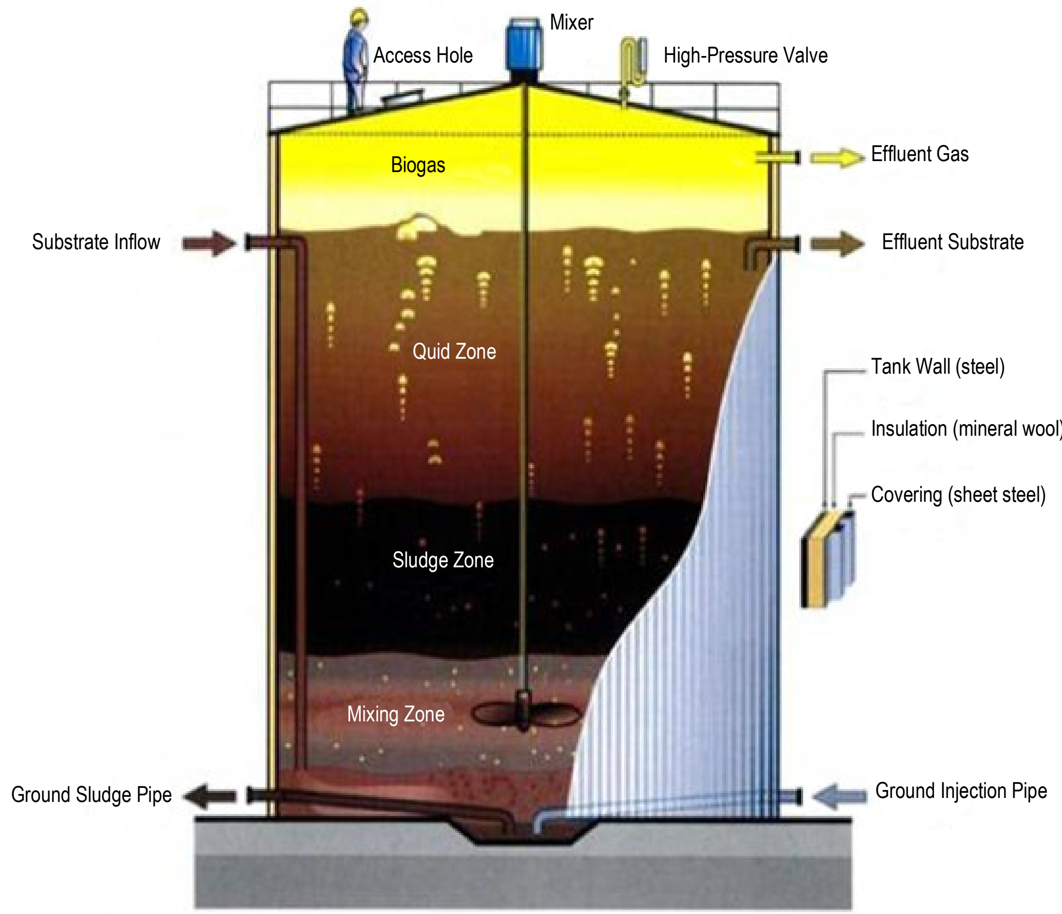
Specific quantities of sorghum silage will be ingested daily into an anaerobic digester tank. Specific quantities are required so that the balance of the mix is maintained. Maintaining the proper mix proportions enables the maintenance of an optimum temperature range necessary to facilitate efficient fermentation. Failure to maintain an optimal temperature range can result in the death or underperformance of the bacteria that is essential to the ongoing fermentation process. Bacteria are the engine that drives the fermentation.

Through the fermentation process, bio methane gas will be produced and captured. The bio methane gas will then become the fuel that is burned in an internal combustion engine. The internal combustion engine generates electricity. The generated electricity will be consumed exclusively by the Sandoval Water Treatment Plant. Electricity will not be purchased from the Public Service of New Mexico (PNM) and the funding that would have otherwise been budgeted for the cost of electricity will be redirected to the purpose of paying for the plant, equipment, maintenance and financing of the Sandoval County BHEC project.

The second step of the conversion cycle is the deployment of an anaerobic digester to convert the mix stream of organic material to bio gas. Anaerobic digestion is defined as a renewable energy source subsequent to the bacterial hydrolysis of organic polymers such as carbohydrates. The corresponding biological degradation produces acidogenic, acetogenic and methanogenic bacteria. Methanogenic bacteria are capable of converting acetic acids into methane and carbon dioxide. This organic stream of produced bio-methane gas is suitable for heat and electrical energy production. This renewable energy source can supplement and eventually replace fossil fuels used in most rural electrical generation systems.

The anaerobic digester consists of a completely closed, concrete digester tank that is covered with an air-tight, inflated, plastic tarp top. Another rigidly inflated plastic sheet dome is located over the gas collection dome. Digester contents are maintained at 135 degrees Fahrenheit with an internal heating system. Digester contents are mixed periodically with internal impellors and gas injection. Hydrogen sulfide in the biogas is removed via an aerobic system to a level that reduces any corrosion related issues in the generator's engine. Treated digester effluent passes through a piping system for deposition into a covered effluent storage tank.

Effluent is pumped to a belt press for solids separation. Recovered solids are deposited in one of the covered concrete-walled storage tanks. Treated, separated liquid, gravity flows into a covered tank/sump where it is either pumped to the digester as recycle or permitted to gravity flow to the storage tank for beneficial crop use as organically stable liquid fertilizer.




All aspects of the system are electronically monitored and recorded to enable optimization of the processes for maximum efficiency.

The utilization of anaerobic digestion will reduce the production of green house gases by:

a. Current supplement and future replacement of fossil fuels
b. Reduction of methane emissions
c. Displacing industrial produced chemical fertilizers
d. Reducing electrical grid transportation losses
e. Providing carbon neutral power production.

The deliverable from this segment of the proposed project is the development, design, construction, operation and economic evaluation of a single stage mesophilic, low temperature, digester that is commercially suited for the organic stream produced by the region supporting the bio-gas production.

### *3.7 The Cogeneration Cycle*

The three principle products produced by the conversion cycle; biogas, digestate and nutrient rich water will be combined and used in selective energy generation and soil regeneration processes. The biogas will be used to power an internal combustion engine that is used to drive an electricity generator. This electricity generator will also be capable of operating with natural gas that is delivered to the site by a pipeline from a natural gas utility provider. The project plans to maximize the operation of the electricity generation using the biomethane gas as the primary energy source. The natural gas would be the back-up energy source that assures uninterrupted power in the event of any scheduled maintenance or unexpected interruption of the biomethane gas production and delivery to the internal combustion engine.

The combustion of the biomethane gas or the natural gas in the internal combustion engine during the electricity generation phase will create waste heat. Waste heat is energy and a resource that is important to the BHEC process. This waste heat is planned to be captured for purposes of warming the anaerobic biodigestation tanks and keeping them at the targeted 135 degree Fahrenheit temperature. The excess heat captured beyond this heat requirement will be used to provide energy requirements for the heating and cooling of the Sandoval County Water Treatment Plant.

### *3.8 The Soil Regeneration Cycle*

The second and third of the principle products produced by the conversion cycle, digestate and nutrient rich waste-water, will be used in composting and oxidation systems that will be designed to promote soil regeneration and bacterial enhancement respectively by the production of peat. The introduction of peat into the new land use plan will promote the reduction of soil acidification accelerated by the use of acid-forming nitrogenous fertilizers. Energy crops, when combined with planned crop rotations and structured land-use programs have documented results that promote the regeneration of regional soil conditions.

By design, BHEC creates additional revenue streams for the operator, producing power locally and regenerating soil from waste products.

The BHEC process is carbon neutral as the growing plants that produce the feedstock up-take more CO2 than is produced by the use of the methane. The competitive advantage of the BHEC process lies in the unique feature that the fuel supply can be "Banked" thereby creating a steady stream of reliable, consistent, electricity that is not subject to interrupting forces beyond the control of the process. This translates to a steady revenue stream that can be characterized for utility scale reliability and investment grade financing.

This critical element is missing from most utility grade applications involving the use of renewable energy. Unlike other forms of renewable energy, BHEC is both reliable and bankable. It provides economical energy at the point of creation and distribution while making full use of its waste products in an environmentally supportive way.

### *3.9 Outputs Summary*

**Finished Product Outputs – Description of Use**

Under the proposed Sandoval County BHEC strategy bio methane production is a closed loop production cycle because strategies have been developed to generate additional revenue streams from the residuals. The Sandoval County BHEC project achieves a zero waste process. Bio methane gas production residuals (waste products) are recycled for beneficial use back into the growing process.

By-products of the bio methane gas production and electricity generation process are heat, bio mass digestate materials, and liquid fertilizer. These by-products have commercial value that contributes to the cash-flow model of the energy strategy enhancing the return on investment (ROI) of this energy strategy.

1. Bio methane – Biogas is the primary output product being produced by the BHEC process. The Biogas recovered in the digester is transported to the gas management building for pressurization

and introduction into the cogeneration engine for the generation of electricity. As circumstances warrant, biogas may be treated prior to use as an engine fuel. In emergency conditions, unused biogas may be flared.

2. Heat – High grade waste heat is generated as a by-product off of the internal combustion engines as a result of the electrical energy generation cycle. This heat can be used to dry the biodigestate, to keep the biodigesters at the desired warm temperature and to provide energy for the heating and cooling needs of the Sandoval County Water Treatment Plant. Harnessing this heat and delivering it to a useful purpose is dependent upon the local proximity of the end-user of the heat to the generation facility.

3. Electrical Energy – Electrical energy is generated as a result of the controlled combustion of the bio methane gases that are generated and captured from the anaerobic digester. This electrical energy is planned to be transmitted into the electric power grid of the Sandoval County Water Treatment Plant and its value represents the equivalent of a critical revenue stream at the core of the project's financial feasibility and ROI model.

4. Residual Products (digestate and nutrient rich water) – The anaerobic digestion does not fully break down the cellulosic and lignon materials that are introduced into the biodigester system. Following the primary fermentation and anaerobic process, these cellulosic digestate materials can be removed and processed through a drying process to create a bedding material that may then be sold to users such as the poultry producing industry. However, this possibility has not been fully developed. Other possibilities are for potting soil conditioners, farm soil conditioners, cattle and hog operation bedding and peat moss substitutes.

   Additionally, nutrient rich water is drawn off of the system and can be sold as liquid organic fertilizer that is high in nitrogen (N), phosphorus (P) and potassium (K). It is proposed that the magnesium being recovered from the water treatment process be used to precipitate magnesium ammonium phosphate (Struvite) a slow release high value Fertilizer. Urea may need to be added in this process to spike the nitrogen value of the end product. The remaining liquid would be used as irrigation water around the plant site or added to the plant's evaporative ponds. Both of these waste product streams have revenue contributing potential that has not been included in the primary financial feasibility studies or ROI models.

### *3.10Biogas Financial Analysis*

A detailed financial model was developed to evaluate whether the use of an anaerobic digester creating biogas for fuel to a Co-Generation engine would be feasible under the current Sandoval County Economic Conditions. The biogas model explored using area agricultural to produce a forage grade sorghum that could be chopped and ensiled for digestion. The digested silage will produce a biogas that can be sent to a biofuel engine for electricity generation and thermal heat recovery. In the model the following parameters were used.

#### 3.10.1 Crop Production Area

The Biogas plant will require a crop production area of approximately 350 acres. To economically transport silage and fertilizer it is recommended that the silage production ground is with a five (5) to 10 mile radius. The following diagrams display available land within a five (5) mile radius and a 10 radius.

3.10.2 Financial Model Input Assumptions & 400 KW Biogas Pro Forma

To accurately construct the financial model certain input parameters had to be utilized. A description of each parameter along with justification regarding model inputs is explained in detail within this section.

The financial model evaluates a 4.25 MW facility located at the water treatment plant to make use of electricity generation and potential waste heat. The financial Model results are displayed in the following section.

### *3.11Proposed Biogas Layout and Estimated Construction Timeline*

The following drawing will display the typical layout for a 4.25 MW biogas facility. The layout has been incorporated into the site design of the Sandoval County Water Treatment Plant..

### *3.12 Biogas Summary of Results and Next Steps*

As energy prices continue to increase the economics of biogas generation will continue to improve. With Biogas generation fluctuating energy prices can be buffered through the production of a renewable energy source. To finalize a design plan the following the actions need to be taken:

- Secure agreements to obtain long term crop production in close proximity to biogas facility
- Verify Production Land Procured is capable of producing desired yields at anticipated cost.
- Secure Agreement with ____________ for resale of excess electricity back into electrical distribution grid
- Develop Alternative Markets for digester by products (Fertilizer and Digestate)

# 4 BIOGAS FINANCIAL ANALYSIS

A detailed financial model was developed to evaluate whether the use of an anaerobic digester creating biogas for fuel to a Co-Generation engine would be feasible under the current Sandoval County water treatment plant economic conditions. The biogas model explored using area agricultural to produce a forage grade sorghum that could be chopped and ensiled for digestion. The digested silage will produce a biogas that can be sent to a biofuel engine for electricity generation and thermal heat recovery. In the model the following parameters were used.

## *4.1 Crop Production Area*

The Biogas plant will require a crop production are of approximately 6,300 acres. To economically transport silage and fertilizer it is recommended that the silage production ground is with a 25 mile radius. The following diagrams display available land within this radius.

INSERT FIGURE SHOWING ESPIRITO SANTO GRANT

## *4.2 Financial Model Input Assumptions and Biogas Pro Forma*

To accurately construct the financial model certain input parameters had to be utilized. A description of each parameter along with justification regarding model inputs is explained in detail within this section.

The financial model evaluates a 4.25 MW facility located at the Water Treatment Plant make use of electricity generation and potential waste heat. The financial model results are displayed in the following section:

## *4.3 Proposed Biogas Layout and Estimated Construction Timeline*

The following drawing will display the typical layout for a 4.25 MW biogas facility. The layout has been incorporated into the site design of the proposed water treatment plant.

INSERT SITE PLAN

## *4.4 Biogas Summary of Results and Next Steps*

As energy prices continue to increase the economics of biogas generation will continue to improve. With Biogas generation fluctuating energy prices can be buffered through the production of a renewable energy source. To finalize a design plan the following primary actions need to be taken.

- Secure agreements to obtain long-term crop production in close proximity to biogas facility.
- Secure contracts for digester by-products (Fertilizer and Digestate)

**Processing Checklist**

Universal Asset Management has developed a complete process checklist that outlines tasks from project development to construction completion. This checklist will be utilized as the roadmap for the project to insure that all tasks are assigned and completed.  The following pages display a Processing Checklist for the Sandoval County Biogas Plant.

INSERT PROCESSING CHECKLIST

## APPENDIX 1 – ENERGY COSTS