Animal Manure and Related Biomass Feedstock Market Assessment and Preliminary Feasibility Study for a Papermill Biomass/CoGen Facility

Task 5 Summary Report

for

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with

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Linpac Paper
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Conceptual Facility Design and Preliminary Requirements

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Task 5 Summary:

The Task 5 workscope involved providing a conceptual view of the proposed Biomass/Cogen facility using the BTA technology as a basis. The Task 5 work identified major equipment and systems for the facility, with corresponding capital cost estimates. The CCI/BTA technology application for the Biomass/Cogen's biogas facility has undergone a preliminary technical evaluation by Linpac and RRSI staff, with assistance from CCI's corporate management and Newmarket engineering and operational staff. The CCI/BTA technology and support systems were shown preliminarily to be technically feasible and viable based on the conceptual engineering and technical evaluation work efforts.

A preliminary review of the CCI/BTA technology was performed, including a plant tour and technical review of the unit operations at the CCI Newmarket, Canada biogas production facility. Based on this work, the targeted Biomass/Cogen facility size is a 165,000 tons per year biomass feedstock with solid/liquid raw material handling capability, using a two stage BTA anaerobic digestion including a hydrolysis step, with a cogeneration option for steam and electricity production, capable of producing 4-5 MW electrical production or equivalent energy. The Biomass/Cogen facility conceptual engineering work developed four options for the boiler or cogeneration use of the biogas, including the following:

Option 1. Retrofit Existing Boiler. In this option, the existing boiler is retrofitted and converted to be able to utilize biogas. The estimated capital cost of the Biomass/Cogen facility with this option is $26,206,481.

Option 2. Steam Turbine. Cogeneration system using a high pressure McBurney package boiler followed by topping cycle Turbosteam turbine. The estimated capital cost of the Biomass/Cogen facility with this option is $29,940,981.

Option 3. Gas Reciprocating Engine. Cogeneration sytem using a Waukesha Gas Engine with steam recovery. The estimated capital cost of the Biomass/Cogen facility with this option is $32,007,402.

Option 4. Gas Combustion Turbine. Cogeneration system with a gas combustion turbine system, consisting of 2 Solar Taurus gas turbines. The capital cost of the Biomass/Cogen facility with this option is $37,976,481.

The Task 5 workscope provides for the preliminary conclusions that The CCI/BTA technology is an effective anaerobic digestion technology which has provided reasonable justification that the BTA technology can effectively process the targeted animal manure and biomass feedstock raw materials. The options for cogeneration or boiler use of the biogas are based on reasonable assumptions and the chosen equipment provides for the use of the biogas as produced. The preliminary operational cost estimates that were developed are reasonable preliminary estimates for comparison and preliminary financial evaluation estimates. The preliminary capital cost estimates for each scenario have been reasonably estimated. These cost estimates appear to be sufficient to cover the cost of equipment and facility construction and installation, and start-up requirements to achieve full production and business operations.

Methodology

The Task 5 workscope involved providing a conceptual view of the proposed Biomass/Cogen facility using the BTA technology as a basis. The Task 5 work identified major equipment and systems for the facility, with corresponding capital cost estimates. The Task 5 work was based on the following conceptual engineering work, feasibility documents or technical evaluations:

- Linpac Cogeneration Study #1.
- Linpac Cogeneration Study #2.
- Linpac and RRSI Tour and Technical Evaluation of CCI's Newmarket BTA Biogas Facility.
- CCI BTA Technology Conceptual Engineering and Cost Estimate Work.
- Linpac and RRSI Conceptual Engineering and Technical Evaluation Work.
- Linpac and RRSI Cogeneration Vendor Equipment and Specification Work.
- Linpac and RRSI Operational Cost Estimate and Capital Cost Estimate Work.

The CCI/BTA technology application for the Biomass/Cogen's biogas facility has undergone a preliminary technical evaluation by Linpac and RRSI staff, with assistance from CCI's corporate management and Newmarket engineering and operational staff. The CCI/BTA technology and support systems were shown preliminarily to be technically feasible and viable based on the conceptual engineering and technical evaluation work efforts as defined below.

Definition of The Engineering

The conceptual engineering work and technical evaluation services (THE ENGINEERING) used to determine the preliminary technical feasibility and capital cost estimates of the project presented in this report are defined as follows, and are subject to the following assumptions and limitations:

- The objective of THE ENGINEERING services and deliverables is to define the necessary CCI/BTA process equipment and systems to allow Linpac to develop reasonable equipment capital cost estimates to plus or minus 20% of total Biomass/Cogen project equipment cost (excluding specialty installation costs, working capital needs, taxes, transportation, corporate costs and after contingency).

- The objective of THE ENGINEERING services and deliverables is to define the necessary building and facility support equipment and systems to allow Linpac to develop reasonable building and support facility equipment capital cost estimates to plus or minus 20% of total Biomass/Cogen project facility or support equipment cost (excluding specialty installation costs, working capital needs, taxes, transportation, corporate costs and after contingency). Preliminary cost estimates are provided for the basic building to provide rudimentary cost expectations for the building, and final costs are dependent on final preliminary design engineering and construction engineering requirements.

- THE ENGINEERING DID NOT provide complete preliminary design, detailed design engineering, construction engineering or specific process or value engineering. Conceptual engineering efforts and technical evaluation efforts were preliminary and rudimentary in nature and developed first in order to show the technology's capability and second to provide preliminary capital cost estimates.

- Should the project proceed to future implementation steps, Linpac and/or CCI will be required to make final design and equipment selections based on agreed upon performance guarantees and any final contract(s) that would develop or be negotiated between Linpac and CCI, or between Linpac and any other chosen equipment suppliers and/or vendors.

- Linpac and/or the Biomass/Cogen owner/operator will be required to perform all required preliminary design engineering, detail design engineering, process engineering, and value engineering to fully scope and define the project based on the final design and equipment selections, and to obtain exact quotations for project procurement efforts from all project supplier or vendors.

The conceptual engineering and technical evaluations provide the basis for THE ENGINEERING efforts. The project capital was calculated and related project workscope needs defined. Reasonable preliminary feasibility conclusions were made based on the result of THE ENGINEERING work and the associated estimates.

Conceptual Engineering and Technical Evaluation

The Task 5 conceptual engineering and technical evaluation work involved developing and generating preliminary conceptual design criteria, operational estimates and preliminary documents necessary to provide a preliminary capital cost estimate for the Biomass/Cogen facility. The targeted facility size is a 165,000 tons per year biomass feedstock with solid/liquid raw material handling capability, using a two stage BTA anaerobic digestion including a hydrolysis step, with a cogeneration option for steam and electricity production, capable of producing 4-5 MW electrical production. Table XXX below provides the targeted Biomass/Cogen facility's basic design criteria and input/output targets.

Table 1: Facility Design Criteria and Input/Output Targets

Design Criteria	Target
INPUTS	
Plant Biomass Waste Tonnage Input	165,000
Percent Biomass Waste Input	91%
Percent Water Input	9%
Additives/Chemical Input	0.01%
OUTPUTS:	
Plant Energy Output	4 - 5 MW
Percent Biogas Output	10%
Percent Compost Output	35%
Percent Organic Water Output	39%
Percent Light Fraction Reject Output	11%
Percent Heavy Fraction Reject Output	2%
Percent Grit Output	3%
Percent Ferrous Output	1%

Based on the conceptual engineering and technical evaluation work performed, the target size of the Biomass/Cogen facility was established as per the above design criteria in Table 1. This size is based on the what is known about the impact of scale learned from CCI. The CCI Newmarket facility size parameter is similar to the one listed above, and this size is believed to be a prudent template for design. Future facility expansions can occur after facility operations and market conditions allow. The design criteria for the boiler and cogeneration options was based around four potential options for the biogas use in energy production, which are described in a following section of this report. Appendix A provides the process flow diagrams (PFD) for the expected Biomass/Cogen facility, with a PFD for the CCI/BTA anaerobic digestion technology, PFD's for the cogeneration options, and support equipment vendor PFD documents, schedules and estimates. Conceptual engineering results, technology evaluations and descriptions follow below.

CCI/BTA Anaerobic Digestion Technology

The CCI/BTA anaerobic digestion technology is the key technology component of the Biomass/Cogen facility. The facility will use the BTA process, a German technology that separates the waste and uses anaerobic digestion to generate biogas in an "in-vessel" odor controlled facility. The technology was developed in the 1980's by Biotechnische Abfallverwertung GmbH (BTA) of Munich, Germany. Commercial BTA plants operate in Europe and Canada. The CCI/BTA anaerobic processing facilities footprints are typically compact facilities. Since the BTA process is all contained within pipework and vessels, and since the design included using a biofilter for facility exhaust air streams, the facilities are environmentally friendly. Odors do not have the potential to develop and escape during the process.

The CCI/BTA technology provides for excellent production rates of biogas from a range of animal manure and biomass feedstocks. The BTA technology unit operations can be consolidated and considered in three major processing components: pre-processing/pre-sorting; BTA technology anaerobic digestion; and compost residual solids treatment. These major processing components are performed using the unit operations shown in the PFD provided in Appendix A. The moisture content of the incoming organic waste stream can range from 90 percent down to 50 percent; therefore, selection of the type of organic wastes received at the facility will need to be monitored to minimize the addition of process water and maximize the amount of waste processed. The operating flexibility in the BTA process allows the system to accommodate these ranges of input and maintain processing capacity. This flexibility is an important feature because waste based raw material streams frequently vary in composition and thus have caused many processing technologies to under perform their expectations.

Preprocessing starts when organic feedstock materials delivered by collection vehicles are offloaded. Liquid materials such as animal manures, waste milk/beverages, or slurries are pumped into storage tanks. Solid materials are offloaded on the tipping floor, then loaded onto a conveyor and sent to the presort station, where oversized and unacceptable materials are removed. After the pre-sort station, the material continues through a trommel screen with two screen sized to separate fine materials (mostly organic), medium sized materials (mostly containers) and large materials such as cardboard, film, plastic and textiles. The front end of the screen is equipped with a series of knives to open plastic bags. Medium and large materials can be both manually and mechanically sorted to remove recyclables and residues. Recyclable material is bales and sent to appropriate markets, and unusable residue is removed and taken for disposal. The remaining organic rich material is ready for the next step.

The BTA anaerobic digestion technology begins with the hydropulper. Organic rich waste is fed to a large capacity hydropulper and mixed with water (or liquid waste). The biomass waste is pulped with process water into a slurry with a solids content of eight to 16 percent. The hydropulper creates an organic pulp and removes contaminants. The BTA process incorporates hydropulping equipment with proven capability of mixing water with the biomass waste, as well as removing the non-organics. Hydropulpers have been routinely used for many years in the pulp and paper industry to pre-process wood pulps and therefore are well proven. This adaptation of the hydropulper equipment has been operated very successfully in BTA plants in Canada and Europe.

In the BTA process, the hydropulper also includes raking equipment to remove the inorganic materials from the slurry. The major component of the non-organic materials separated by the rakes on the hydropulpers is plastic film. The plastic film can either be disposed of in a landfill site, sold for reprocessing, or with the proper equipment reprocessed on site for sale as recycled resin. Lightweight contaminants and non-organic materials, such as plastic missed in the presort separation process are removed. Additionally, heavyweight non-organic materials from the slurry are removed. The materials expected to be present in the waste stream include metals, glass stones and bones. The pulping step is followed by a stage that removes sand and grit using a hydrocyclone. Hydrocyclones are commonly used in industry for removing solids from slurries. The slurry that is pumped to the hydrocyclones, to separate the inert grit and sand from the slurry, is a key step which had caused some problems in the slurry pipework and pumps in earlier facilities. These inert materials can be used in certain applications such as asphalt or concrete, or will require disposal in a landfill site.

The remaining pulp is pumped to the anaerobic digester for decomposition into biogas and compost. Anaerobic digestion is a biological process that uses bacteria to break down solids without the presence of oxygen. Anaerobic digestion is where the slurry undergoes biological action to produce biogas, which is typically 65% - 75% methane. The digestion process takes days and results in two beneficial by-products: biogas and compost. In anaerobic digestion, the optimum conditions of the organics within the digestion process are approximately eight to 16 percent solids. Anaerobic digestion produces little exothermic energy and most of the energy is retained in the methane gas produced from the process. Anaerobic digestion systems; therefore, process the organics in a liquid slurry form. In typical anaerobic digestion processes, some slurries or sludges from a treatment facility can be very low in solids and may have to be dewatered prior to the digestion process. The use of liquid animal manures may require the same type of dewatering step, or the liquid manure used as is in combination with dryer feedstock materials to obtain the proper mill process water balance. The biogas is fed to cogeneration units where it is used to produce electricity and heat/steam.

In the BTA technology process, the degritted slurry is pumped to suspension buffer tanks. These tanks provide the process with storage capacity to even out the flow of waste materials delivered to the facility on a daily basis and to provide a uniform flow to the digestion process. Slurry from the buffer tanks is pumped to the anaerobic digestion process. Organics that are not suitable for the slurry undergo a separation step into a intermediate hydrolysis unit operation, to convert the organics and celluloses to digestible material suitable for methane production and re-entry into the digestion slurry. Digested sludge is pumped from the digestion tanks to centrifuges for dewatering. Centrifuges are used for dewatering sewage sludges and are common equipment in the sewage treatment industry. While these processes are individually proven and commonly used, working efficiently in an integrated system requires complex process control systems. BTA provides such computerized process control systems for the management of the process.

The solids treatment is when the waste biomass from the process slurry that is not converted to methane is removed from the process and converted to compost using aerobic methods. The compost fraction is created from undigested waste organics. In aerobic composting processes, the waste processed is a solid with an optimum moisture content of between 50 to 60 percent. Aerobic composting processes require bulking agents to be mixed with the organics to aid in the distribution of air (oxygen) through the waste biomass so that aerobic bacteria can flourish. These bulking agents also assist in reducing the moisture content of the waste to optimum conditions. The capacity of the aerobic facility has to account for the addition of bulking agents. The type and amount of the bulking agents will depend on the type of waste biomass organics to be processed. Aerobic composting typically requires an additional 25 to 30 percent of bulking agents which can increase the size of the facility composting area. The compost will be cured and distributed for soil amendment or land application use, horticultural use, and other uses depending on the regional needs and requirements.

CCI Newmarket Biogas Facility Review

The BTA technology has proven operating facilities in Canada and Europe and the waste stream processed at these facilities is for all practical purposes identical to that to be processed in the United States. Representatives of the Linpac team have visited the CCI Newmarket, Canada operating facility to review the technology. The purpose of the tour was to review the BTA technology based system during facility startup and full operation of the plant.

The CCI Newmarket facility is a $20 million (Canadian dollars) one stage full scale biogas plant that is fully operational and produces biogas for generating electrical energy for the local utility. A second stage digestion expansion is planned that would cost approximately $7 - $10 million (Canadian dollars). Linpac and RRSI engineering staff toured the CCI biogas generation plant in Newmarket, Ontario, Canada. Plant Executive Director John Brewster gave an initial overview of the facility. Then, Senior Process Control Operator Bill MacDonald led a walking tour of the plant and described various components of the methane generation process and material handling. Bill MacDonald were enthusiastic about the BTA technology used in the CCI Newmarket plant. Although their plant was in a startup phase, they said that current indications were that methane production and plant capacity would be significantly higher than expected.

Each of the major systems was observed and evaluated, and a description of each of the key unit operations shown in the PFD is given below. Appendix B provides corresponding pictures of the CCI Newmarket plant that are provided to document the CCI/BTA technology in operation, and presented to aid in review of the BTA methane generation technology. The facility is clean with very minimal odor. The facility makes significant use of computer controls to operate, maintain and troubleshoot problems in each major component.

Raw Materials Tipping Floor

Organic waste materials are brought to the facility in covered trucks and tipped loose onto the receiving floor. The material is removed from a truck within 24 hours of its arrival and placed on the tipping floor. The plant typically receives a few different types of organic wastes. At the time of our visit, for example, there was outdated produce in one pile on the tipping floor, and restaurant food waste with some packaging material in another pile. In order to maintain a steady "diet" for the methane generating bacteria, operators mix different kinds of waste into one of several recipes. The response of each recipes is tested and recorded. This performance information is used to refine the recipes to optimize plant performance.

Materials are either loaded directly on a conveyor to the pulping system, or sent first to a trommel screen and sorting area for pre-processing. The trommel screen breaks plastic bags of commercial restaurant waste and prevents the largest materials from entering the pulper. Some recyclables are reclaimed from the trommel screen rejects. A variety of biomass organic feedstocks was and may be used, and some experimentation was ongoing and required to develop optimal "recipes" for maximum methane generation. For animal manure feedstocks, recipes will have to be developed, and it is likely the animal manure will be run in combination with some other biomass feedstock.

Pulping and Grit Removal and Pre-processing

A movable conveyor system directs materials from the tipping floor and trommel screen areas to one of three pulping units in the facility. Each pulper has a skimming unit to remove lightweight materials such as plastic bags remaining in the material mix. Water is added to the organic materials to aid in the pulping process. After pulping, the slurry is sent to a centrifuge separation system, which has three output streams. The light fraction is sent to a sorting process to remove plastic recyclables, with the remainder sent to landfill. In a similar fashion, the heavy fraction is sorted for metals, with the remainder used for road aggregate.

Methane Generation System

The organic slurry remaining after pulping and grit removal is processed for methane production in the methanizer. Based on future design engineering and balances, the additional pulping or slurry capacity can allow for an additional methanizer unit operation, increasing biogas production. Insoluble organics are removed in a bank of screw presses. These insolubles would be further digested in a hydrolysis reactor during two-stage digestion, but during current single stage operation, these solids become residuals from the process that are added to the compost. The liquid containing soluble organics is reduced to a low consistency. The pH is adjusted and the material is fed to the anaerobic digestion tank. Dissolved solids are reduced by this process and chemical oxygen demand (COD) is brought virtually to zero. Methane is collected at the top of the digestion tank and sent to the cogeneration system after water is removed from the gas.

Residuals Handling

From the process stream, solid organic materials remain after the soluble organics are removed (in single stage digestion, which is the current level of operation). These solids are readily compostable in an aerobic composting process. Currently, the uncomposted solids are sold or given away to a soil products company which carries out the needed composting before selling the material. Amendments such as sawdust are typically mixed with these solids for better drying and aeration during aerobic composting.

Liquid residual from the methane generation process is partially recycled back into the process water. The remainder, is sent to sanitary sewer. It contains some dissolved solids, but has low biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Although not currently done at Newmarket, some European facilities convert the liquid residuals into a liquid fertilizer for sale in agricultural and farm markets.

Plastics, metals and other non-digestible materials removed from the process stream in the trommel screen, hydropulper and grit removal system are processed further to recover recyclables. Magnetic and eddy current separators make possible the removal of metals from the residual stream. Glass and other heavy materials are recycled as road aggregate. Plastics are manually sorted. Non-recyclable solids from the process are sent to landfill. A system of chutes and bins is used to collect sorted materials for transport off site.

Biofilter

The entire facility has a negative pressure that prevents odors from escaping the plant. A large ventilation system in the tipping floor area pushes several air changes per hour through a biofilter system to minimize odors both inside and outside of the facility. The exhaust air passes through a mixture of wood bark and compost, which removes odor-causing compounds. As a result, the working air quality inside the building is quite good, with only mild detectable odors in the tipping floor area. Outside the plant, the odor is barely detectable. The Newmarket facility is located within a commercial and office park, and so odor is not allowed or tolerated.

Cogeneration System

Two 1 Megawatt internal combustion engine and generator sets on site are available to produce electric power and heat for the plant, using biogas produced in the plant, and, when necessary, supplemental natural gas. At the time of our visit, the plant in a startup phase, producing about 1 MW worth of biogas. During full single stage operation, they expected to produce about 2 MW worth of biogas. With two stage digestion, to be implemented at a later time, the expected production was more than twice as high, or about 5 MW or power. The plant requires about 1 MW of power to operate. Any power in excess of this amount generated on site may be sold to the local electric utility. The biogas can work with either existing boilers fitted for biogas flow requirements, or cogeneration equipment made to use biogas as the fuel.

Based on the CCI Newmarket plant tour and technology review, the visit to CCI's facility showed the BTA technology as viable and feasible for use as the anaerobic digestion biogas technology with the planned Biomass/Cogen facility.

Cogeneration Options

The Biomass/Cogen facility conceptual engineering work developed four options for the boiler or cogeneration use of the biogas. Option 1 involved retrofitting the existing mill boiler suitable for biogas use and add the biogas to the natural gas supply to generate steam only, for producing mill steam requirements only. Options 2, 3 and 4 looked at various cogeneration units where the biogas was used as part of the fuel. These options produced The options are described below.

Option 1. Existing Boiler. In this option, the existing boiler is retrofitted and converted to utilize biogas, or a mixture of biogas and natural gas, at existing capacity, producing steam at 225 psi, 450 F. Approximately 25-30% of the fuel would be supplied by the biogas facility. The cost of this option would only include tie-in piping costs from the biogas generation facility. The savings is the amount of gas displaced by biogas, namely 25% of current gas usage. Only steam for mill use is produced. No electricity is generated with this scenario. This option requires the lowest capital investment, because the cogeneration capital costs are minimal.

Option 2. Steam turbine cogeneration system. High pressure 100,000 pph McBurney package boiler followed by a topping cycle Turbosteam turbine with exhaust at 225 psi, 450 F. If boiler output is at 650 psi, 700 F, the steam turbine output is 1.9 Mwatt at full capacity. Approximately 20-25% of the fuel used would be supplied by the biogas facility. The cost savings is a little more complicated. Use 7% more total fuel gas to obtain same amount of steam as before, but generate 1.9 MW of electricity at the same time. 20-25% of the natural gas would be replaced by biogas. The capital investment is higher than in Option one, but lower than in Options 3 or 4.

Option 3. Gas Reciprocating Engine for cogeneration. 2910 kWatt Waukesha Gas Engine with 3400 pph steam recovery at 225 psi, 400 F. The steam would supplement output from the existing boiler, reducing natural gas consumption by roughly 3-4%. 2.9 Mwatt of electricity would be available for plant use or sale as “green energy.” This would reduce electricity costs to the plant by 20-25%. Capital investment for this option is higher than for Options 1 or 2, but less than in Option 4.

Option 4. Gas combustion turbine cogeneration system. Replace the existing boiler with a gas combustion turbine system, consisting of 2 Solar Taurus gas turbines and associated controls and piping. Fuel use would increase approximately 10%, but the system would produce virtually all of the electrical power needed by the Linpac plant. In our application, a portion of the natural gas fuel (approximately one-quarter to one-third) would be replaced by biogas. The operating cost savings would be sizable. The electric power bill would be essentially eliminated, while fuel usage would increase by 10%. 20-25% of the fuel could be replaced by biogas. To achieve these significant gains, more capital investment would be required for this option than for Options 1, 2 or 3.

Options 2, 3, and 4 above would install a new cogeneration unit that is conceptually sized to match with mill steam requirements, based on the total linerboard mill steam requirements. These options add the biogas to the natural gas supply necessary to run the cogeneration unit, supplying all mill steam, and some or all of the electrical needs. These options allow the mill to meet the target steam requirements for production while taking advantage of the biogas vs. natural gas substitution. The sizing of the cogeneration units also allows for any future biomass facility increased capacity and expansion phases, where biogas production would be increased by increasing the anaerobic digestion biogas component of the facility. The options allow any additional biogas production to be readily used by the mill for the natural gas substitution, without having to retrofit or enlarge the cogeneration units.

Preliminary Capital Cost Estimates

Appendix C, D, E, and F provide the preliminary capital cost estimates for options 2, 3, 4 and 5 respectively. Based on the conceptual engineering work these equipment lists were developed and used to generate preliminary capital cost estimates for the four options. Tables 2, 3 4 and 5 provide summaries of the preliminary capital cost estimates for the four options.

Table 2: Option 1 Capital Cost Summary*

Project Capital Item	Cost ($US)
Raw & Finished Materials Handling	$ 725,926
BTA Equipment	$ 7,988,889
Cogeneration Equipment	$ 398,148
Auxiliary Equipment	$ 555,556
Building Costs	$ 8,003,704
Engineering	$ 4,744,444
Startup	$ 1,407,407
Optional Equipment	$ 0
Project Contingency @ 10%	$ 2,382,407
Total Project Capital Costs	**$ 26,206,481**

**see Appendix C for optional equipment list and costs*

Table 3: Option 2 Capital Cost Summary*

Project Capital Item	Cost ($US)
Raw & Finished Materials Handling	$ 725,926
BTA Equipment	$ 7,988,889
Cogeneration Equipment	$ 3,793,148
Auxiliary Equipment	$ 555,556
Building Costs	$ 8,003,704
Engineering	$ 4,744,444
Startup	$ 1,407,407
Optional Equipment	$ 0
Project Contingency @ 10%	$ 2,721,907
Total Project Capital Costs	**$ 29,940,981**

**see Appendix D for equipment list and costs*

Table 4: Option 3 Capital Cost Summary*

Project Capital Item	Cost ($US)
Raw & Finished Materials Handling	$ 725,926
BTA Equipment	$ 7,988,889
Cogeneration Equipment	$ 5,671,712
Auxiliary Equipment	$ 555,556
Building Costs	$ 8,003,704
Engineering	$ 4,744,444
Startup	$ 1,407,407
Optional Equipment	$ 0
Project Contingency @ 10%	$ 2,909,764
Total Project Capital Costs	**$ 32,007,402**

**see Appendix E for equipment list and costs*

Table 5: Option 4 Capital Cost Summary*

Project Capital Item	Cost ($US)
Raw & Finished Materials Handling	$ 725,926
BTA Equipment	$ 7,988,889
Cogeneration Equipment	$ 11,098,148
Auxiliary Equipment	$ 555,556
Building Costs	$ 8,003,704
Engineering	$ 4,744,444
Startup	$ 1,407,407
Optional Equipment	$ -
Project Contingency @ 10%	$ 3,452,407
Total Project Capital Costs	**$ 37,976,481**

**see Appendix F for equipment list and costs*

The capital cost estimates above represent a reasonable preliminary cost estimates that are representative of each scenario's project costs, and can be used in determining and assessing the preliminary expectation of project feasibility and viability for each of the facility choices.

Preliminary Operational Cost Estimates

Preliminary operational cost estimates for some key parameters are provided in Appendix G, based on each of the previous section's described options. These operational costs do not represent the complete operational costs the plants may or will occur, as they are conceptual views of some key parameters. Detailed operational costs will have to be developed based on the specific plant requirements and supplier of vendor contracts for chemicals, etc.. Some preliminary operational cost estimates were developed based on the CCI Newmarket facility operational factors and their expected application in the Cowpens regional area. The facility should be energy self sufficient, saving some purchased operational costs. Table 6 below provides preliminary cost estimates for key operational cost areas for the Biomass/Cogen facility.

Table 6: Some Key Preliminary Operational Cost Estimates

Operating Cost Area	Cost ($ per Input Ton)
Plant Staffing	$8.00 - $10.00
Fresh Water	$0.10 - $0.20
Waste Water	$0.15 - $0.20
Solid Waste (w/o market recycling)	$4.00 - $4.25
Process Equipment Maintenance	$2.75 - $3.00
Electrical Maintenance	$0.80 - $1.00
Building/Property Maintenance	$0.15 - $0.25
Handling Equipment Maintenance	$0.25 - $0.30
Biofilter Maintenance	$0.15 - $0.25
Chemicals (defoamer/flocculents/agents)	$2.50 - $3.00
Plant Operating Fee	$1.20 - $1.25
Plant Operating Contigency Funds	$1.10 - $1.50

The preliminary operational cost estimates shown are reasonable estimates that do not appear to add detrimental cost areas to the operations and negatively affect the mill's operational cost structure.

Optional Equipment

The capital cost lists show a sheet for "optional equipment", which has been zeroed out for the purposes of the preliminary capital cost estimates. These optional equipment items are presented because the eventual Biomass/Cogen facility could take advantage of additional optional equipment to either increase the biomass feedstock grades or types of materials that can be used, or provide value added conversion to some of the facility's residuals or waste by-products. This could include:

- Eddy Current Separator - can be used to separate waste materials into components, increasing the sales price or value in the appropriate recycled market.
- Magnetic Separator - can be used to separate ferrous materials out of residuals and wastes.
- MRF Sort Line - manned stations can sort high value materials out, such as newspaper or sorted papers from the input side, or aluminum cans and other high value items from the output side.
- Thermal Vessel Processing - can be used to break down non source separated wastes, MSW or other composite wastes to more efficiently remove the biomass component.

- Alternate Fuel Pelletizers - can be use to pelletize residuals including waste cellulose and/or polyethylene materials to produce an alternate fuel for sale as a stoker boiler coal substitute.
- Continuos Batch Washers - can be used to wash fiber or plastic residuals or byproduct to provide a cleaner more high quality material, increasing the sales price of the recycled material.
- Resin Pelletizers - can be used to pelletize plastic residuals to provide recycled resin pellets for sale to the plastic lumber or composite industry, increasing the facility revenue.
- Fluff Dryer - can be used to dry cellulose or plastic materials to decrease moisture content for shipping savings or for quality improvements that can increase the sales price of the materials.
- Roll-off or Liquid Tanker Truck - can be used to provide owner controlled transportation of feedstocks, using roll-offs for solid and tanker for liquid, to procure high volume sources.

The above optional equipment choices will have to be evaluated for their benefit individually or in combination. Some of the evaluation work can be done using vendor pilot facilities.

Conclusions

The Task 5 workscope provides for the following conclusions:

- The CCI/BTA technology is an effective anaerobic digestion technology which has provided reasonable justification that the BTA technology can effectively process the targeted animal manure and biomass raw materials.
- The CCI/BTA technology is a proven technology that based on the preliminary estimates and evaluations is reasonably assumed to be technically feasibly and viable for use in the Biomass/Cogen operations to produce biogas for use as fuel.
- The CCI/BTA technology currently is used in various facilities in Europe and Canada. A plant tour and technical evaluation of the startup operations at the CCI Newmarket facility provided preliminary verification of the technology's feasibility for use in the Biomass/Cogen facility.
- The options for cogeneration or boiler use of the biogas are based on reasonable assumptions and the chosen equipment provides for the use of the biogas as produced.
- Based on CCI's existing Newmarket production data and results, as well as BTA data for European facilities, the operational cost estimates that were developed are reasonable preliminary estimates for comparison and preliminary financial evaluation estimates.
- The preliminary capital cost estimates for each scenario has been reasonably estimated These cost estimates appear to be sufficient to cover the cost of equipment and facility construction and installation, and start-up requirements to achieve full production and business operations.

Appendix A
CCI/BTA Technology PFDs and Support Documents

Appendix B
Plant Tour Photos of CCI Newmarket Facility and Unit Operations

Appendix C
Option 1 Preliminary Capital Cost Estimate

Appendix D
Option 2 Preliminary Capital Cost Estimate

Appendix E
Option 3 Preliminary Capital Cost Estimate

Appendix F
Option 4 Preliminary Capital Cost Estimate

Appendix G
Preliminary Operational Cost Estimates