Funding provided by:

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Ausenco Sandwell

Process Infrastructure

Power & Energy

Project No. 114800
Revision Number 3

IAFBC
Abbotsford, BC

Project Definition and Feasibility Study for Poultry Litter and Animal Carcass Gasification Plant

13 December 2010

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Revision Status

Revision	Date	Description	Author		Approver	
			FirstName LastName	Position Title	FirstName LastName	Position Title
3	2010-12-13	Issued as Final	Ed Burnukoglu	P.Eng.		
2	2010-11-16	Final report	Ed Burnukoglu	P.Eng		
1	2010-10-15	Final report	Ed Burnukoglu	P.Eng		
0	2010-08-18	Draft Report	Ed Burnukoglu	P.Eng.		

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Funding Acknowledgement

This report was funded by the Investment Agriculture Foundation of BC through the Livestock Water Tissue Initiative. The Foundation manages and distributes federal and provincial funds in support of innovative projects for the benefit of BC's agriculture and agri-food industries.

Executive Summary

In broadest terms, the purpose of this study is to investigate the economic and operational feasibility of gasification of poultry litter, spent hens and specified risk material (SRM). The feasibility study is based around a specific example site and a defined volume of feedstock with known characteristics. The main goal of the gasification project will be to turn waste management problems into renewable energy production and net environmental benefits.

The poultry industry is looking for ways to divert poultry litter from sensitive aquifers. The industry is also feeling increased pressure to find alternatives to land application of poultry litter due to the ever intensifying land squeeze in the Lower Mainland. In addition, the poultry industry is looking for a less costly way to dispose of spent hens. For its part, the abattoir industry is facing unprecedented waste disposal costs for SRM as a result of tightening regulations. It has become a business imperative for the abattoir industry to find alternative waste management options at a lower cost.

Investment Agriculture Foundation of British Columbia (IAFBC) and the Ministry of Agriculture (MoA) are trying to assist the agricultural industry and local governments in preparing for emergencies resulting in mass animal mortalities. In certain situations, combustion would be the only appropriate, safe and legal emergency disposal alternative. No suitable combustion capacity exists within a reasonable transportation range from the Lower Mainland, which is the geographical area of B.C. where emergency animal carcass disposal is the most challenging. To have emergency combustion capacity available in an instant at the time of need the facility in question must be able to operate continuously based on a solid business model, independent of emergencies, built around continuous waste streams, such as poultry litter, spent hens, and SRM.

With this as a backdrop the poultry industry and abattoir industry have come together with IAFBC and MoA as a steering committee to investigate if gasification with the purpose of generating energy may present a feasible solution to their combined issues. To this end, the steering committee wishes to develop a site-specific economic feasibility assessment for gasification of poultry litter, spent hens and SRM on a continuous basis, with the ability to significantly increase the animal carcass tissue component of the feedstock in the event of an emergency.

Ausenco Sandwell has been retained to provide project definition, feasibility study and capital cost estimate for a poultry litter and animal carcass tissue gasification plant.

The selected host site for energy sales is Lehigh cement plant in Delta, BC.

The selected energy generation path for the gasification plant would be to produce syngas to be used directly in the cement kiln.

The gasification plant will supply about 75 GJ/h of energy to the cement kiln, which represents approximately 10-15 % of total energy usage for the kiln.

The design feedstock volumes for the gasification plant are as follows: 117 t/d broiler chicken litter, 29 t/d turkey litter, 10 t/d spent hens, 15 t/d cow SRM, and 4 t/d cow non-SRM, for a total feedstock volume of 175 t/d.

The gasification plant will normally operate 300 d/a to allow for scheduled and unscheduled shutdowns for the cement kiln, as well as normal scheduled maintenance shutdowns for the gasification plant.

The operational scale of the gasification plant will be to process 175 t/d of poultry litter and animal carcass tissue based on 300 d/a of operations.

The emergency feedstock processing capacity of the plant will be approximately 140 t/d.

The selected gasification plant technology is a pressurized bubbling fluid bed reactor, complete with gas cooling, gas cleaning and conditioning equipment to produce a clean burning gas.

The estimated capital cost of the Project is approximately $49,950,000. The summary breakdown of the capital cost estimate is as follows.

CAPITAL COST SUMMARY	
DIRECT COSTS	**$CAD**
Site works	**6,221,000**
Fuel receiving, storage and handling	**17,562,700**
Gasification plant	**9,656,000**
Power supply	**947,000**
TOTAL DIRECT COSTS	**34,387,200**
INDIRECT COSTS	**7,220,000**
TOTAL DIRECT AND INDIRECT COSTS	**41,607,200**
CONTINGENCY ALLOWANCE (20%)	**8,342,800**
TOTAL PROJECT COST	**49,950,000**

The accuracy of the above estimate is -20/+30%.

The total annual energy deliveries will be approximately 540,000 GJ/a.

The financial analysis indicates that with the current project capital cost the project is not financially viable with a Net Present Value (NPV) of $-21,100,000.

For the initial analysis, Sandwell Ausenco has used the most favourable values, i.e. those which will provide the maximum financial returns. The less favourable values of the variables were used in second financial analysis. The favourable values used in the analysis are; 30 $/t tipping fee for spent hens, 264 $/t tipping fee for SRM, 15 $/t transportation cost for poultry litter, and 15 $/t CO_2 carbon offset credit.

Using the most favourable values, the projected net present value (NPV) is negative for the 70/30 % debt/equity case. The projected real rate of return on equity (ROE) for the proposed new gasification plant is also negative. For this project to have a NPV of $0 and not changing any of the assumptions, a government contribution of $24.3 million would be required.

The above executive summary highlights the main points of the report, which follows.

Addendum to Executive Summary

As stated in the preceding Executive Summary, the project as described in the present report does not lend itself to an economically feasible undertaking, due to mainly very high capital costs and also due to low tipping fees specified in the original request for proposal. The GIAC committee has suggested that an attempt be made to lower the capital cost as much as possible and increase the tipping fees to the values which are more in line with current costs to the producers. This addendum describes the potential cost savings options, and proposes an alternative electric power generation system.

One of the most costly components of the project is the 30 day fuel storage and handling facilities as described in the following report. The requirement for a 30 day storage facility was due to the need to accommodate the periods when the cement kiln is shutdown and no syngas can be delivered to the energy host. This required a very large enclosed storage building, a very costly and elaborate odour control system and auxiliaries. It was suggested that the fuel storage requirements be reduced to maximum ten days to allow for normal stoppages in fuel deliveries. In addition, to compensate for shortness of fuel storage space, it was suggested that a secondary path of syngas utilization be installed in the form of electric power generation to allow the gasification plant to continue to operate without disrupting the fuel deliveries during periods of cement kiln shutdowns. It was also suggested that this secondary energy generation path might also be very useful during emergency periods if and when they happen to coincide with the cement kiln shutdown periods. Although this approach would add significant costs to the project, it was decided that the additional costs would be justified in terms of potential benefits it may bring to the project.

The following is a brief description of the proposed changes to the project:

- Reduce the fuel storage requirements to ten days,
- Install a secondary syngas energy utilization path in the form of electric power generation,
- Increase the number of days of operation from 300 to 341 per year
- Maintain the same annual amounts of spent hens and SRM but increase the broiler and turkey litter to 51,000 tonnes per year

Proposed Changes to Fuel handling System

The initial study results were presented to the GIAC Steering Committee members, 20 September 2010. As presented, the project was not economically viable; consequently, instructions were given to reduce the capital and operating costs by undertaking several measures.

In the fuel handling area, the prime measure identified for reducing the capital cost was to reduce the fuel storage capacity from 30 days to 10 days. Subsequent to the meeting and upon further study, it was found that the 10days worth of poultry litter could be stored in two (2) silos, thereby eliminating the large fuel storage hall and minimizing the overall area required for the site. Additionally, it is possible to reduce the costly odour control system to $1/10^{th}$ of the previous size. Also, the silo system has 100 % live-storage, meaning that it is possible to eliminate the mobile equipment and the operating personnel in the fuel handling area.

Project Memorandum 05, Fuel Handling System, Alternative #1, which describes the alternative system for the fuel handling area, is included in the Appendix I.

Proposed Alternative Electric Power Generation Path

As an alternative option, the use of the syngas in specially designed commercially available reciprocating engines to generate electricity is proposed. General Electric Company supplied Jenbacher engines are commercially being used for the purpose of generating power using low btu syngas. Four to five Model JMS-620 generating units will be required to consume all the syngas generated. Each unit is capable of producing 3,000 kW on natural gas, and the predicted power generation with syngas would be about 1,944 kW, and the guaranteed power generation would be 1,494 kW. For the purpose of this alternative estimate, four (4) units are proposed. The total guaranteed power generation would be 12,000 kW on natural gas, and 6,000 kW on syngas. If an economically feasible Power Purchase Agreement (PPA) can be negotiated, the power plant can operate on natural gas throughout the year producing 12,000 kW power for sales to grid, and during cement kiln shutdown or emergency periods the plant can switch over to a combination of syngas and natural gas, generating 12,000 kW, and generating additional revenues for the project. Some typical layouts and a process flow diagram are included in Appendix I.

Alternative Capital Cost Estimate Summary

ALTERNATIVE CAPITAL COST SUMMARY	
DIRECT COSTS	**$CAD**
Site works	**3,980,700**
Fuel receiving, storage and handling	**9,935,300**
Gasification plant	**9,656,000**
Power supply	**947,000**
Power generation (4xJMS-620 Reciprocating engine generator system)	**12,671,000**
TOTAL DIRECT COSTS	**37,190,000**
INDIRECT COSTS	**7,810,000**
TOTAL DIRECT AND INDIRECT COSTS	**45,000,000**
CONTINGENCY ALLOWANCE (20%)	**9,000,000**
TOTAL PROJECT COST	**54,000,000**

The accuracy of the above estimate is -20/+30%.

The total annual energy deliveries will be approximately 615,000 GJ/a from the gasification and 311,000 GJ/a from using natural gas to generate electricity.

The financial analysis indicates that with the current project capital cost the project is not financially viable.

Again Sandwell Ausenco has used the most favourable values, i.e. those which will provide the maximum financial returns. The favourable values used in the analysis are; 30 $/t tipping fee for spent hens, 264 $/t tipping fee for SRM, 15 $/t transportation cost for poultry litter, and 15 $/t CO_2 carbon offset credit. It is unclear what contract could be negotiated with BC Hydro for purchasing the electricity generated. The model assumes 3 cents over the cost of natural gas.

Using these values, the projected net present value (NPV) is -$3,500,000 in the 70/30 % debt/equity case. The projected real rate of return on equity (ROE) for the proposed gasification plant and electricity generation is 3.5%. For this project to have a NPV of $0 and not changing any of the assumptions, a government contribution of $4.0 million would be required. A $4.0 million contribution would also raise the real ROE to 5.0%.

If BC Hydro was to purchase the electricity at 4 cents over the cost of natural gas the NPV increases to $5.1 million and the real ROE increases to 7.2%.

The above executive summary highlights the main points of the report, which follows in Appendix I.

1 Introduction

1.1 Background

In broadest terms, the project requires that the economic and operational feasibility of gasification of poultry litter, spent hens and specified risk material (SRM) be investigated. The feasibility study is to be based around a specific example site and a defined volume of feedstock with known characteristics. The main goal of the gasification project will be to turn waste management problems into renewable energy production and net environmental benefits.

The poultry industry has for a long time been looking for ways to divert poultry litter from sensitive aquifers. The industry is also feeling increased pressure to find alternatives to land application of poultry litter due to the ever intensifying land squeeze in the Lower Mainland. In addition, the poultry industry is looking for a less costly way to dispose of spent hens. For its part, the abattoir industry is facing unprecedented waste disposal costs for SRM as a result of tightening regulations. It has become a business imperative for the abattoir industry to find alternative waste management options at a lower cost.

Investment Agriculture Foundation of British Columbia (IAFBC) and the Ministry of Agriculture (MoA) are trying to assist the agricultural industry and local governments in preparing for emergencies resulting in mass animal mortalities. In certain situations, combustion would be the only appropriate, safe and legal emergency disposal alternative. No suitable combustion capacity exists within a reasonable transportation range from the Lower Mainland, which is the geographical area of B.C. where emergency animal carcass disposal is the most challenging. To have emergency combustion capacity available in an instant at the time of need it is required that the facility in question is able to operate continuously based on a solid business model, independent of emergencies, built around continuous waste streams, such as poultry litter, spent hens, and SRM.

With this as a backdrop the poultry industry and abattoir industry have come together with IAFBC and MoA as a steering committee to investigate if gasification with the purpose of generating energy may present a feasible solution to their combined issues. To this end, the steering committee wishes to develop a site-specific economic feasibility assessment for gasification of poultry litter, spent hens and SRM on a continuous basis, with the ability to significantly increase the animal carcass tissue component of the feedstock in the event of an emergency.

It is an important component of this study to assess the opportunity for a facility like the one studied here to provide emergency animal tissue disposal capacity. However, it is not possible to achieve dependable emergency gasification capacity without having an independent solid business case for continuous daily operation. To have the gasification plant operating daily in accordance with a solid business plan based on continuously available feedstock is paramount for the facility to be in good order and ready to go with experienced operators in case of an emergency. That is why the feasibility for the daily operation should be considered a priority when balanced against the capacity for emergency animal tissue disposal.

1.2 Description of Intended Feedstock

1.2.1 Continuous Feedstock

Continuous Feedstock is intended to consist of constant proportions of poultry litter (majority), spent hens (minority) and SRM (minority). Average transportation costs for litter, hens and SRM is assumed to be $15.00 per tonne.

1.2.1.1 Poultry Litter

The type of poultry litter that is applicable to this project is broiler litter and turkey litter. Both fractions consist of feces, wood shavings or saw dust bedding material and some feathers. It is estimated that up to 120 tonnes/day or 43,800 t/a of broiler and turkey litter may be available for gasification (20 % of total poultry industry output in the Lower Mainland). The actual interest of supplying litter to a gasification project will depend on the economic upside of such an endeavour.

1.2.1.2 Spent Hens

Spent hens are birds that have reached the end of their productive life span as egg layers. In most cases the meat is not salvageable at a reasonable rate of return. Consequently, the bird carcasses become a waste product that is normally rendered for extraction of tallow and production of meat and bone meal. Rendering represents a cost to egg producers of approximately $30/tonne. Depending on the economical upside of an alternative involving gasification as much as 8 tonnes/day or 2,920 t/a of spent hens may be available.

1.2.1.3 Specified Risk Material (SRM)

At the beginning of July, 2007, enhanced animal health safeguards came into effect to help eliminate bovine spongiform encephalopathy (BSE), or mad cow disease, from Canada. To this end, stringent requirements for disposal (destruction or containment) were introduced for certain cattle tissue capable of transmitting BSE. This tissue has been termed specified risk material (SRM). SRM is defined as the skull, brain, trigeminal ganglia (nerves attached to the brain), eyes, tonsils, spinal cord and dorsal root ganglia (nerves attached to the spinal cord) of cattle aged 30 months or older, and the distal ileum (portion of small intestine) of cattle of all ages. The SRM discussed here is a continuous waste product from the abattoir industry combined with normal continuous production losses from animal husbandry industries.

Canadian Food Inspection Agency (CFIA) who regulates SRM management has put rules in place for the destruction of SRM through “combustion”. Dual chamber incineration at high enough temperatures and with certain demands on temperature monitoring is approved as a safe SRM destruction method under these rules. Gasification, which is the technology that is investigated in this study, at the same temperatures, while meeting the same temperature monitoring and design criteria, would also be acceptable. It is required to fit the operational parameters of the investigated gasification project to the CFIA SRM destruction criteria relevant to gasification. The relevant SRM destruction criteria are:

1. The primary chamber is preheated to a minimum of 850 ºC prior to the addition of SRM. If the primary chamber is not preheated, any secondary chamber must be heated to a minimum of 850 ºC and maintained at or above this temperature during the entire incineration cycle, including the period of charging.
2. SRM remains in the primary chamber at a temperature of 850 ºC or above for the length of time required to reduce all organic inputs to ash. Alternate parameters in time and temperature may only be used if based on acceptable results of a specific risk assessment conducted or approved by the CFIA.
3. Upon exhausting, all matter volatilized by the primary chamber is further subjected to an additional controlled residency time of at least 2 seconds in secondary chamber at a minimum temperature of 850 ºC.

Current disposal pathway represents a cost to abattoirs of $264/tonne. Depending on the economical upside of an alternative involving gasification as much as 12 tonnes/day or 5,475 t/a of SRM may be available from the Lower Mainland with additional 3 tonnes/day potentially available from Vancouver Island and Southern Interior combined.

1.2.2 Occasional Emergency Feedstock

It is hoped that the gasification facility proposed here also may provide temporary animal carcass disposal capacity for occasional emergencies, such as BSE (bovine spongiform encephalopathy) or avian flu outbreaks. In such an event, the normal daily feedstock would be disrupted in favour of a significantly increased proportion of animal carcass tissue. The type of animal tissue would vary depending on the type of emergency. For example, the tissue in question would be exclusively poultry in the case of an Avian Influenza emergency, while a flood scenario would generate a mix of tissue with an emphasis on cattle tissue and related SRM. The maximum proportion of animal tissue in the gasification feedstock would be determined by the technical limitation of the gasification.

2 Site Location

The selected site for the feasibility study is the Lehigh cement plant in Delta, B.C.

This site was selected for the following reasons:

- Lehigh cement plant as a host will be able to utilize all the syngas generated by the gasification plant to be used in their cement kiln, and
- There is a large land area available for the gasification plant at close proximity to the cement kiln.

The Project Memorandum No.2 Site Evaluation and Selection in Appendix B describes in more detail the process of comparison, evaluation and selection of candidate site amongst other roster sites.

3 Energy Host

The Lehigh cement plant in Delta was selected as the host for the energy generated by the gasification plant.

The average fuel energy usage is about 525 GJ/h.

Their main fuel is pulverized coal used in the cement kiln, with additional alternate fuel such as used tires. Natural gas is used only for start-up.

As a host, the cement plant can take the syngas from the gasification plant, and it can be introduced directly into the kiln preferably at the front end through a dedicated burner/nozzle arrangement.

The gasification plant can supply about 10-15 % of the total fuel energy requirement in the plant, during normal production periods when the kiln is in operation.

The main incentive for the plant would be to be able to sell “Green Cement” (cement made from carbon neutral fuel) as will as to lower their overall fuel costs, to lower their carbon footprint and generate additional savings through a lower carbon tax.

The cement plant goes through regular maintenance shutdowns lasting approximately three weeks. During these shutdown periods the cement plant cannot accept the syngas from the gasification plant.

4 Energy Generation Path

The selected energy generation path for the gasification plant would be to produce syngas to be used directly in the cement plant. The syngas generated will have to be conditioned, cleaned, cooled as required for acceptable quality for the cement kiln operation and transported to the cement kiln. A dedicated burner nozzle arrangement will be used to burn the syngas in the cement kiln.

Based on this concept, the gasification plant will not need any air pollution control equipment, and will not have any additional emission source. The existing cement kiln air pollution control equipment will handle the additional flue gas generated from the syngas. It is anticipated that, the replacement of coal fuel with syngas will not significantly increase or decrease the present levels of emissions from the cement kiln operations.

It is estimated that the net total energy delivery to the cement kiln in the form of syngas will be in the order of 75 GJ/h on the basis of chemical and sensible heat (to be confirmed by selected technology supplier). The amount of energy delivered would be equivalent to 20.8 MWt.

5 Operational Scale of the Gasification Plant

As mentioned in section 3, the cement plant host shuts down for a period of three weeks for regular planned maintenance at least once a year. Depending on the market conditions and inventory conditions, more frequent scheduled shutdowns can be expected. As project design criteria, it is decided that the gasification plant design will allow for at least two (2) shutdowns per year, each lasting three weeks. This criterion will determine on site fuel storage requirements as well as the nominal plant capacity.

Allowing for two (2) 21-day shutdowns per year, and also allowing for normal plant availability of about 90-95 %, the plant operational scale will be based on 300 d/a (days per annum) or 7,200 h/a (hours/annum) continuous operation.

5.1 Feedstock Volumes

The gasification plant will be designed for the following continuous yearly as received feedstock volumes.

- Poultry litter, 120 t/d, 365 d/a, 43,800 t/a,
- Spent hens, 8 t/d, 365 d/a, 2,920 t/a, and
- SRM, 15 t/d, 365 d/a, 5,475 t/a.

Based on 300 d/a continuous operation, the gasification plant nominal operational scale will be defined as follows.

- Poultry litter, 146 t/d (80 % broiler litter, 20 % turkey litter), 300 d/a, 43,800 t/a,
- Spent hens, 10 t/d, 300 d/a, 3,000 t/a, and
- SRM, 19 t/d, 300 d/a, 5,700 t/a.

The total nominal feedstock processing design capacity of the gasification plant will be 175 t/d with above fuel mix proportions.

5.2 Design Fuel Mix

Based on the above feedstock volumes and proportions, the gasification plant design fuel mix will be defined as follows.

Table 5.2 Fuel Mix Analysis

	Units	Broiler Chicken Litter	Turkey Litter	Spent Hens	Cow SRM	Cow Non-SRM
Ultimate Analysis-Dry Basis						
Carbon	**%wt**	40.41	43.29	53.33	70.32	57.66
Hydrogen	**%wt**	5.20	5.68	7.81	10.27	8.65
Nitrogen	**%wt**	4.31	4.65	8.05	2.89	4.56
Sulphur	**%wt**	0.60	0.42	0.47	0.24	0.28
Ash	**%wt**	19.23	13.23	11.69	3.01	10.93
Oxygen	**%wt**	30.25	32.73	18.64	13.27	17.90
Total	**%wt**	**100**	**100**	**100**	**100**	**100**
HHV	**kJ/kg**	16,400	18,220	24,290	27,970	27,880
LHV	**kJ/kg**	15,290	16,700	22,610	25,760	24,015
As Received Fuel Quantity	**t/d**	**117**	**29**	**10**	**15**	**4**
As received Moisture Content	**%**	**22**	**43**	**59**	**45**	**47**

6 Gasification Plant Description

6.1 Fuel Handling, Receiving and Storage

6.1.1 Poultry Litter

Poultry litter will be delivered by self-unloading trucks equipped with 40' – 53' trailers. The trucks will drive into the storage building through fast-acting doors and will discharge their loads onto the floor. Broiler litter and turkey litter will be stored in separate piles, as the moisture contents are quite different. A front-end loader will be utilized to build the storage piles. The loader will reclaim material from the piles and will mix it so as to maintain a relatively stable moisture content. The loader will move the mixed poultry litter to an in-floor, live-bottom reclaimer.

The reclaimer will have 8 hours of live-storage, so that the front-end loader doesn't have to be operated during the night shift. The reclaimer will be variable speed and will discharge through a lump breaker onto a belt conveyor, which will transport the litter to a scalping screen located in a tower adjacent to the gasifier building. The belt conveyor will be equipped with a belt weigh scale to measure the flow from the storage building.

Reject over-sized material passing over the end of the scalping screen will fall into a bunker, which will be periodically emptied and trucked to landfill. Acceptable sized material passing through the screen will fall onto a short belt conveyor, which will transport the litter to a fuel mixer where the animal tissue will be introduced into the flow. This belt conveyor will be equipped with a magnet for removing tramp ferrous metal.

The fuel mixer will mix the litter and animal tissue to provide a uniform fuel quality and will discharge it into a screw conveyor system, which will transport the fuel mix to the fuel feed bins, which are located in the gasifier building. A bypass is included, which will permit the conveyor system to be emptied under an emergency situation. The fuel bins, which are supplied with the gasifier package, will meter the fuel into the gasifier.

6.1.2 Animal Tissue

Animal tissue will be pre-processed off-site, where it will be ground-up to a pumpable form and treated with a chemical, which will prolong its storage life. The animal tissue will be delivered in sealed containers by truck. The trucks will discharge their loads into a receiving hopper from which the animal tissue will be pumped to three (3) storage tanks. The tanks will be equipped with variable speed extractors, which will discharge into metering pumps. The metering pumping system will discharge into the fuel mixer. The receiving hopper will be housed in an enclosed building.

6.1.3 Fuel Feed Control System

The normal fuel mixture delivered to the gasifier will be 83 % poultry litter and 17 % animal tissue; but the reclaim systems for each stream will be variable speed so that the amounts of material can be varied as required. Additionally, the entire fuel feed system from both streams between the storage units and the fuel feed bins will be variable speed and will be kept full; the intent being that the feed system can respond immediately to the level controls in the fuel bins thereby minimizing the lag time and enabling a near constant fuel level to be maintained.

6.1.4 Fuel Storage

Space has been provided for up to 30 days of storage for both poultry litter and animal tissue; the intent being to permit the facility to continue to receive fuel when the host plant is shut down and the gasifier is not working. The poultry litter will be stored in a totally enclosed building. The animal tissue will be stored outdoors in sealed tanks.

6.1.5 Dust Control

A dust control system will be installed at the poultry litter storage building, which will collect dust from the poultry litter reclaimer, the conveyor from the storage building and the conveyor to fuel mixer. Material discharged from the dust collector will discharge onto the conveyor from the storage building. The dust control system will consist of a high efficiency cyclone and fan and will be equipped with a spark detection and deluge system.

6.1.6 Odour control

Air will be withdrawn from the poultry litter storage building, the animal tissue receiving building and the animal tissue storage tanks by an odour control system; thereby keeping them under a negative pressure and minimizing the leakage of odours. The odour control system will be equipped with a biofilter. All exterior conveyors will be sealed and vented to the odour control system.

6.1.7 Truck Scale / Undercarriage Wash

All trucks entering and leaving the site will pass over a truck scale and will be weighed in and out.

A truck washing and disinfecting system will be provided so that the trucks can be cleaned before re-entering the public roadways. Water will be collected, filtered and recirculated through the system. Make-up water and disinfecting chemicals will be added as required.

All of the roads and yard will be paved and will be drained to a common sump, from which heavies and floaters will be removed, prior to being drained to the municipal sewer.

6.1.8 Fire Protection

Fire protection systems will be provided for all fuel handling areas including the litter storage building, the animal tissue receiving building, the conveyors and the truck wash building. Fire protection systems will include sprinkler systems and fire hose stations.

6.1.9 Operation

The truck scale is the unattended type, with control panels located adjacent to the truck driver's door. Traffic lights will be provided to control entry onto the scale. The scale will be connected via a LAN to the plant information system.

6.1.9.1 Poultry Litter System

During the daytime, when poultry litter trucks are being processed, a person will be operating the front-end loader in the litter storage building. The operator will build the storage piles, reclaim material from the piles and build a pile over the in-floor reclaimer.

The poultry litter reclaimer and conveyor system will be controlled from the main plant control room. CCTV will be provided in key locations to give the operator visual contact with the area. Other systems, such as the dust control and odour control systems will also be controlled from the main plant control room via an HMI.

6.1.9.2 Animal Tissue System

When a truck delivering animal tissue is being processed, the truck driver will notify the plant operator via an intercom that he has dumped his load into the receiving hopper. The plant operator will select one of the tanks to receive the material and then start the transfer pump, which will run until the receiving hopper is empty or the tank is full.

The animal tissue metering system will be controlled from the main plant control room. The operator will be able to select the tank from which to remove animal tissue and will be able to control the appropriate blend of animal tissue and poultry litter to suit the current gasifier operating conditions.

6.1.9.3 Truck Washing System

The truck washing system is entirely automatic. Sensors will detect when a truck approaches and will open the doors and start the pumps and blowers. Likewise, sensors will detect when a truck has exited the facility and will stop the pumps and close the doors.

Refer to the Fuel Handling System process flow diagram, which is included in the appendices.

6.2 Gasification Plant Technology Supplier Selection

Based on the selected host's energy offtake requirements, the gasification plant energy delivery option was determined to be simply to generate syngas which will be directly transported to the cement kiln for final combustion.

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Based on the above selected energy generation path, the following technology suppliers were invited to submit a proposal based on their own process design experience:

- Krann Engineering (Canada),
- Primenergy LLC (USA),
- Energy Products of Idaho (USA),
- Frontline Engineering Inc. (USA), and
- Res/OP (Canada).

Primenergy LLC and Energy Products of Idaho declined to submit proposals.

Based on the Comparison of Tenders (COT) of the remaining three (3) technology suppliers' proposals, FRONTLINE Engineering was selected as the technology supplier for the purpose of this feasibility study.

6.3 Gasification System Process Description

The proposed gasification system is a pressurized, bubbling bed gasifier which will convert a mixed feedstock containing poultry litter and animal carcass tissue into a very clean burning fuel gas. The pressurized system eliminates the need for complete cooling and compressing of the producer gas (syngas), greatly simplifying the system.

Frontline's process approach employs dry sorbent (limestone) injection into the gasifier and high efficiency particulate filtration after gas cooling step to remove particulate matter, alkali and chloride constituents before combustion. By trapping these contaminants in the fuel gas at pressure, the cost of controlling them is greatly reduced. In addition, problems relating to fouling and corrosion are virtually eliminated since the alkali and chloride are removed before delivery to the burner. The amount of chlorine in the feedstock is very high. The proposed system has been shown to virtually completely capture chlorine from biomass feedstocks, and capture more than 90 % of chlorine from refuse-derived fuel type feedstocks.

Gasification based energy production has the potential to provide superior process efficiency, reliability, and emissions profile, relative to direct combustion. The advantages of the gasification-based approach are particularly pronounced when the feedstock to be converted into energy is challenging.

The heart of the proposed gasification system is its pressurized bubbling fluidized bed reactor. Fluidized beds are well known for their excellent fuel particle size flexibility, and their ease of scalability. In addition, the bubbling fluidized bed design gives the system good temperature stability compared to other gasifier systems. Large masses of sand bed media keep the reactor temperature stable in the face of rapidly changing feedstock conditions.

Feedstocks that are high in ash content or feedstocks that have high level of alkali (potassium and sodium), phosphorus, chlorine, and sulphur in their makeup present difficult challenges to combustion based approaches. The proposed gasification system which combines high efficiency bubbling fluidized bed conversion with dry sorbent injection and high efficiency filtration has the ability to convert these difficult fuels efficiently into a clean-burning combustible fuel gas.

By including dry sorbent injection technology with the gasifier, the proposed gasification system can capture chlorine in solid form, which is then captured in a high efficiency hot gas filter, along with fine precipitated alkali and other particulate matter.

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6.4 Gasifier Operating Parameters

Table 6.4.1 Feedstock

Description	Units	Quantity
Heating value of feedstock, dry basis, HHV	kJ/kg	18,523
Moisture content	%	30.86
Carbon content-dry basis	%	44.32
Hydrogen content-dry basis	%	5.91
Nitrogen content-dry basis	%	4.53
Sulfur content-dry basis	%	0.52
Oxygen content-dry basis	%	27.92
Chloride content-dry basis	%	0.56
Ash content-dry basis	%	16.24
TOTAL	**%**	**100.00**
Chlorine sorbent requirement, % of dry fed	%	1.80
Bed media purge/makeup, % of dry feed	%	10.09
Stoichiometric air/oxygen requirement-dry fuel	kg/kg	6.41

Table 6.4.2 Gasifier Parameters

Description	Units	Quantity
No. of gasifier trains		1
Blast		Air
Blast rate	Kg/h	8,727
Gasifier operating pressure	Bar(a)	2.80
Gasifier operating temperature	C	816
Total system efficiency	%	82.7
Hot gas efficiency	%	80.2
Carbon conversion	%	90.00
Carbon content in biomass char	%	20
Biomass char heating value (HHV)	kJ/kg	6,419
Delivered syngas energy content (chemical + sensible)	GJ/h	75
Cold gas energy content (chemical only),	GJ/h	66.5
Feed, HHV energy basis	GJ/h	94
Gasifier air compressor	kW	550
Other power consumers	kW	225

Table 6.4.3 Producer Gas Parameters

Description	Units	Quantity
Producer gas rate	Kg/h	15,144
Producer gas delivered temperature	C	413
Producer gas heating value (wet basis)	kJ/kg	4,361
Producer gas moisture content	%	20
Producer gas molecular weight (wet basis)		24.1
Producer gas HHV (wet basis, normal conditions)	kJ/m3	4,433
Producer gas molecular weight (dry basis)		26.8
Producer gas HHV (dry basis, normal conditions)	kJ/m3	5,555
SYNGAS COMPOSITION, POST FILTER, % Vol (wet basis)		
CO	%	13.9
H2	%	10.00
CH4	%	3.9
C2H4	%	1.4
C2's-other	%	0.2
C3's	%	0.1
CO2	%	11.2
H20	%	19.8
N2	%	39.1
Tars (as naphthalene)	%	0.28
NH3	%	0.95

Table 6.4.4 Material Flows and Utilities

Description	Units	Quantity
Feedstock, dry basis,	t/day	120
Feedstock-as received	t/day	175
Sorbent (chlorine)(Limestone)	t/day	2.2
Bed media	t/day	12.25
Char-ash production	t/day	27.22
Gasifier electrical power requirement	kWe	770
Gasifier air	kg/h	8,727
Cooling water		Not Required
Steam		Not Required
Nitrogen		Not Required

Description	Units	Quantity
Natural gas (for start-up only)		
Instrument air		Not Required
Plant air		Not Required
Capacity factor	%	90
Feedstock (bone dry)	t/a	36,000
Feedstock-as received	t/a	52,500
Sorbent (limestone)	t/a	660
Bed media (sand)	t/a	3,675
Biomass char produced	t/a	8,166
Number of days of operation	d/a	300

6.5 Civil Works

Civil costs are based on preliminary sketches and designs including the following major site related elements:

6.5.1 Earthworks:

Comprises the earthwork associated with clearing, stripping, mass earthwork cutting and filling including build-up of the site by an additional 3 metres.

6.5.2 Water Supply & Distribution:

The source of plant water supply is via a tie-in to the existing city water main within the Lehigh cement plant property limits. From here the water for plant and for fire protection systems usage is distributed to the face of the various buildings and conveyors and to a plant ring main fire hydrant system.

6.5.3 Domestic Sewer System:

Domestic sewer is collected at the various relevant collection locations and conveyed by domestic sewer to the existing Lehigh cement plant sewer system.

6.5.4 Storm Drainage:

The plant site area including roads and yards are drained to a common sump from whence it is piped to an existing municipal sewer.

6.5.5 Miscellaneous:

Miscellaneous additional civil considerations include such items as:

- Fencing,
- Security,
- Roads and paving, and
- Yard surfacing/paving.

6.6 Structural Considerations

Building superstructure costs are based on an analysis of written proposal quotations from three established pre-engineered building vendors, for the major process buildings, i.e., poultry litter storage building, truck wash, animal tissue receiving and gasifier building superstructures.

Administration office building budget costs were obtained from established temporary trailer suppliers as provided for similar industrial projects.

The remaining structural costs were calculated from quantities and their associated costs.

The quantities were established from:

- General arrangement and concept drawings,
- Pre-engineered building technical information submitted with their proposal quotations,
- In-house experience from previous relevant projects,
- Preliminary designs and detailed concept sketches broken down into various pay categories, and
- Detailed quantities take-off calculations per Ausenco Sandwell estimating standard practices.

6.7 Electrical Power System

A 69KV 3PH, 60 Hz BC Hydro transmission line will supply incoming power to the site. The transmission line will terminate at a main disconnect switch, in front of the plant main circuit breaker. The incoming voltage will be stepped down by transformers to 4160 volts for large motors, 600 volts for medium and small motors, and 120 volts for the control system, instruments and lighting.

Indoor switchgear shall generally consist of vacuum circuit breakers used for feeders, bus work, and necessary CTs, PTs, and protective equipment. Medium voltage switchgear and motor control centre shall generally consist of incoming vacuum circuit breaker or fused load break switch, feeder vacuum circuit breakers and motor starters. Metering shall include a power factor meter, volt meter and ammeter. Phase and ground over current protection shall be provided. All medium voltage switchgear, transformers, and MCCs shall be located indoors in a suitable electrical room.

Power for all instruments, PLCs, HMIs, and alarm systems shall be provided from a separate UPS supported power source. Control power will be 120 volts. Control power will have independent circuit breakers, regulating transformers, and control power distribution panels.

The electrical room will be suitably pressurized and air conditioned to limit the temperature to 30 degrees C. Fire detection equipment will be located in the electrical room. A centralized alarm panel in the control room will provide a central monitoring system for all fire systems. The fire detection system will be monitored and include ventilation system interlocks. All access holes will be sealed with approved fire stops and protected against entry of rodents and moisture.

General area lighting shall be provided by photocell controlled floodlights. Lighting along roads or in the parking area shall be conventional street-lighting luminaries or poles at a height of approximately 10 m. Emergency lighting will be provided where required such as around stairways, exits, and around equipment where personnel would otherwise be endangered in the event of a power failure. The emergency lighting shall consist of self-charging units complete with lamps, storage battery, charger and automatic transfer relay.

6.8 Process Controls

The general and sequential control of the plant shall be through a Programmable Logic Controller (PLC) installed in a separate panel in the electrical room. The PLC panel shall be constructed for floor mounting and the panel shall be suitable for bottom or top cable entry. Panduit wire enclosures will be used in the PLC panel. Any control relays will be fixed or din rail mounted in the PLC panel.

The PLC shall be provided with power from an uninterruptible power supply (UPS). The PLC shall be used to provide discrete and analog control/status of motors and field devices as necessary. The PLC may control/monitor motors using analog input and output modules or communicate with the motor starters over a recognized protocol such as DeviceNet or ProfibusDP for control and diagnostics. The PLC can be programmed and commissioned using software from a desktop or laptop computer using ethernet communication.

All emergency stop switches (pull cords or pushbuttons) shall be hardwired. Electrical supply for instrumentation will be 120 vac or 24VDC. 24VDC power sources will be installed in the PLC panel. The instrumentation shall be electronic with a 4 to 20 mA DC signal range. Any control valves shall be provided with electric actuators.

Manufacturers will supply devices for their own equipment. The PLC will utilize these devices to control and protect the equipment and personnel. Conveyors and other equipment may be installed with emergency pull cord switches, belt misalignment switches, speed switches, plug chute switches, start up horns/lights, and control stations to locally operate the equipment.

All motors shall be controlled from either a local start-stop/jog station located next to the motor or from a computer based human machine interface (HMI) system located in the control room. The HMI will communicate with the PLC over an Ethernet plant network. Through the HMI, the operator will be able to start and stop all plant equipment either independently or in a group. The operator will be able to monitor all equipment’s status and alarms. The HMI will have the capability of trending various data for the operator.

7 Capital Cost Estimate

7.1 Basis of Estimate

One capital cost estimate has been provided in Appendix E.

The estimate is based on the cost of equipment, material and labour as of third quarter of 2010 in Canadian dollars with no allowance for escalation.

7.2 Direct Costs

7.2.1 Civil/Structural

Civil and structural cost estimates are based on general arrangement drawings, concept sketches and pre-engineered building vendor technical proposal information.

Quantities for other associated building elements have been established from preliminary designs and concept design sketches.

Pre-engineered building costs are based on Vendor budget proposal quotations. Costs associated with these quantities have been calculated by Ausenco Sandwell estimating department’s recently updated data base information.

7.2.2 Mechanical

Equipment costs are based on preliminary design layouts and PFD and factoring of similar historic work.

Budget prices were obtained for the following major equipment:

- Gasification plant,
- Biomass receiving hopper,
- Scalping screen,
- Conveyors,
- Reclaimer,
- Animal carcass tissue storage tanks,
- Truck wash station, and
- Truck scale.

7.2.3 Piping

Piping costs are based on costs from previous projects of similar capacity and layout.

7.2.4 Electrical

Electrical equipment costs are based on preliminary motor lists.

Motors, starters and cabling costs are factored based on regularly supplied costing data using latest cost multiplier.

7.2.5 Instrumentation

Instrumentation costs are factored based on Ausenco Sandwell's current historical cost database.

7.2.6 Taxes and Freight

Freight is included in the individual items. HST is not included.

7.2.7 Duty

Duties are not included.

7.2.8 Construction Labour

The labour rates used reflect local labour rates and include fringe benefits, contractor overhead and profits and construction equipment rentals.

7.2.9 Construction Contracts

The estimate is based on the majority of the work being carried out under firm price lump sum contracts. No allowance is included for contracts awarded on a cost plus basis.

7.3 Indirect Costs

Allowances are made for the following indirect costs, (see summary sheets)

- Preliminary and detailed engineering,

- Geotechnical investigations and surveys,
- Construction management,
- Construction insurance,
- Temporary facilities,
- Commissioning and start-up assistance,
- Vendor erection supervision,
- Premium time spot,
- Living allowance and travel,
- Training, and
- Spares.

7.4 Contingency

A contingency allowance equivalent to a percentage of DIRECT and INDIRECT costs is included, (see summary sheets for the amount specific to each estimate). The contingency allowance is provided to cover those costs that are unforeseen at the time the estimate is produced and may become apparent as detailed design and construction proceed. The contingency does not provide for cost changes associated with scope changes.

7.5 Exclusions

The following costs are not included in this capital cost estimate:

- Land procurement,
- Removal of contaminated material,
- Owner's construction overhead,
- Fuel supply study,
- Environmental permitting, testing and modelling,
- BCTC transmission line and connection charges,
- HST,
- Mobile equipment,
- Escalation, and
- Interest during construction.

7.6 Capital Cost Summary

The detailed capital cost sheets are presented in Appendix F. The following table summarizes the total project cost estimate.

Table 7.6 Capital Cost Summary

CAPITAL COST SUMMARY	
DIRECT COSTS	**$CAD**
Site works	**6,221,000**
Fuel receiving, storage and handling	**17,562,700**
Gasification plant	**9,656,000**
Power supply	**947,000**
TOTAL DIRECT COSTS	**34,387,200**
INDIRECT COSTS	**7,220,000**
TOTAL DIRECT AND INDIRECT COSTS	**41,607,200**
CONTINGENCY ALLOWANCE (20 %)	**8,342,800**
TOTAL PROJECT COST	**49,950,000**

8 Operating Cost Estimates

8.1 Plant Personnel

Assuming the gasification plant is run as an independent operation, with no connection to the Lehigh cement plant operations, the following table is the suggested staffing breakdown.

Table 8.1 Plant Personnel

Position	Personnel
Plant manager	1
Operations manager	1
Shift engineers	4
Fuel handling operators	3
Maintenance technicians	4
Secretary/administrative assistant	1
Total	**14**

Assuming an average salary for these personnel, including benefits, training, overtime and payroll taxes of $70,000 per annum, gives an average payroll of $1,000,000 per year.

8.2 Plant Operations and Maintenance Costs

Annual operating supplies for the gasification plant are estimated as follows:

Table 8.2 Plant Operations and Maintenance Costs

Item	Unit	Cost
Limestone (660 t/a, @15$/t)	$/a	$10,000
Sand (3673 t/a @10$/t)	$/a	$40,000
Electricity (10GWh/a @ $60,000/GWh)	$/a	$600,000
Natural gas	$/a	$10,000
Mobile equipment and vehicle fuels	$/a	$100,000
Mobile equipment maintenance	$/a	$50,000
Spare parts	$/a	$50,000
Total	$/a	**$850,000**

8.3 Administration and Overhead Costs

Annual administration and overhead costs for the proposed plant are estimated as follows:

Table 8.3 Administration and Overhead Costs

Item	Cost
General office expenses	$20,000
Purchased professional services	$30,000
Insurance	$150,000
Property and other taxes, permits and licences	$150,000
Travel costs	$10,000
Environmental compliance testing, non-destructive testing	$40,000
Total	**$400,000**

8.4 Ash Disposal

It is assumed that char and fly ash is to be landfilled. Other uses, such as land application and use as an agricultural soil additive, or raw material for the cement plant operations could be investigated once the plant is in operation, and adequate chemical analysis and testing can be performed.

The total annual quantity of ash is estimated to be about 8,166 t/a.

It is estimated that the operation of landfill site in accordance with provincial environmental regulations would cost about $100,000/a. Transport of the ash from plant to the landfill site will depend on the distance. It has been assumed that a suitable site would be developed within 10 km. The annual cost of ash transportation is estimated to be $100,000/a.

The total ash disposal costs are estimated to be around $200,000/a.

9 Feasibility Assessment and Financial Analysis

9.1 General

For this study the gasification plant is to be located on the Lehigh cement plant site in Delta, BC. In the financial analysis it has been assumed that land and other infrastructure facilities would be provided to the gasification plant by Lehigh cement at no cost to the gasification project. It is also assumed that syngas would be sold to Lehigh cement at the coal fuel replacement cost, 6.50 $/GJ. Carbon offset credits for displacement of fossil fuel by burning bioenergy in the cement kiln has been accrued to the gasification plant. The gasification fuel qualifies for carbon credits valued at $15.00 per tonne and the plant will produce 59,400 tonnes of carbon suitable for the credit.

These assumptions create the most favourable financial situation for the proposed gasification plant. If this project proceeds, charges for use of the cement plant land and infrastructure, the selling price of the syngas, and the receipt of carbon credits would be the subject of negotiations between Lehigh cement and the gasification plant owners.

9.2 Income Tax

The rate of corporate income tax generally applicable to this bioenergy project if set up as a separate corporate entity in British Columbia, is 29 percent. Bioenergy projects are eligible for accelerated write-off off under Class 43.1 and 43.2 of the federal income tax act. This project meets the requirements of Class 43.2, where the annual heat rate from fossil fuel must be below 4,750 Btu / kWh (equivalent to 5.0 MJ / kWh). The applicable CCA rate is 50 % (declining balance).

Other project start-up expenses, such as feasibility studies, engineering and design work could quality as Canadian Renewable and Conservation Expenses (CRCE). These can be deducted in full in the year incurred and carried forward indefinitely.

Taxable income has been calculated as estimated gross plant profits less allowable depreciation as allowed under Class 43.2.

Dividend payments have not been considered in this analysis.

9.3 Syngas Price

The syngas produced will be used in the cement kilns to displace a portion of the pulverized coal used to fire the kiln. Syngas will displace about 14 % of the normal coal used and will provide 75 GJ/h of the total average energy consumption of 525 GJ/h.

The current cost of coal delivered to the cement plant site is about 100 $/tonne. This cost is equivalent to a net heat cost of 4 $/GJ. This is about half the current cost of heat from natural gas burning. In two years the cement plant will also be paying about $2.50 in carbon tax per GJ of heat from the coal.

For this study it is assumed that the syngas price will be 6.50 $/GJ as a direct replacement for the coal currently used in the cement kiln.

9.4 Gross Return on Investment

A simple method of evaluating the financial worth of a project is the gross rate of return on the total capital investment, before any interest charges, depreciation or taxes. The gross return of the proposed gasification project, operating at the full capacity, is summarised in Table 9.1.

Table 9.1 – Projected Gross Return on Plant Investment

Item	Amount $CAD
Total net annual revenues	$5,984,000
Total annual operating cost	$3,248,000
Gross annual operating profit	$2,736,000
Total capital investment	$49,950,000
Gross rate of return	5.5%

- The projected gross return indicates a payback period of 18 ¼ years for the total capital investment for the gasification plant. By normal industry expectations, this payback period indicates that this project is not attractive from a financial prospective.

9.5 Financial Projections

The assessment of financial viability of this proposed gasification plant is based on the cash flow projections for the period from the first draw down of capital funds to the end of the initial 20-year operating period. The projected cash flow statements and financial returns are presented in Appendix H.

Ausenco Sandwell has developed a computer model to test the profitability of the proposed biomass-fired gasification plant project. This model is based on a discounted cash flow analysis to determine the discounted rate of return on capital employed.

The model includes debt repayment and financing costs based on a 70 to 30 debt to equity ratio for the project. These rates of return on equity investment are calculated using the same discounted cash flow approach.

The model generates the cash flow projections and calculated real or inflation-free and nominal internal rates of return for the 20-year projection period. Major capital expenditures start about 12 months prior to plant start-up. The projections are expressed in constant dollars as at the third quarter of 2010, thus the projected returns are in real terms, that is, on an inflation-free basis.

The revenues from new gasification plant operations reflect the sale of syngas to the cement plant and tipping fees charged for the spent hens and SRM. Sale of carbon offset credits is also included as income for the gasification plant.

Cash outflows reflect the estimated gasification plant operating costs excluding depreciation. Capital expenditures include all estimated capital costs to be incurred by the plant project from its inception until the end of the 20-year analysis period. Provisions to reflect termination of the analysis are included on the 20th operating year, including working capital recovery and a nominal salvage value for the plant equipment.

It has been assumed that the proposed gasification plant will run at about 85% of capacity during the first year of operation and 100% from year two to year 20.

Starting in the third year of plant operation, an allowance had been included in the model for capital reinvestment in the plant for periodic major maintenance and upgrading of plant equipment. An allowance for replacement of mobile equipment is included every six years. These allowances are for maintaining equipment quality standards and operating efficiencies, as newer technologies become available. The reinvestment allowances are not intended to cover expenditures for major expansions of plant capacity, or normal maintenance and repairs.

The financing arrangement assumed for this study is a debt to equity ratio of 70 to 30. The interest payable on the debt was assumed to be 5.0 %/a, with interest during the construction period being capitalized. The debt repayment is assumed to be over a 15-year period commencing at the end of the first year of plant operation.

For this initial analysis Sandwell Ausenco has used the most favourable values, i.e. those which will provide the maximum financial returns. The less favourable values of the variables were not calculated

The projected cash flow, using the most favourable values for the cost variables, for a typical year and returns over the 20-year analysis period, are shown in and 9.3. The complete cash flow projections, over the 20-year analysis period, are presented in Appendix H.

Table 9.2 - Typical (Year 10) Gasification Plant Projected Cash Flow Statement – 70 / 30 Debt to Equity

	$/a
Revenues	$5,984,000
Operating cost	$3,248,000
Cash from operations	$2,736,000
Interest payment	$751,000
Income tax paid	$397,000
Capital reinvestment	0
Debt payment	$2,502,000
Net cash flow	-$914,000
Real return on equity (ROE)	negative
Real NPV	-$21,230,000

The projected net present value (NPV) is negative in the 70/30 debt/equity case. The projected real rate of return on equity (ROE) for the proposed new gasification plant is also negative.

9.6 Sensitivity Analysis

With large negative returns, even with the higher values for the selected variable costs, a conventional sensitivity analysis is not applicable. With up to 30 % changes in the revenue or cost streams, the projected returns remain negative.

To achieve a positive ROE and NPV the project capital cost would need to be reduced by about 50%, for the 70/30 debt/equity case. This would require some form of green energy subsidy or other grant to substantially lower the project capital cost.

Another way to make this project more financially attractive would be to charge higher tipping fees. An increase in tipping fees to 45 $/t for spent hens, 400 $/t for SRM, and charge 15 $/t for poultry litter (the trucking cost) would generate a projected real return of 1 % (4 % on a nominal basis) and a negative NPV of over $8 million.

10 Environmental Considerations and Air Quality Assessment

10.1 Air Emissions

Gasification technology differs fundamentally from combustion in terms of emissions. Taking advantage of the “window of opportunity” that gasification affords, to clean the producer gas prior to combustion means that the usual considerations for Best Available Control Technology (BACT), NOx, SOx, and VOC’s will have very different meanings and application in a gasification-based system. Those considerations will still apply to the combustion system for the producer gas, but strictly speaking, do not apply to the gasification system itself.

As explained in earlier sections, the energy generation path selected for the project is to produce syngas to be directly used in the host cement kiln as a supplementary fuel. Based on this principle, there will be no final incineration of the syngas within the plant boundary limits, hence no continuous emission source from the gasification plant. At times however, there will be an emergency flare stack during emergency shutdown and cold startup, and the syngas will be incinerated through the emergency flare. However, this is not considered as a normal, continuous emission source which needs to be continuously monitored and controlled.

The preliminary fuel analysis indicates that there is considerable amount of chlorine compounds in the fuel mix. Apart from being detrimental to the cement kiln operations, these chlorine compounds will create Chloride emissions through the cement kiln stack. The selected bubbling fluidized bed technology is proposing to employ a dry sorbent injection system to remove all chloride compounds from the syngas.

The dry sorbent media used for the removal of chloride compounds will be limestone ($CaCO_3$). Basically limestone calcines to CaO in the gasifier, and this material hydrates to $Ca(OH)_2$. Then $Ca(OH)_2$ reacts with HCl to initially form an intermediate compound, Calcium hydroxychloride CaOHCl, which then dissociates to form hydrated lime $Ca(OH)_2$ and calcium chloride (CaCl).

The limestone in the fluidized bed gasifier does not capture sulphur, since that reaction (which is very common in flue gas desulfurization processes) requires an oxidizing environment so that the lime can react with SO_2 : $Ca(OH)_2 + SO_2 = CaSO_4 + 2H_2O$. The limestone in the cement kiln should trap pretty much all of the SO_2 formed on combustion of the producer gas from an emissions perspective.

The syngas which will be transported to the cement kiln for final combustion will replace approximately 10-15 % of the fuel input in the form of fossil fuel (coal). In this respect, the introduction of the syngas into the cement kiln will not significantly increase or decrease presently existing emission levels from the cement kiln. However, a more detailed assessment of the impact on emissions due to introduction of syngas into the cement kiln operations will have to be undertaken during the next detailed phase of the project, and some actual testing will have to be performed to validate the results of the assessment.

In terms of CO_2 emissions (GHG) the proposed gasification plant will be carbon neutral. Based on the fuel mix analysis listed in Table 5.2 the feedstock will have carbon content of approximately 43.55 % on dry basis. This is equivalent to 53 t/d of elemental carbon in the 175 t/d of feedstock processed, which will generate about 58,569 t/a carbon dioxide based on 300 d/a operation. As a result, this project will result in the net reduction of carbon emissions equivalent to the amount of coal being displaced, which is 10-15% of the coal being used at the cement plant. This results in approximately 58,600 t/a carbon credits being generated. ,.

10.2 Ammonia Emissions due to Use of Poultry Litter as Manure

Handling and disposal of poultry litter has become an issue in the Lower Mainland, where most industry is located.

Presently most of the poultry litter is disposed in the form of surface applied low cost fertilizer.

Agriculture is a major source of ammonia emissions to the atmosphere, and land application of manure as fertilizer contributes approximately half of the ammonia emissions attributed to the agricultural activity.

Poultry litter as a nutrient source is frequently applied in excess of needs, so it is anticipated that removal of some poultry litter would not necessarily result in it being replaced by other nutrients (i.e. commercial fertilizer).

The diversion of part of the poultry litter generated in the Lower Fraser Valley for the gasification purpose will remove equivalent amount of poultry litter from land application and remove corresponding amount of ammonia emissions to the atmosphere.

Ammonia losses from poultry manure on the first day after application are approximately 20 % and eventually reach 80 % if the manure is not incorporated. Based on the total nitrogen in the poultry litter fuel mix, the quantity of avoided ammonia emissions would be approximately 2,000 t/a. In the Lower Fraser Valley airshed approximately 18,000 tonnes per year of ammonia are emitted. Removing 10,000 t/a of poultry litter that is spread would reduce ammonia emissions in the sensitive airshed by approximately 12% - 40% depending on the manure application process.

10.3 Leaching of Nitrates into Aquifiers

Application of poultry litter at rates that exceed crop nutrient requirements can result in high concentrations of nitrate in agricultural soils. Ground water contamination by leaching of nitrates is a serious concern over the Abbotsford Aquifer. Long term monitoring over this aquifer has shown that ground water nitrate concentrations generally exceed the Canadian Drinking Water Guidelines.

From poultry nutrient movement studies, it was found that although poultry litter produced on the aquifer generally leaves the area, an equal amount is brought back onto the aquifer area.

Reducing the amount of poultry litter applied over the aquifer area would reduce the risk of soil nitrate accumulation and would directly benefit the ground water resource of the aquifer.

Some ammonia emitted to the atmosphere is deposited locally through wet deposition (via precipitation) and may contribute to elevated soil nitrate concentrations as the ammonia converts to ammonium and then is nitrified in the soil to nitrate. Therefore, reducing overall ammonia emissions will also directly benefit the ground water resources of the aquifer.

Appendix A – Glossary of Terms

Glossary of Terms

Abbreviation	Term
a	annum
BSE	Bovine Spongiform Encephalopathy
^{o}C	Celsius
CCTV	Closed Circuit Television
CFIA	Canadian Food Inspection Agency
d	days
d/a	days per annum
GJ	Giga Joules (10^{9} Joules)
GJ/a	Giga Joules per annum
GJ/h	Giga Joules per hour
GST	Goods and services Tax
h	hour
HHV	High Heat Value
IAFBC	Investment Agriculture Foundation of British Columbia
J	Joules
k	kilo (1000)
kg	kilogram (1000 g)
kJ	kilo Joules
kJ/kg	kilo joules per kilogram
kJ/m^{3}	kilo joules per cubic metre
kW	kilo Watt
LHV	Low Heat Value
NPV	Net Present Value
ROE	Return On Equity
SRM	Specified Risk Material
t	metric tonne (1000 kg)
t/d	tonnes per day
t/a	tonnes per annum

Appendix B – PM No. 3 Site Evaluation and Selection

Appendix C – PM No. 4 Project Concept Definition

Appendix D – Gasification Plant Technical Specifications

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Appendix E – Technology Supplier Proposals

- **Krann Engineering**
- **Frontline Engineering**
- **Res/Op Technologies**
- **Comparison of Tenders-COT**

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Appendix F – Detailed Estimate Sheets

Appendix G – Drawings

Process Flow Diagrams

- **114800-261-1001-rev.P3 Fuel Handling System- Process Flow Diagram**
- **114800-280-1001-rev.P0 Gasifier System-Process Flow Diagram**

General Arrangement drawings

- **114800-261-2001-rev.P0 Poultry Litter Storage Building-General Arrangement**
- **114800-280-2001-rev.P0 Gasification Plant-Site Plan**
- **114800-280-2002-rev.P1 Gasification Plant-General Arrangement**
- **114800-280-2003-rev.P0 Gasifier Building-General arrangement**

Electrical Single Line Diagrams

- **114800-E-5SK1-rev.P1 Electrical One Line diagram Sheet 1**
- **114800-E-5SK2-rev.P1 electrical one Line Diagram Sheet 2**

Ausenco Sandwell

Appendix H – Financial Analysis-Base Option

Appendix I - Gasification Plant with Power Generation Alternative

Table 9.1 Alt-Gross Return on Investment-Alt.

Table 9.2 Projected Cash Flow Statement –Alt.

PM-5. Fuel Handling System, Alternative

Hand Sketch-Elevation, Alt#1

Hand Sketch-Alt#1-Site layout

Hand Sketch-Alt#1, Layout

JMS-620-Configuration for 3 units

JMS-620-Process Diagram

JMS-620-Drawings

Alt.#1 Cost estimate Summary

Gross Return on Investment

A simple method of evaluating the financial worth of a project is the gross rate of return on the total capital investment, before any interest charges, depreciation or taxes. The gross return of the proposed gasification project for Alternative #1, operating at the full capacity, is summarised in Table 9.1.Alt.

Table 9.1Alt – Projected Gross Return on Plant Investment-Alt

Item	Amount $CAD
Total net annual revenues	$8,408,000
Total annual operating cost	$3,156,000
Gross annual operating profit	$5,252,000
Total capital investment	$54,000,000
Gross rate of return	9.7%

The projected gross return indicates a payback period of 10 ½ years for the total capital investment for the gasification plant. By normal industry expectations, this payback period indicates that this project is not attractive from a financial prospective.

The projected cash flow, using the most favourable values for the cost variables, for a typical year and returns over the 20 –year analysis period, are shown in Table 9.2.Alt.

Table 9.2Alt - Typical (Year 10) Gasification Plant Projected Cash Flow Statement – 70 / 30 Debt to Equity-Alt

	$/a
Revenues	$8.408,000
Operating cost	$3,156,000
Cash from operations	$5,252,000
Interest payment	$811,000
Income tax paid	$1,114,000
Capital reinvestment	0
Debt payment	$2,704,000
Net cash flow	$623,000
Real return on equity (ROE)	3.43%
Real NPV	-$3,564,000

The projected net present value (NPV) is negative in the 70/30 debt/equity case. The projected real rate of return on equity (ROE) for the proposed new gasification plant is 3.43%

If BC Hydro was to purchase the electricity at 4 cents over the cost of natural gas the NPV increases to $5.1 million and the real ROE increases to 7.2%.

The complete cash flow projections, over the 20-year analysis period, are presented in Appendix J.

Appendix J - Financial Projections for Power Generation Alternative