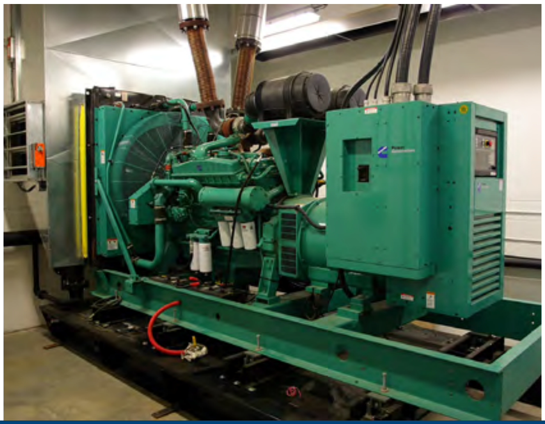
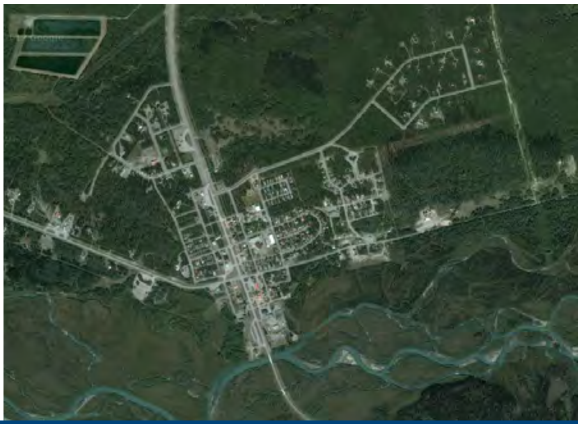




REPORT

Final FEED Report

Front End Engineering Design (FEED) Study
Yukon Bioenergy Demonstration Project
in Haines Junction, Yukon

Yukon Energy Corporation
2 Miles Canyon Road, Whitehorse, YT Y1A 6S7

October 18, 2013

Stantec

Disclaimer

This document entitled Final Report - Front End Engineering Design (FEED) Study, Yukon Bioenergy Demonstration Project in Haines Junction, Yukon was prepared by Stantec Consulting Ltd. for the account of Yukon Energy. The material in it reflects Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This version of the report is to support Yukon Energy's public release of the document. Due to the sensitive nature of the feedstock costing information and proprietary and confidential information provided by the equipment vendors, some information has been omitted. Omitted information was deemed to represent breaches of trust related to information transfer during the course of the study, and would impact the competitive advantage of the new company's operations, equipment vendors, and feedstock suppliers.

Executive Summary

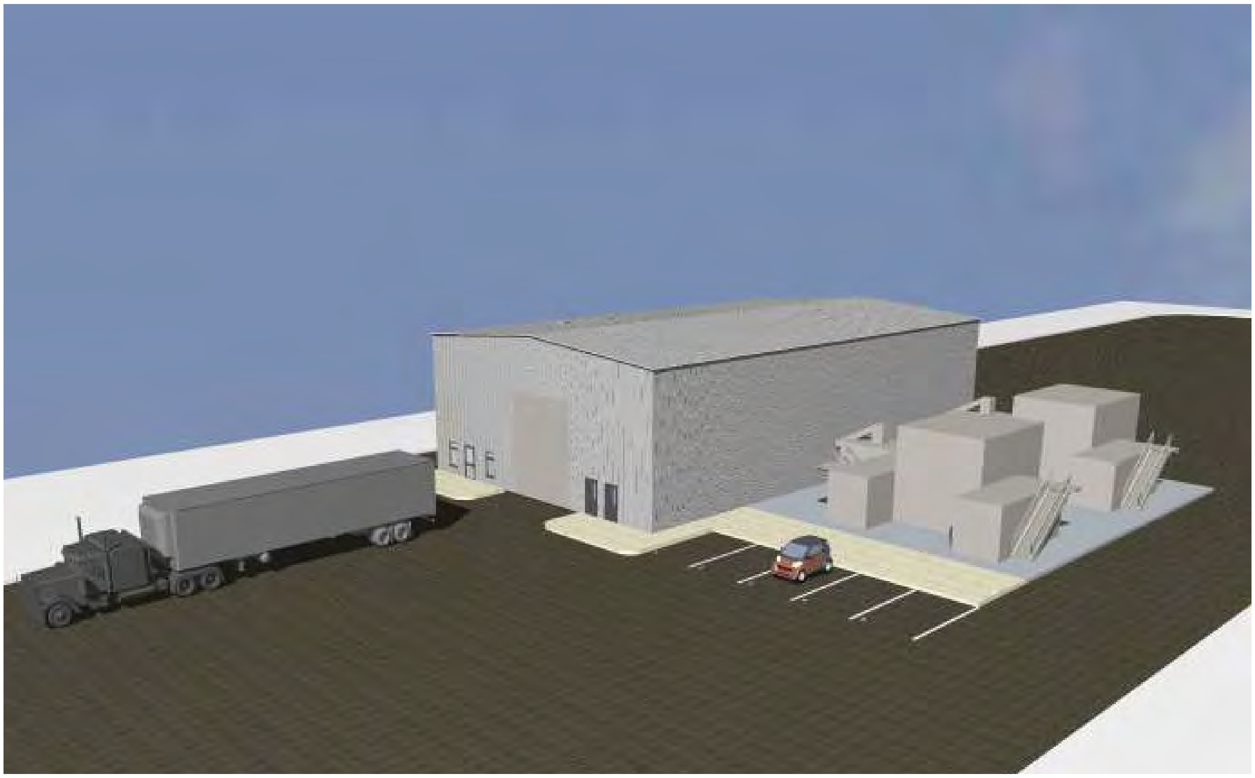
Stantec Consulting Ltd. (Stantec) has been contracted by a Steering Committee led by Yukon Energy Corporation (YEC) and the Champagne and Aishihik First Nations (CAFN) to complete a Front End Engineering Design (FEED) Study for the Yukon Bioenergy Demonstration Project in Haines Junction, Yukon. The focus of the study was to evaluate available biomass gasification technologies for application in the North in the range of 2 MW_e – 4 MW_e and determine its potential viability. The primary objectives were to complete a preliminary design of the facility, define its business case, draft baseline conditions and an impact assessment to form part of a submission to the Yukon Environmental and Socio-Economic Assessment Board (YESAB), and develop and support the engagement of CAFN members and members of the public.

The first steps in the study were to review the available gasification technologies and conduct site visits with members of the Steering Committee. The cursory technology review revealed that although available around the world, gasification technology using a reciprocating engine (as required for the project) is not developed to a high level of commercialization seen with conventional technologies. Any installation made for this project would be one of only a few in Canada, and one of only a handful in comparable cold climates. Furthermore, for most of the vendors contacted for quotations, this installation would represent one of only a few supplying their technology in conjunction with a reciprocating engine.

After narrowing the technology search by those applicable to the study's requirements, three vendors were approached to conduct site visits. Stantec and members of the Steering Committee visited Nexterra, Entropic, and Community Power Corporation (CPC) installations in Canada. Following the site visits, giving consideration to the technology review and waste heat usage, the facility's preliminary design would focus on a smaller generation capacity (0.5 MW_e to 2.0 MW_e) to better align with heating requirements of the village (for combined heat and power production) and to facilitate consideration of smaller gasification technology vendors.

Using the CPC units as a basis, Stantec prepared a preliminary design for a 500 kW_e gasification plant to be located near the centre of Haines Junction to facilitate heating local buildings. Given the smaller installation capacity, the focus of the design was to allow for future expansion for the facility once it is proven at the 500 kW_e scale as a demonstration project. Therefore, the preliminary design incorporated the ability to expand by an addition 500 kW_e, and increase in size to 2.0 MW_e to meet the study objectives. Opinions of probable capital cost and a rendering of the potential facility are presented below:

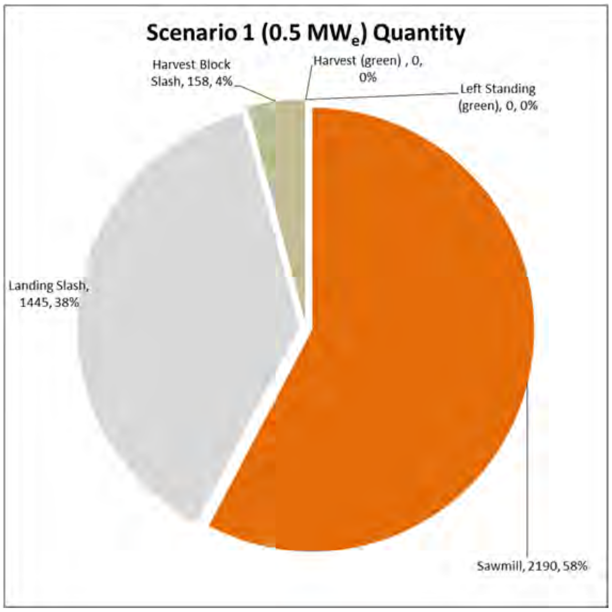
Option	Description	Opinion of Probable Capital Cost
1	500 kWe – Full Building Enclosure	$ 12.7 M
2	500 kWe – Architectural Building Enclosure	$ 13.5 M
3	500 kWe – Fuel Handling Enclosed	$ 11.4 M
4a	1,000 kWe – 500 kWe Expansion	(Exp = $ 9.8 M) $ 22.5 M
4b	2,000 kWe – 1,500 kWe Expansion	$ 45.0 M

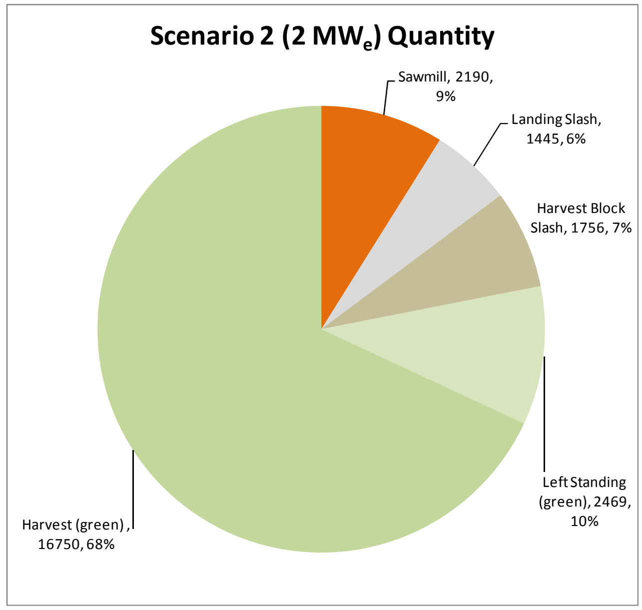


500 kW_e – Fuel Handling Enclosed – Artistic Concept

With any biomass installation, the two greatest ongoing costs are those to fuel the plant, and those for operation and maintenance (O&M). Stantec developed an opinion of operating costs, using the minimum number of operators requested for CPC's equipment, while AGFOR conducted a feedstock assessment to support determining the plant fuel costs as well as the development of the impact assessment. AGFOR's assessment determined that based on existing harvesting operations, a plant capacity of 500 kW_e could likely be supplied with minimal impact to existing operators/policies. This supply would be primarily sawmill residues and forest harvesting residues at the landing and in the harvest block; mostly dead trees from the spruce beetle infestation until that supply runs out. The larger plant capacities would require additional biomass supplied from new harvesting operations/policies and would extend into harvesting green trees sooner. Based on meeting with local regulators and harvesting operators, an opinion of probable supply costs below were determined, including sourcing breakdown.

Option	Description	Opinion of Probable Cost ($/GMT)
500 kWe	Roadside Chipping and Supplied Directly to Plant	Omitted
	Secondary Storage and Chipping	Omitted
2,000 kWe	Roadside Chipping and Supplied Directly to Plant	Omitted
	Secondary Storage and Chipping	Omitted

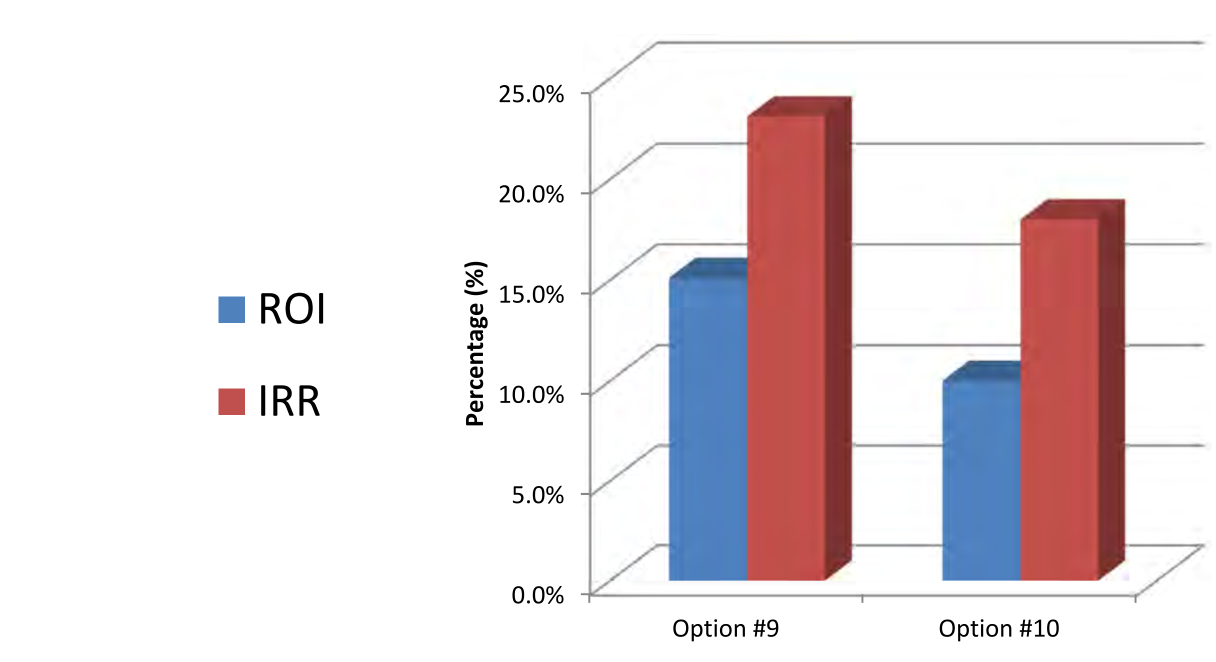




With a preliminary plant and feedstock supply concept established, a draft Environmental and Socio-economic Impact Assessment (IA) was prepared based on information currently available on the project and existing conditions in the area. The report includes an overview of the effects assessment and regulatory regimes associated with permitting the project, scoping of the assessment to include relevant Valued Components (VC), summaries of baseline conditions for each VC and expected effects and proposed mitigation. Determination of significance was based on residual effects after implementation of mitigation. Adaptive management and monitoring activities are also outlined where deemed applicable. The environmental and socio-economic impact assessment report draft is included in an appendix and is drafted to support a complete project submission to YESAB at a later date. The public and First Nation consultation activities are covered in the IA, with the draft engagement plan presented in a separate appendix.

The final aspect of the study was a review of the business model, funding opportunities and assessment of financial viability. Options for owning and operating different aspects of the plant are presented and weighed. The most suitable approach will be dependent on the technology and vendor selected, and the level of involvement in fuel supply the New Company (NEWCO) wishes to assume. A number of avenues for project funding are available, but will again depend on the technology and approach taken on the project; more risky, new technologies that do not have a commercial offering would likely qualify for additional funding, but more commercial technologies likely will not qualify. Continued funding through NRCan, which has funded this study in part, is a top candidate.

The financial analysis focused on ten (10) different plant options that varied with respect to generation capacity, building enclosure design, and vendor selection. To determine the potential viability of these options, financial cases were prepared for each installation taking into account the plant life span, capital and operation costs, and feedstock costing among other key parameters. Without any initial capital subsidization, none of the options were viable. Project viability was achieved for a select number of options assuming the project partners could successful receive capital subsidies from one or more sources. Impacts of electricity pricing in conjunction with capital subsidy were also explored to assess viability. The highest returns came from switching technology vendors to Proton Power from CPC with the financial results shown in the table below due to their lower quoted price.



500 kW$_e$	**Item**	**Option #9 – 500 kW$_e$ Fuel Enclosed** **\$50/GMT, \$200/MWh, 67% Capital Subsidy**
	Return on Investment (ROI)	15.1%
	Internal Rate of Return (IRR)	23.1%
2.0 MW$_e$	**Item**	**Option #10 – 2000 kW$_e$ Fuel Enclosed** **\$50/GMT, \$200/MWh, 67% Capital Subsidy**
	Return on Investment (ROI)	10.0%
	Internal Rate of Return (IRR)	18.0%

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1.0 Project Definition

At the project's onset, it was necessary to define the technology base that would be applicable to the project and the community that would house it. To this end an initial catalogue of technologies was prepared, reviewed and ranked, and ultimately used to determine the project's path forward. This section covers an overview of the findings of this effort as was presented in the project's Interim Report #1. The interim report is attached in Appendix A for further information and reference.

1.1 CATALOGUE OF TECHNOLOGIES

The production of electricity through the conversion of biomass can be accomplished using a variety of different processes and a multitude of feedstocks. The production of bioenergy not only employs a previously underutilized fuel source, but also mitigates the effects of energy production on the environment. When selecting the appropriate technology, it is important to keep in mind the available feedstocks, required amount of generated electricity, environmental standards, capital cost, and process efficiency (McKendry, 2001). Accordingly, with timber being the sole feedstock at the present time, and the target energy production range at the time of the interim report being 2 - 4 MW_e, three different types of biomass conversion options will be investigated: gasification, pyrolysis and an externally fired gas turbine.

1.1.1 Conversion Options

Each of the conversion options, along with their different reactor types and/or arrangements are described in detail in the report presented in Appendix A. Summary tables for the main advantages and disadvantages for the host of technologies are presented in Table 1.1 and 1.2. Of all the technologies, the updraft and downdraft gasifiers were the most applicable to the requirements of the project from the standpoint of complexity, power generation capacity, feedstock acceptance, and level of development.

Table 1.1 Properties of Gasification Reactor Types (McKendry, 2001)

Reactor Type	Advantages	Disadvantages
Fixed bed, updraft	Simple, inexpensive process Exit gas temperature about 250°C Operates satisfactorily under pressure High carbon conversion efficiency Low dust levels in gas High thermal efficiency	Large tar production Potential channeling Potential bridging Small feed size Potential clinkering
Fixed bed, down draft	Simple process Only traces of tar in product gas	Minimum feed size Limited ash content allowable Limits to scale up capacity Potential for bridging and clinkering
Fluidized bed, circulating	Flexible process Up to 850°C operating temperature	Corrosion and attrition problems Poor operational control using biomass
Fluidized Bed, bubbling	Flexible feed rate and composition High ash fuels acceptable Able to pressurize High CH_4 in product gas High volumetric capacity Easy temperature control	Operating temperature limited by ash clinkering High product gas temperature High tar and fines content in gas Possibility of high C content in fly ash

Table 1.2 Advantages and Disadvantages of Biomass Pyrolysis Systems (Vamvuka, 2011)

Reactor Type	Advantages	Disadvantages
Fluid type	Good solids mixing High heat transfer rates Good temperature control Ease of scaling	Heat transfer to bed must be proven at large scale Max particle sizes up to 6 mm If circulating, increased complexity of system, char attrition and reactor wear
Entrained flow	None	Low heat transfer rates Limited gas/solid mixing Small particle sizes required
Rotating cone	Good solids mixing No carrier gas required Ease of scaling Small investment cost	Heat transfer to bed must be proven at large scale Small particle sizes required
Vacuum reactor	No carrier gas required Lower temperature required Can process larger particles	Low heat transfer rates Solids residence time high Liquid yield rather low
Ablative reactor	Heat transfer gas not required Lower temperature required Can process larger particles Compact design and intensive system	Reaction rates limited by heat transfer to the reactor Char abrasion Scaling is costly

1.2 TECHNOLOGY REVIEW AND RANKING

Throughout the world one can find biomass gasification taking place from a scale suitable to heat a home, to that to capable of generating electricity to supply the grid. The focus of this study was to concentrate on a gasification technology capable of producing a syngas for cleanup that could then be introduced to a reciprocating engine in the initial capacity range of 2 – 4 MW_e. Although the technology could be innovative, it must be at or near commercialization to facilitate its installation in a northern community (i.e., not for research but practical/reliable use). Several technologies also require the use of steam, which is not available through co-locating near an existing facility, nor considered for self-generation. Two other biomass technologies were showcased for comparison (external fired gas turbine and pyrolysis-oil/ethanol/bio-oil).

To facilitate screening of the technologies, a ranking or scoring system was established to support the technology recommendation. The criterion used for the ranking system as well as the points awarded by criterion are outlined in Table 1.3. The ranking system does not include items affecting all the biomass systems, such as feedstock availability, socio-economic viability, job creation, or permitting requirements as these are common to all the systems at this level of evaluation.

Table 1.3 Interim Report Screening Criterion

Level of Development	R&D / Pilot – 0 Pts.	Demonstration – 3 Pts.	Commercial – 5 Pts.
Capacity Range	Outside 2-4 MW_e – 0 Pts.		Within 2-4 MW_e* - 5 Pts.
Use of Engine for Power	No – 0 Pts.		Yes – 5 Pts.
Gasification Complexity**	Advanced – 0 Pts.	Standard – 3 Pts.	Direct Comb. – 5 Pts.
Installation Base	1 Installation – 0 Pts.	2 Installations – 3 Pts.	More than two – 5 Pts.
Steam Required	Yes – 0 Pts.		No – 5 Pts.
Achievable Score	**Minimum – 0 Pts.**		**Maximum – 30 Pts. (100%)**

* Includes modular units capable of entering range (i.e. if maximum size is 1 MW_e, two units could be installed to enter desired range). Units significantly larger than the range would be excluded due to uncertainties regarding scale-down.

** Complexity is based on system design. Advanced is representative of dual bed or pressurized gasifiers, BFBs, and CFBs; Standard represents draft gasifiers (low to medium Btu syngas) to clean-up and the engine; and Direct Combustion is for the externally fired gas turbine.

1.2.1 Catalog of Technologies

In the interim report, each technology was ranked according to the screening criterion presented in Table 1.3. A sample of the scorecard developed for each technology considered is presented on the following page in Table 1.4. Please refer to Appendix A for the scorecards prepared for the other technology vendors.

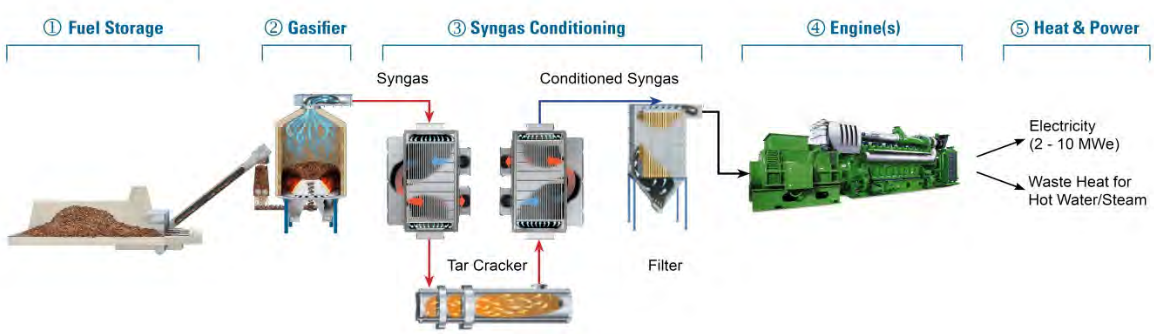
Table 1.4 Sample Technology Screening Scorecard

Developer / Company:	Nexterra Systems Corp.	**Location:**	Multiple – Oak Ridge, Vancouver, Victoria, North Carolina, New Westminster, UBC
Owner:	Various	**Status:**	Operational
Technology:	Dual Bed (BFB & CFB)	**Tech Status:**	Demonstration CHP
Capacity:	UBC: 2 $MW_{e,}$ 3 MW_{th}	**Application:**	CHP w/ District Heating

Nexterra is the most recognizable Canadian gasification vendor. With installations of their gasifier throughout Canada and the USA, they have developed a solid platform for biomass gasification (low-medium calorific value syngas). Their most recent installation on the University of British Columbia campus is their first CHP using a reciprocating engine. The complexity of the system is Standard with an updraft gasifier and syngas clean-up. Nexterra's gasifier is a proven technology (for heating and steam turbine applications, but not in conjunction with an engine) and does not require steam.

Level of Development	Demonstration – 3 Pts.
Capacity Range	Within 2-4 MW_e - 5 Pts.
Use of Engine for Power	Yes – 5 Pts.
Gasification Complexity	Standard – 3 Pts.
Installation Base	1 Installations – 0 Pts.
Steam Required	No – 5 Pt.
Score	**21 Pts. (70%)**

Nexterra Advanced Biomass Heat and Power System



SIMPLIFIED ILLUSTRATION

① Fuel Storage - wood residue delivered to storage facility and conveyed to gasifier.

② Gasification Technology - gasification process converts wood residue into clean, renewable synthetic gas or "syngas."

③ Syngas Conditioning Technology - syngas is conditioned and upgraded to meet fuel specification for engine.

④ Engine(s) - high-efficiency internal combustion engine(s) operates on syngas instead of natural gas to generate electricity & heat.

⑤ Heat & Power - systems will generate heat & electricity at small-scale (2 - 10 MWe) economically with efficiencies of up to 65%.

1.3 TECHNOLOGY SELECTION

A summary of the technology scorecards determined in the interim report is presented in Table 1.5 on the following page. In reviewing each vendor's score, the top scores, greater than 20 pts., were ranked from one (1) to six (6). Given the criteria considered, the smaller, modular systems in the smaller capacity ranges took the top two rankings: (1) Community Power Corp., and (2) Biomass Engineering Ltd. The other downdraft unit, Pyroforce ranked third (3) followed by the alternative external fired gas turbine unit (4) Talbott's/Entropic. The final two rankings represent the larger updraft systems: (5) Nexterra, and (6) B&W Vølund. As a select number of vendors were used to represent each category, the groupings in the table highlight which has the best potential to be applicable to this project. This approach was selected with the understanding that bids from additional vendors would be considered later in the project.

1.3.1 Interim Report #1 Technology Recommendation

The technology summary in the previous subsection ranked three (3) technologies as front-runners based on their current installation base and applicability to general project requirements. In order to make a meaningful recommendation at the time the interim report was completed, it was also important to assess as many known considerations as possible. Additional consideration was given to feedstock supply (or lack of secure supply), the availability of trained operators, and plant efficiencies (or production of waste heat). These additional considerations lead to the recommendation to consider a smaller sized plant (or small capacity units) as they require less fuel (easier to secure feedstock), typically required a lower skillset operator (ex-electricians/mechanics compared to stationary engineers), and scored higher on the screening assessment. Part of this recommendation also served to match the plant capacity to the building heating load available in the village.

Table 1.5 Summary of Vendor Scorecards

Technology	Developer/ Owner	Level of Develop.	Capacity Range	Engine	Complexity	Installation Base	Steam Req.	Score	Rank	Elec. Eff.*	Enivron
'Large Scale" Gasification											
Bubbling Fluidized Bed (5,500 kW_e)	Andritz-Carbona (EU – Denmark)	5	0	5	0	0	0	10 (33%)			
2 – 4 MW_e Gasification											
Updraft Gasifier (2,000 kW_e)	Nexterra (CAN – BC)	3	5	5	3	0	5	21 (70%)	5	26%	
Updraft Gasifier (2,000 kW_e)	B&W Vølund (EU – Denmark)	5	5	5	0	5	0	20 (67%)	6		
Dual Bed (2,700 kW_e)	FICFB (Repotec) (EU – Austria)	3	5	5	0	3	0	16 (53%)			
Small Scale / Modular Gasification											
Downdraft Gasifier (100 kW_e)	Community Power Corp. (NA – USA)	5	5	5	3	5	5	28 (93%)	1	20%	California Certified
Downdraft Gasifier (300 kW_e)	Biomass Engineering (EU – UK)	5	5	5	3	3	5	26 (87%)	2		
2-Zone Downdraft (150 kW_e)	Pyroforce (EU – Swiss)	3	5	5	3	3	5	24 (80%)	3		

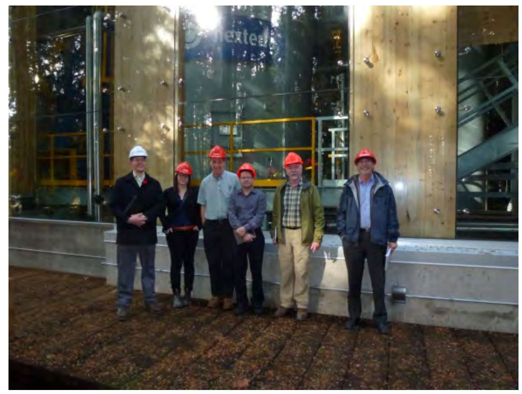
* Approximate based on published information

1.4 FACILITY VISIT OF SELECT TECHNOLOGIES

Based on the results of technology assessment it was desired to see a number of units in operation. Interim Report #2, available in Appendix B, covers the results of the vendor visits in detail. The next two sub-sections present the overall results of the Nexterra and CPC site visit.

1.4.1 Nexterra Visit

The site visit for Nexterra took place at 10:00 am on Monday, November 5, 2012 on the UBC campus. Phil Beaty, Vice President, Strategic Relationships, for Nexterra, and Brent Sauder, Director, Strategic Initiatives for UBC facilitated the visit. Initially the group met in a conference room on campus to discuss the university's experience during the project's development and execution. This was followed by a guided tour of the facility with the Nexterra representative and operating staff only. During the visit, the plant was operational.



1.4.1.1 Project Overview

This project was kick-started by John Grace of UBC based on his academic research into gasification and more specifically gas conditioning/clean-up. UBC and Nexterra wanted a demonstration-sized plant to prove the concept and facilitate R&D at the university. Based on the UBC concept, GE came in as a partner and supported the development.

UBC is unique in that it is its own municipality with its own substation. The challenge in BC is the low power rates brought on by their hydro resources. That said, UBC still had the desire to demonstrate a BC technology in BC. On the waste heat side, they are also in the process of converting their existing steam district heating system over to hot water.

For UBC the social license was the first step, with five (5) sites initially under consideration. Faculty members were quick to get onboard for the research ability, and the community soon adopted a “yes, in my backyard” mentality. In the end, the unit was located on the edge of the campus in order to reduce truck traffic for fuel deliveries. During full operation, UBC receives three (3) trucks a day, with enough storage for a three (3) day weekend.

On the permitting side, UBC requested the strictest emission regulations be met. To that end, UBC requested that the system be designed and will be tested to meet Metro Vancouver requirements, as well as those in the USA jurisdictions of San Joaquin Valley and the state of Massachusetts. The facility is further equipped with a local and external air shed monitoring system.

Building construction was initially completed using standard steel building formats. During the project's development UBC worked with FP Innovations and selected a new construction method – cross-linked timber or CLT. The current facility uses CLT for the roof and walls of the building.

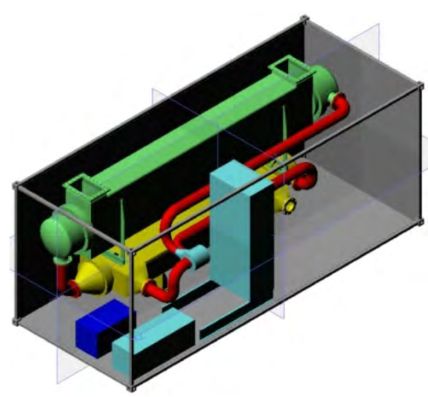
The Nexterra system does require trained operators to run the facility. Operators would require similar skills to that of boiler operators, and if a hot water system was installed, they would not require steam tickets. That said, a 4th to 3rd class ticket would be a starting point for skilled operator requirements. Although the system is automated, skilled operators are required to react quickly in an upset condition. As a minimum, the system requires two (2) full-time staff on-site 24 hours a day / 7 days a week. Currently the UBC plant operates in eight (8) hours shifts, requiring a minimum of eight (8) trained operators to support the plant.

1.4.1.2 Overall Impression

General impression of the group following the visit was that the installation was very large and more complex than expected. The size of the facility, number of operators, and perceived complexity of operation did not seem appropriate for a unit to be located in Haines Junction. The capital cost, maintenance requirements, parts availability, and service technician/operator skill set were also of concern. Mr. Beaty re-iterated that the UBC unit was the first of its kind for Nexterra and they are not actively marketing it. It will be more than a year before annual performance numbers are available, and only then would Nexterra begin to entertain installing their second unit. Further discussion revealed that Nexterra is not interested in a northern site for their second installation.

1.4.2 Entropic Visit

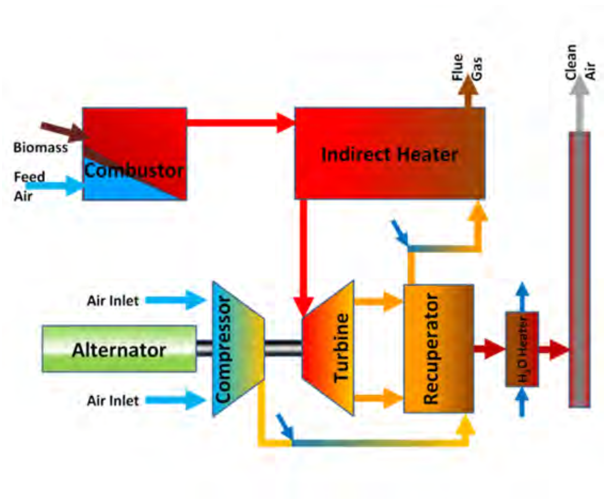
The site visit for Entropic took place at 9:00 am on Tuesday, November 6, 2012 on the University of Manitoba (U of M) campus. Dr. Eric Bibeau, NSERC/Manitoba Hydro Industrial Research Chair in Alternative Energy and co-founder of Entropic, facilitated the visit. Initially the group met in Dr. Bibeau's office on campus to discuss Entropic's technology and product development. This was followed by a guided tour of the installation with Dr. Bibeau. During the visit, the plant was not operational and it was unclear when it would achieve demonstration status.



1.4.2.1 Project Overview

Entropic is in the R&D stages of their technology. The concept is to design a biomass system with a small footprint that can compete on a conventional technology's price point of $\$4M/MW_e$.

Using the price point as a basis Dr. Bibeau and this team are trying to apply a hybrid Brayton Cycle to achieve high efficiency power generation in a modular package of 250 kW_e.



The Entropic design builds upon that of the indirect fired Brayton Cycle. The principle difference is in the thermodynamics in that they inject water at critical points in the process to increase unit efficiency. Although only currently theoretical in models, the team at U of M are trying to get their unit up and running. Should they be successful, the hybrid design touts the benefits of maximized energy transfer through increase mass through the turbine, decreased turbine inlet temperature (therefore reduced stress on the unit), maximize equipment capacities, and overall increase in efficiency – to double that of a standard externally fired unit.

1.4.2.2 Overall Impression

General impression of the group following the visit was that this technology/vendor was not appropriate for future consideration. The technology is not near a viable status for consideration on this project, though appears promising.

1.4.3 CPC Visit

The site visit for Community Power Corporation (CPC) took place at 1:00 pm on Tuesday, November 6, 2012 at Pineland Forest Nursery in Hadashville, Manitoba. Carl Peterson, Field Engineer, facilitated the visit for CPC. This unit is located on, and integrated to Pineland's operations, but is owned by Manitoba Hydro. Jeremy Langner is the Project Manager for Manitoba Hydro (MH), but was unavailable at the time of the site visit. Mr. Langner did provide Stantec with some information on the project as a follow-up to the visit. The General Manager of Pineland, Trevor Stanley, was also unable to attend the site visit, but joined the group later in the evening to answer questions and discuss the project. The tour of the unit took place immediately upon arrival, with questions & answers carrying the group through until departure. During the visit the plant was operational.

1.4.3.1 Project Overview

The following overview was developed from follow-up information provided by Mr. Langner.

The CPC system is manufactured in a series of five (5) 20 ft. shipping containers. Shipping the unit in this containerized form allows the majority of the work to be performed at the manufacturer’s facility. The Pineland system was installed in June and July 2012, and Manitoba Hydro/CPC/Pineland have been testing it ever since. The unit has been run to peak capacity and has been able to generate a maximum of approximately 120 kW_e of electricity gross, with about 20 kW_e of parasitic loss. Pineland is also recovering heat off of the engine’s cooling jackets and exhausts, and sending this to a thermal loop to heat greenhouses. The heat supplements Pineland’s existing 2 MW_{th} biomass boiler, located in an adjacent building.

The CPC system uses a stainless steel downdraft gasifier with air injection points throughout the fixed bed. A vibrating grate can dump material if required. The temperature profile is precisely controlled throughout the bed to insure good gas quality. This allows the filtration system to be very simple – filter bags with backup carbon safety filters. This filters out a very fine carbon dust from the gas. The gas is then sent to two (2) 8.1 L V8 spark-ignition engines, each connected to a 65 kW_e alternator. Another feature of the system is the biomass dryer that uses heat from the gas cooling heat exchanger to dry the feedstock. This allows MH/Pineland to accept up to 45% moisture content, and dry down to approximately 15% moisture.

With regards to fuel rates and flows, MH currently pays in the range of $55 to $65 per tonne as delivered for their biomass supply. The wood chips come from several sources within 2 hours or less of the project site. The fuel consumption is stated by CPC as 90 kg of dry biomass per hour, however, MH have not been running consistently enough to determine a more accurate figure. The CPC system can accept ¼” x ¼” through 2” x 2” chips.

As far as maintenance costs are concerned, MH does not have enough data to provide concrete figures. It will highly depend on the number of oil changes per month. CPC has specified an oil change every 10 days. MH are also budgeting the equivalent of 1 hour per day of daily checks, and two (2 to 3 man-days per month spent on gasifier maintenance. During this initial start-up phase, these numbers are expected to be higher.

Operating efficiency is also difficult to determine giving the limited operating hours. Assuming MH/Pineland are burning 90 kg/hr for 100 kW of output (net), and the biomass has a higher heating value of 20 MJ/kg (dry), MH would have a net electrical efficiency of approximately 20%. MH believes that the total efficiency will be at least double when they include the heat.

In a discussion with the Mr. Peterson, CPC typically provides four weeks of commissioning and start-up services. This includes two (2) weeks on-site to commission the unit and systems, one (1) week of full-time training for site personnel, and one (1) week of field supervision following the training. Beyond the four (4) weeks, Mr. Peterson indicated that CPC monitor the unit remotely for any system warnings or errors. As for the level of skill required to operate the units, Mr. Peterson indicated that the majority of operators are ex-electricians or ex-mechanics. Ex-electricians are preferred give the system electronics and potential advantage when troubleshooting problems, but both have been successful at operating the units.

1.4.3.2 Overall Impression

General impression of the group following the visit was that this technology/vendor was the most appropriate of those visited for Haines Junction. Apart for the small capacity (100 kW_e) the plant's simplicity of operation, level of operator skill required, and proven heat recovery potential make it a strong candidate for installation in the Yukon.

2.0 Preliminary Design

The following subsections outline the preliminary engineering for the FEED study. The first subsection reviews information on the vendors contacted as part of the RFQ process. Vendor information packages are presented in Appendix C for the Steering Committee's review and reference. Not all information requested is available and follow-up requests and questions have been made to the vendors.

The final two subsections outline the facility siting exercise as well as aspects of the preliminary design and opinions of probable cost. The costing presented covers the preliminary options to utilize the CPC 500 kW_e (2 x 250 kW_e) units both inside a building (Option #1) and outside a building (Option #3). An option to have the building exterior completed with an architectural design is also provided (Option #2). As the intent would be to expand the demonstration project in the near future, a fourth option is presented to expand the initial 500 kW_e plant by an additional 500 kW_e in Option #4.

Each option is reviewed briefly in this report with additional information available in Appendix D (Option #1), Appendix E (Option #2), Appendix F (Option #3), and Appendix G (Option #4). Appendices contain the engineering drawings created to support the costing effort as well as the more detailed line item opinions of probable capital cost.

2.1 VENDOR RESPONSE TO RFQ

Each of the vendors contacted as part of the RFQ process are reviewed in the following subsections with their detailed packages contained in Appendix C. Information contained here and in the appendix represents vendor proprietary information and costing. This should not be considered for distribution outside the project team.

2.1.1 B&W Volund

Despite initially being a promising technology source, discussions with B&W Volund revealed otherwise. Upon conversing about the project details, particularly the feedstock characterization, it was determined that the moisture content present in the feedstock was too low for use in B&W Volund's technology. They therefore declined to provide a quotation/information package.

2.1.2 Nexterra

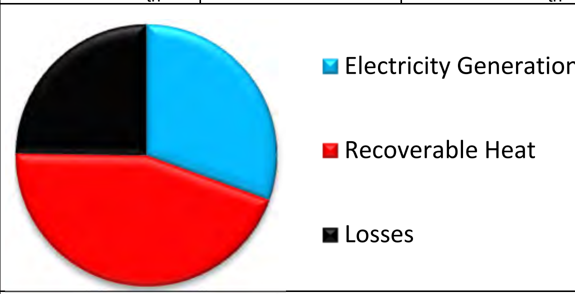
As mentioned previously during the site visit of their facility at UBC, while being an appropriate technology it is not being actively marketed. Nexterra wishes to operate the UBC unit for at least a year before pursuing a second installation. Even after a year, the general impression provided by Nexterra was that the next installation is not likely to be in the North.

2.1.2.1 Vendor Summary

To quickly highlight key aspects of the vendor's response, Table 2.1 has been prepared to summarize data provided. A comparison table of all vendors is available in the next sub-section.

Table 2.1 Nexterra Summary

nexterra		**Headquarters:**	Vancouver, British Columbia	
Developer / Company:	Nexterra	**Vendor Rep:**	None	
System Information	**Quoted Capacity:**	$2.0\ MW_e$		
	Model Number:	Standard CHP System		
	System Configuration:	1-Stage Updraft Gasifier, 1x IC Engine		
	**denotes scaled values*	**As Quoted**	**$500\ kW_e$**	**$2.0\ MW_e$**
Fuel Requirements	**Moisture Content as Fired:**	20%		
	Feedstock Consumption (dry basis):	1,474 kg/hr 3,250 lb/hr	N/A	1,474 kg/hr 3,250 lb/hr
	Feedstock Size:	N/A		
Unit Performance	**Net Electric Generating Capacity:**	$2.0\ MW_e$	N/A	$2.0\ MW_e$
	Operating Parasitic Load:	N/A	N/A	N/A
	Availability:	91%		
	Recoverable Heat:	$2.93\ MW_{th}$	N/A	$2.93\ MW_{th}$



Unit Performance	**Cogeneration Efficiency:**	75%		
	Electrical Efficiency:	31%		
Commercial	**Delivery Lead Time:**	N/A		
	Published Equipment Price:	\$18M - \$20M	N/A	\$18M - \$20M

2.1.3 Community Power Corporation

In response to our RFP, Community Power Corporation responded with a budgetary proposal for the design, supply, transportation to site, and supervision of erection and startup, of a demonstration bioenergy system. The proposal outlined several risks that CPC was concerned with that may have a significant impact on the project. These included:

- Long-term bioenergy system reliability and availability (downtime) have not yet been confirmed in a remote, cold climate community.
- Impact of cold climate is not yet known on system performance.
- Operation and maintenance costs need to be verified.
- Sustainable biomass harvesting plan needs to be confirmed.
- Impact of biomass variability on system performance needs to be confirmed (biomass type, heating value, cleanliness, moisture content, etc.).
- Requirements for and impact of permitting and environmental performance requirements are not fully understood.
- Availability of local operators with appropriate maintenance skills.

Given the number and importance of these risk areas, CPC strongly recommends consideration of an initial, single BioMax 100 (kW_e) demonstration system that can address the risk areas at lower cost while still providing all of the insight needed to design and implement the larger follow on 500 kW_e to 2 MW_e deployment. Therefore, based on CPC's experience in bioenergy and renewable energy demonstration projects in remote communities throughout the world, they propose consideration of one, 100 kW_e BioMax bioenergy as described in their proposal.

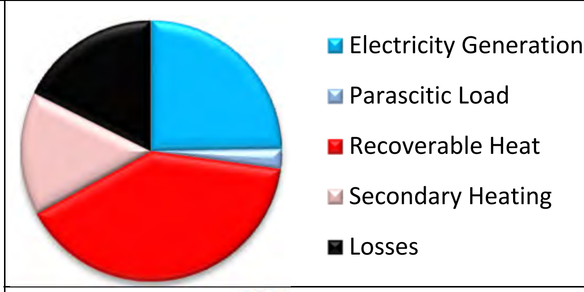
2.1.3.1 Vendor Summary

To quickly highlight key aspects of the vendor's response, Table 2.2 has been prepared to summarize data provided. A comparison table of all vendors is available in the next sub-section.

2.1.3.2 Vendor Response

A copy of CPC's response to the RFQ is included in Appendix C for reference as received.

Table 2.2 Community Power Corporation Summary

Community Power Corporation — A Wholly Owned Subsidiary of Afognak Native Corporation		**Headquarters:**	Littleton, Colorado	
Developer / Company:	Community Power Corporation	**Vendor Rep:**	None	
System Information	**Quoted Capacity:**	100 kW_e		
	Model Number:	BioMax 100 CHP System		
	System Configuration:	1-Stage Downdraft Gasifier, 2x IC Engines		
	**denotes scaled values*	**As Quoted**	**500 kW_e**	**2.0 MW_e**
Fuel Requirements	**Moisture Content as Fired:**	15%		
	Feedstock Consumption (dry basis):	91 kg/hr 200 lb/hr	363 kg/hr* 800 lb/hr*	1,452 kg/hr* 3,200 lb/hr*
	Feedstock Size:	Chip size: <51 mm		
Unit Performance	**Net Electric Generating Capacity:**	100 kW_e	2x 250 kW_e	8x 250 kW_e
	Operating Parasitic Load:	10 kW_e	40 kW_e*	160 kW_e*
	Availability:	80%		
	Recoverable Heat:	161 kW_{th}	644 kW_{th}*	2,576 kW_{th}*
	Secondary Heat for Drying:	62 kW_{th}	248 kW_{th}*	992 kW_{th}*
	Cogeneration Efficiency (with / without Secondary Heat Recovery):	 80% / 65%		
	Electrical Efficiency:	25%		
Commercial	**Delivery Lead Time:**	7-8 months		
	Quoted Equipment Only Price:	$ Omitted	$ Omitted	$ Omitted

BioMax100 in Manitoba

BioMax250 from Quotation

2.1.4 WEISS

To achieve the targeted 2 MW_e production capacity, WEISS and Scan American presented their standard 500 kW_e unit modular form. This size supported the RFQ requirements and aligned with the concept design change to only 500 kWe capacity.

2.1.4.1 Vendor Summary

To quickly highlight key aspects of the vendor's response, Table 2.3 has been prepared to summarize data provided. A comparison table of all vendors is available in the next sub-section.

2.1.4.2 Vendor Response

A copy of Weiss' response to the RFQ is included in Appendix C for reference as received.

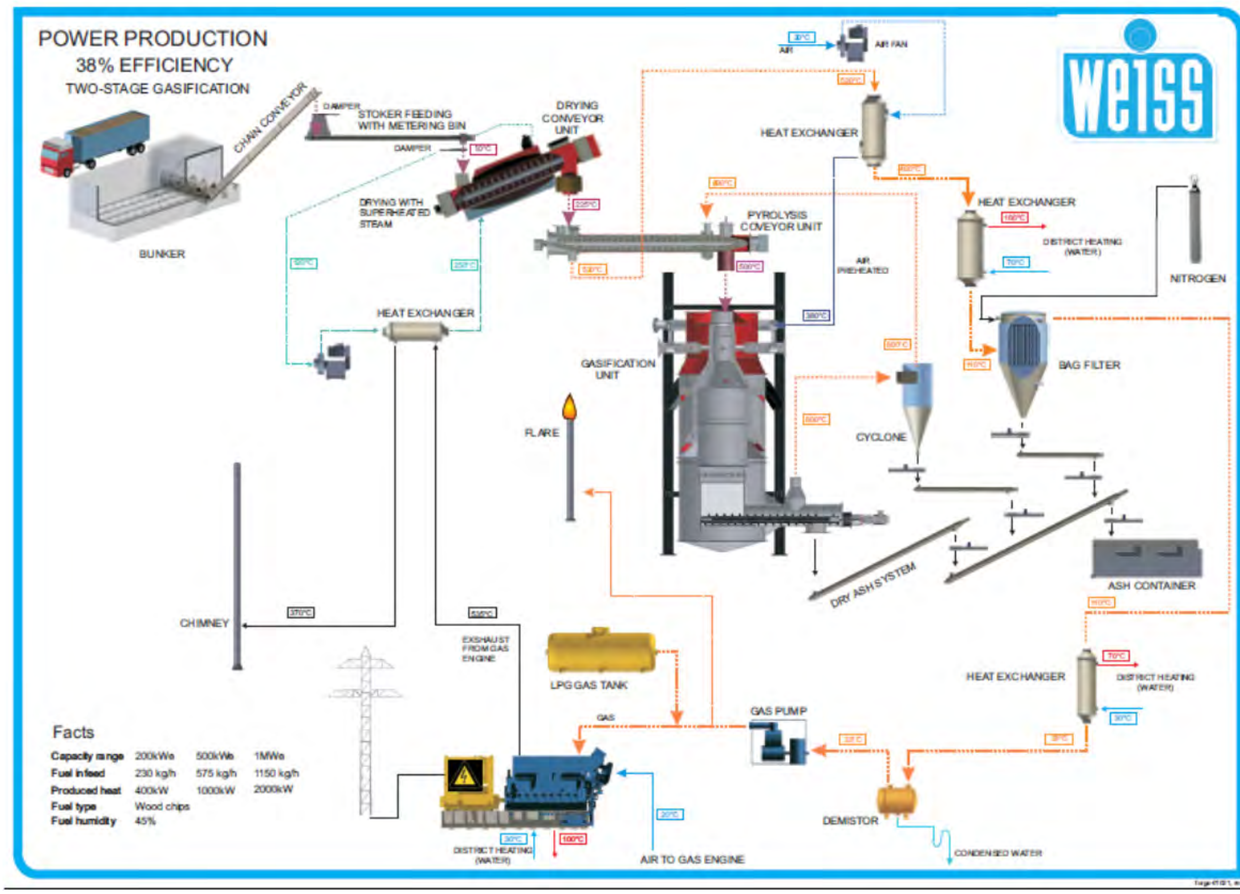
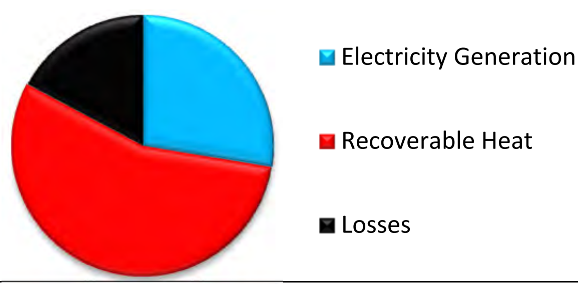


Table 2.3 Weiss (Scan America) Summary

		Headquarters:	Copenhagen, Denmark
Developer / Company:	Weiss Envikraft A/s	**Vendor Rep:**	Barry Griffith, Kansas City, MO

System Information	**Quoted Capacity:**	1000 kW_e (1000kW_e, 2000kW_t)		
	Model Number:	Not specified		
	System Configuration:	1xGasification Unit, 1x 800 amp Genset		
		As Quoted	**500 kW_e**	**2 MW_e**
Fuel Requirements	**Moisture Content as Fired:**	35-55%		
	Feedstock Consumption (dry basis):	1150 kg/hr 2535 lb/hr	575 kg/hr 1268 lb/hr	2300 kg/hr 5071 lb/hr
	Feedstock Size:	Chip size: G100		
Unit Performance	**Net Electric Generating Capacity:**	2x500 kW_e	500 kW_e	4x500 kW_e
	Operating Parasitic Load:	N/A	N/A	N/A
	Availability:	Not specified		
	Recoverable Heat:	2000 kW_{th}	1000 kW_{th}	4000 kW_{th}
				
	Cogeneration Efficiency:	83%		
	Electrical Efficiency:	28%		
Commercial	**Delivery Lead Time:**	9-12 months		
	Quoted Equipment Only Price:	$ Omitted	$ Omitted	$ Omitted

2x 500 kW_e Plant Model

2.1.5 Proton Power

The system provided by Proton Power, in response to the RFQ, utilizes the CHyP (Cellulose to Hydrogen Power) product built by Proton Power Inc. to produce up to 2.0 MW_e of electricity using woody biomass as the fuel source. Each CHyP unit that makes up the system is an electrical resistance, multi-zone reactor system specifically designed for the continuous reaction of cellulosic feed materials to a maximum operation temperature of 1200 °C in a non-oxidizing atmosphere. The quotation includes preassembly, mounting, test operation and customer operational witness inspection of all supplied system components and controls prior to shipment to the installation site.

The 250 kW_e system will consist of the following unit operations:

- Automatic biomass processing and feed hoppers.
- CHyP reactor to produce high content hydrogen syngas.
- Automatic solids removal station to collect biochar for packaging, burial or resale.
- Gas cooling and gas cleanup stages.
- Gas composition monitoring for process control.

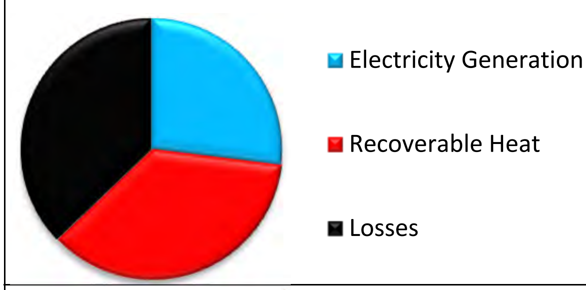
2.1.5.1 Vendor Summary

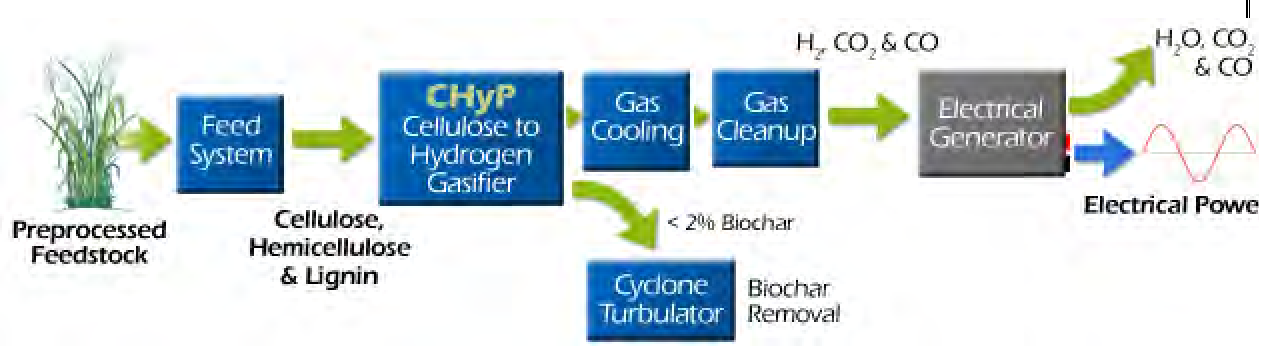
To quickly highlight key aspects of the vendor's response, Table 2.4 has been prepared to summarize data provided. A comparison table of all vendors is available in the next sub-section.

2.1.5.2 Vendor Response

A copy of Proton Power's response to the RFQ is included in Appendix C for reference as received.

Table 2.4 Proton Power Summary

Proton Power — Renewable. Clean. Energy.		**Headquarters:**	Lenoir, TN	
Developer / Company:	Proton Power, Inc.	**Vendor Rep:**	K. Burnham, Kelowna, BC	
System Information	**Quoted Capacity:**	2.0 MW_e (8x 250 kW_e)		
	Model Number:	250 kW_e CHyP (Cellulose to Hydrogen Power)		
	System Configuration:	1x Multi-zone Reactor, 1x IC Engines		
		As Quoted	**500 kW_e**	**2.0 MW_e**
Fuel Requirements	**Moisture Content as Fired:**	15%		
	Feedstock Consumption (dry basis):	1,670 kg/hr 3,673 lb/hr	417 kg/hr 919 lb/hr	1,670 kg/hr 3,673 lb/hr
	Feedstock Size:	Chip size: <6 mm		
Unit Performance	**Net Electric Generating Capacity:**	8x 250 kW_e	2x 250 kW_e	8x 250 kW_e
	Operating Parasitic Load:	N/A	N/A	N/A
	Availability:	92.5%		
	Recoverable Heat:	2,664 kW_{th}	666 kW_{th}	2,664 kW_{th}
				
	Cogeneration Efficiency:	63%		
	Electrical Efficiency:	27%		
Commercial	**Delivery Lead Time:**	12-18 months		
	Quoted Equipment Only Price:	$ Omitted	$ Omitted	$ Omitted

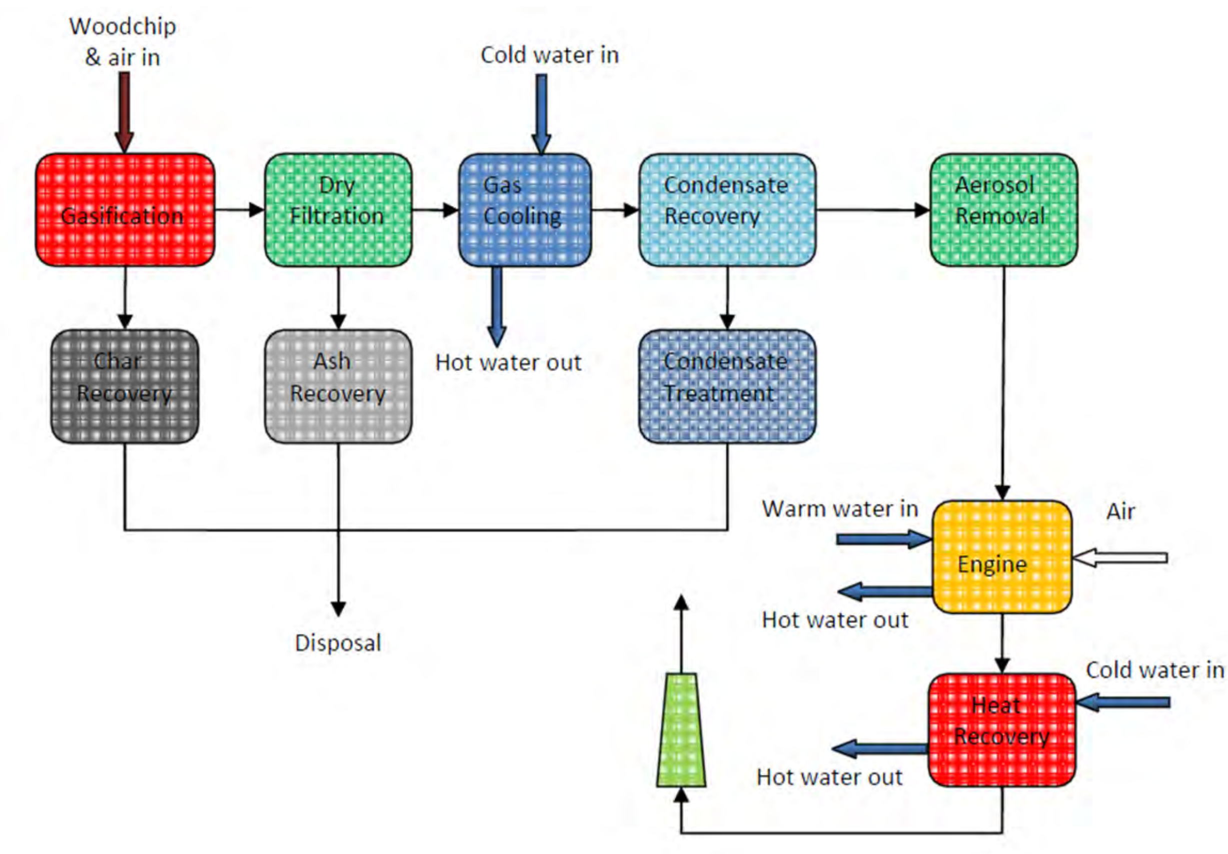


CHyP Process from Quotation

2.1.6 Biomass Engineering Ltd.

In response to our RFQ, Biomass UK responded with a proposal comprising the technical specifications and a budgetary estimate of the design, supply, delivery, installation, testing and commissioning of a 500 kW gasification plant.

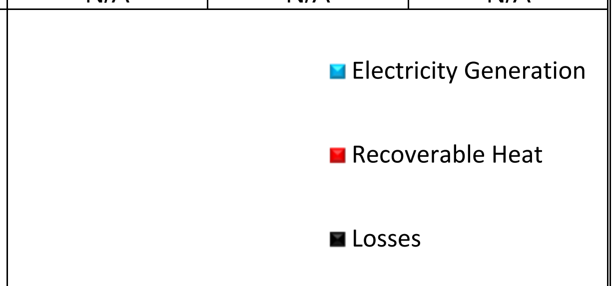
Biomass Engineering Ltd. was established over 10 years ago and since that time has specialized in the design, development and supply of advanced gasification systems and the necessary ancillary equipment. Biomass Engineering specializes in the design, manufacture, installation and commissioning of compact gasification plants and equipment for converting the energy stored in wood into electricity and heat. The Biomass Engineering gasifier is designed to convert wood fuel into a steady stream of syngas, seen below:

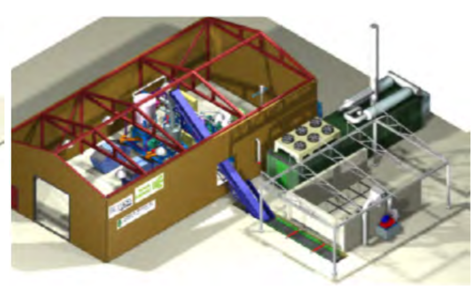


2.1.6.1 Vendor Summary

To quickly highlight key aspects of the vendor’s response, Table 2.5 has been prepared to summarize data provided. A comparison table of all vendors is available in the next sub-section. Beyond the system price, many detailed on the system operation were omitted.

Table 2.5 Biomass Engineering (UK) Summary

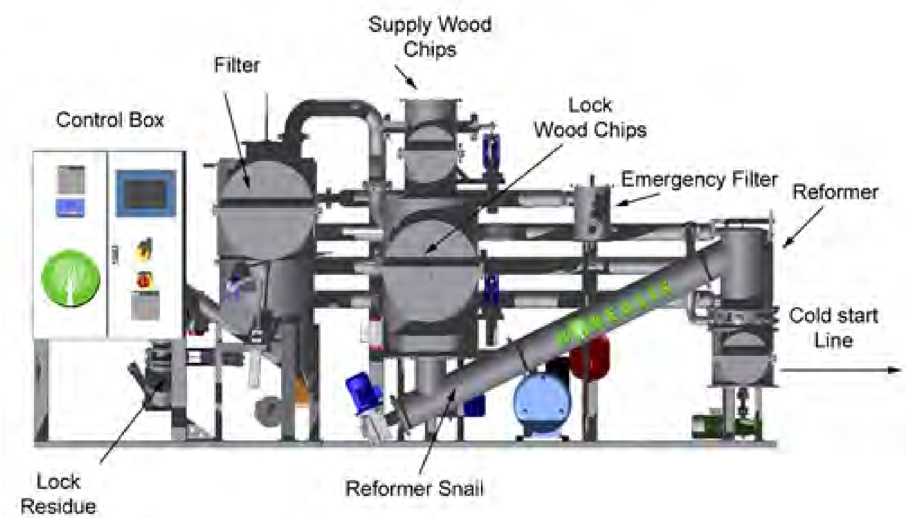
Biomass engineering		**Headquarters:**	Newton-le-Willows, England	
Developer / Company:	Biomass Engineering UK	**Vendor Rep:**	Dave Clitheroe	
System Information	**Quoted Capacity:**	500 kW_e (500kW_e, 2000kW_t)		
	Model Number:	Not specified		
	System Configuration:	1x Gasification Unit, 1x 500kW Gas Engine		
		As Quoted	**1 MW_e**	**2 MW_e**
Fuel Requirements	**Moisture Content as Fired:**	<20%		
	Feedstock Consumption (dry basis):	N/A	N/A	N/A
	Feedstock Size:	Chip size: < 100x100x30 mm		
Unit Performance	**Net Electric Generating Capacity:**	2x250 kW_e	4x250 kW_e	8x250 kW_e
	Operating Parasitic Load:	N/A	N/A	N/A
	Availability:	Not specified		
	Recoverable Heat:	N/A	N/A	N/A
				
	Cogeneration Efficiency:	Not specified		
	Electrical Efficiency:	24%		
Commercial	**Delivery Lead Time:**	Not specified		
	Quoted Price:	$ Omitted	$ Omitted	$ Omitted



2.1.7 Borealis Wood Power Corporation (Spanner Re2 GmbH)

Technology Background

Borealis Wood Power Corporation is a Canadian company established in 2012, dedicated to marketing the Borealis CHP wood-plant system in Canada. Its focus is on both the market development and technical support for this system developed by Spanner Re2 GmbH of Germany and licensed to Borealis Wood Power Corporation. The system is marketed under the Borealis name and customized to the needs of the Canadian marketplace.

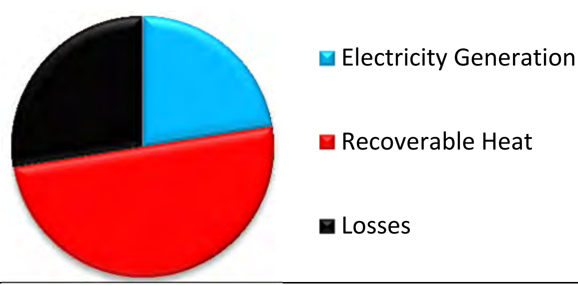


The reactor supports changing the wood chip fuel into wood gas. At the pyrolysis zone, the wood decomposes and begins reducing from its visible wood state. The fuel is then converted to a coal-like hydrocarbon and transported to the oxidation zone where part of the carbon is burned with injected air at approximately 800°C. As the gases move over the hot ember bed (oxidation zone) the tar and hydrocarbons are separated from the gas, resulting in a gas with very low tar.

2.1.7.1 Vendor Summary

To quickly highlight key aspects of the vendor's response, Table 2.6 has been prepared to summarize data provided. A comparison table of all vendors is available in the next sub-section.

Table 2.6 Borealis Wood Power Corporation (Spanner) Summary

BOREALIS Wood Power Corp.™		**Headquarters:**	Burlington, Ontario	
Developer / Company:	Borealis Wood Power Corp.	**Vendor Rep:**	Kevork Sevadjian	
System Information	**Quoted Capacity:**	45 kW_e (45kW_e, 100kW_t)		
	Model Number:	SPANNER 45 kW Wood Power Plant CHP Model 50GH-8 AP		
	System Configuration:	1xGasification Unit, 1xPSI 5.7 Vortec Engine		
		As Quoted	**495 kW_e**	**2.03 MW_e**
Fuel Requirements	**Moisture Content as Fired:**	15%		
	Feedstock Consumption (dry basis):	45 kg/hr 99 lb/hr	495 kg/hr 1091 lb/hr	2025 kg/hr 4464 lb/hr
	Feedstock Size:	Chip size: G30-G40		
Unit Performance	**Net Electric Generating Capacity:**	45 kW_e	11x 45 kW_e	45x 45 kW_e
	Operating Parasitic Load:	N/A	N/A	N/A
	Availability:	Not specified		
	Recoverable Heat:	100 kW_{th}	1100 kW_{th}	4500 kW_{th}
				
	Thermal (CHP) Efficiency:	73%		
	Electrical Efficiency:	23%		
Commercial	**Delivery Lead Time:**	Not specified		
	Quoted Price:	$ Omitted	$ Omitted	$ Omitted

2.1.8 E-Rational (ORC –Technology)

After re-assessing the amount of heat that can be utilized, it was found that a very high percentage would go unused during the summer months. It was therefore determined that the implementation of an Organic Rankine Cycle (ORC) might be beneficial by converting the remaining heat into electricity. E-Rational was selected as the most appropriate technology provider as it has the ability to utilize hot water, although only at 8-10% efficiency.

2.2 VENDOR COMPARISON

The Table 2.7 summarizes various parameters as they relate to each of the selected vendors (with little information available from Nexterra, it was excluded from this comparison). An initial assessment of the table information reveals several obvious omissions, denoted as “N/A”. In many circumstances, this lack of data can be accredited to the specific vendor, whereby much of this information could only be provided following a definitive order or down payment, or with vendors stating that more investigation would be required on their part into many project aspects before more accurate information could be provided. Therefore, vendor comparisons could not be adequately made across all fields, however much of the information provided gives a good general impression of the technology capabilities as a whole.

Table 2.7 Vendor Comparison

		Nexterra		Community Power Corporation A Wholly Owned Subsidiary of Afognak Native Corporation			Weiss			Proton Power		Biomass engineering			Borealis Wood Power Corp.™		
System Information	**Quoted Capacity:**	2.0 MW$_e$		100 kW$_e$			1000 kW$_e$			2.0 MW$_e$ (8x 250 kW$_e$)		500 kW$_e$			45 kW$_e$		
	Model Type/Number:	Standard CHP System		BioMax 100 CHP System			N/A			250 kW$_e$ CHyP (Cellulose to Hydrogen Power)		N/A			SPANNER 45 kW$_e$ Wood Power Plant CHP Model 50GH-8 AP		
	System Configuration:	1-Stage Updraft Gasifier		1-Stage Downdraft Gasifier, 2x IC Engines			1xGasification Unit, 1x 800 amp Genset			1x Multi-zone Reactor, 1x IC Engines		1x Gasification Unit, 1x 500kW Gas Engine			1xGasification Unit, 1xPSI 5.7 Vortec Engine		
**denotes scaled values*		**500 kW$_e$**	**2.0 MW$_e$**	**As Quoted**	**500 kW$_e$**	**2.0 MW$_e$**	**As Quoted**	**500 kW$_e$**	**2 MW$_e$**	**500 kW$_e$**	**2.0 MW$_e$**	**As Quoted**	**1 MW$_e$**	**2 MW$_e$**	**As Quoted**	**495 kW$_e$**	**2.03 MW$_e$**
Fuel Requirements	**Moisture Content as Fired:**	20%		15%			35-55%			15%		<20%			15%		
	Feedstock Consumption (dry basis):	N/A	1,474 kg/hr 3,250 lb/hr	91 kg/hr 200 lb/hr	363 kg/hr* 800 lb/hr*	1,452 kg/hr* 3,200 lb/hr*	1150 kg/hr 2535 lb/hr	575 kg/hr* 1268 lb/hr*	2300 kg/hr* 5071 lb/hr*	417 kg/hr* 919 lb/hr*	1,670 kg/hr 3,673 lb/hr	N/A	N/A	N/A	45 kg/hr 99 lb/hr	495 kg/hr* 1091 lb/hr*	2025 kg/hr* 4464 lb/hr*
	Feedstock Size:	N/A		Chip size: <51 mm			Chip size: G100			Chip size: <6 mm		Chip size: < 100x100x30 mm			Chip size: G30-G40		
Unit Performance	**Net Electric Generating Capacity:**	N/A	2.0 MW$_e$	100 kW$_e$	2x 250 kW$_e$	8x 250 kW$_e$	2x500 kW$_e$	500 kW$_e$	4x500 kW$_e$	2x 250 kW$_e$	8x 250 kW$_e$	2x250 kW$_e$	4x250 kW$_e$	8x250 kW$_e$	45 kW$_e$	11x 45 kW$_e$	11x 45 kW$_e$
	Operating Parasitic Load:	N/A	N/A	10 kW$_e$	40 kW$_e$*	160 kW$_e$*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Availability:	91%		80%			N/A			92.5%		N/A			N/A		
	Recoverable Heat:	N/A	2.93 MW$_{th}$	161 kW$_{th}$	644 kW$_{th}$*	2,576 kW$_{th}$*	2000 kW$_{th}$	1000 kW$_{th}$*	4000 kW$_{th}$*	666 kW$_{th}$*	2,664 kW$_{th}$	N/A	N/A	N/A	100 kW$_{th}$	1100 kW$_{th}$*	4500 kW$_{th}$*
	CHP Efficiency:	75%		80% (w/secondary heat recovery) 65% (w/o secondary heat recovery)			83%			63%		N/A			73%		
	Electrical Efficiency:	31%		25%			28%			27%		24%			23%		
Commercial	**Delivery Lead Time:**	N/A		7-8 months			9-12 months			12-18 months		N/A			N/A		
	Quoted Equipment Only Price:	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted	Omitted

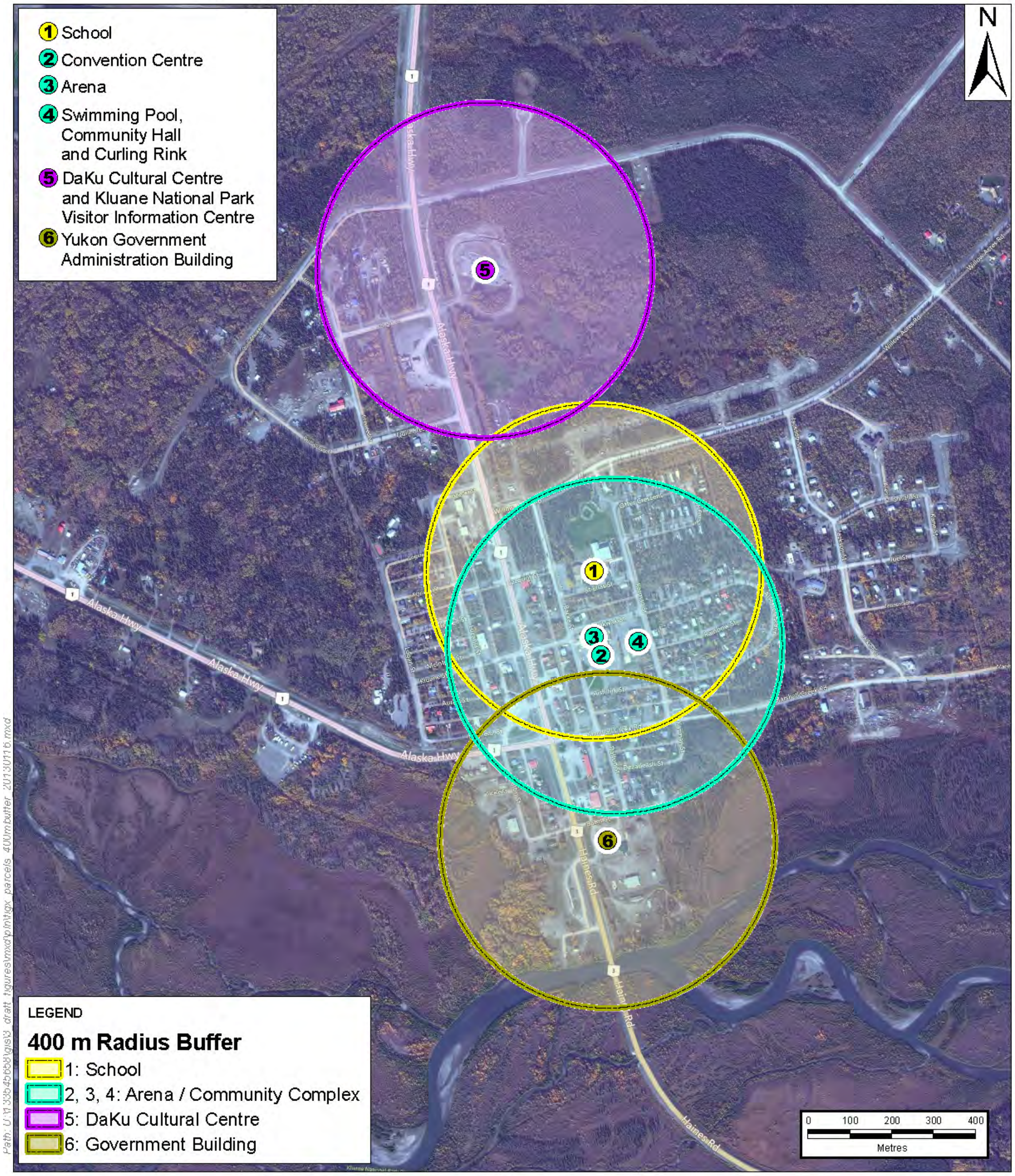
2.3 FACILITY SITING ASSESSMENT

In order to progress preliminary engineering it was necessary to select a site for the biomass plant. In parallel to the Stantec FEED study, Clean Technology Community Gateway (CTCG) was conducting an Evaluation of Waste Heat Potential study (CTCG, 2013). The results of the study were provided in mid-December and indicated that of all the potential waste heat uses, building heat would be the recommend usage (in particular heating only the school if a 500 kW_{th} plant was used). Further to their recommendation, CTCG referred Stantec to a previous Morrison-Hershfield (MH) district heating study for the village as a basis for potential building connection.

Using the results of the CTCG and MH study, Stantec developed a map using our in-house GIS capabilities to outline potential areas to locate the biomass plant. The map excerpt presented in Figure 2.4 shows 400 m buffer zones around buildings that could use the biomass plants waste heat. The buffer zone was established based on viable distance from heat loads determined by CTCG.

Based on the results of the waste heat study and the map areas indicated in Figure 2.4, Stantec recommended proceeding with a location near the school (see Figure 2.5) to capture the school heating load. This location had several advantages associated with it, including

- Being located near the existing diesel generator site.
- Close to the school but off school property – there is a tree line and road between the school and the plant.
- The district heating pipeline from the plant can run down the existing road to the school.
- Future expansion of the line further south would allow the plant to pick up the other buildings identified by CTCG/MH.
- If a greenhouse was of interest now (or becomes of interest in the future), it can be located on school property and fed from the network.
- Truck traffic would be kept to main traffic arteries (out of residential neighborhoods) – potential to receive fuel from the Alaska Highway entrance to the existing diesel site or new entrance.
- Tie in to the grid would be less complicated as the unit would be right next to the switchyard.
- Allows for the possibility of supplying syngas to the existing diesel generators – something CPC has indicated is a possibility.
- Potential exists to tie into the cultural centre to the North.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Properties near the Project Feed Study for Yukon Bioenergy Haines Junction, Yukon	Scale: 1:12,500	Project No.: 133545658	Data Sources: Geomatics Yukon Imagery: (c) 2010 Microsoft Corporation and its data suppliers	Fig. No.: 1	Stantec
Client: Yukon Energy Corporation	Date: (dd/mm/yyyy) 16/01/2013	Dwn. By: JAB / Appd. By: VLC			

Stantec Consulting Ltd. © 2013 Map: NAD83 CSRS Yukon Albers

Figure 2.1 Building Heating Locations with 400 m Buffers

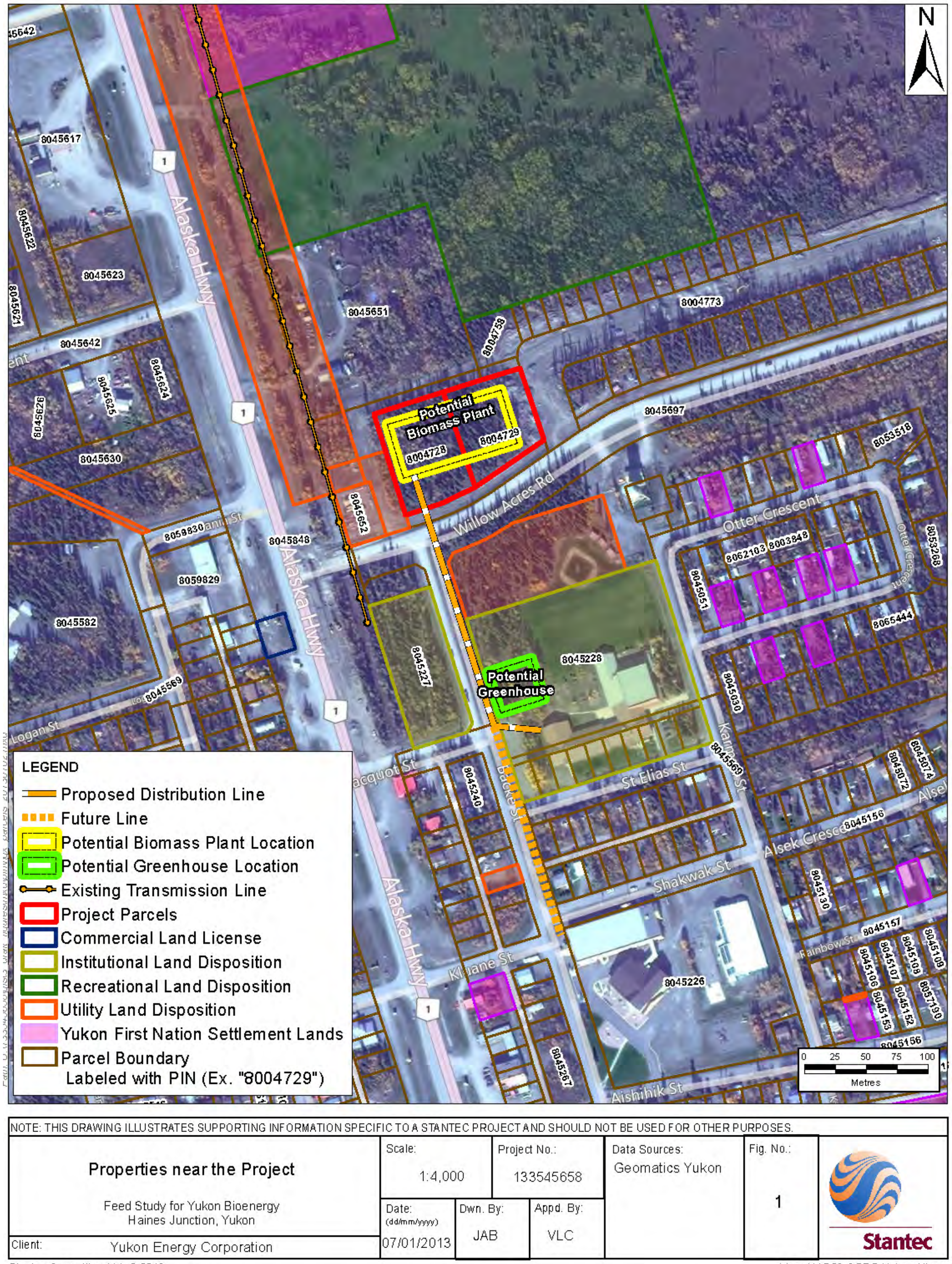


Figure 2.2 Biomass Potential Plant Location

2.4 PRELIMINARY DESIGN AND CAPITAL COST

As mentioned previously, the overall intent of the project is to demonstrate the viability of biomass power generation in the Yukon. For the purposes of the FEED design, it was assumed that the demonstration plant would start as a 500 kW_e power plant, and expand in the future once its operation and financial viability are confirmed. Using this approach, three (3) options to initiate the project were considered: Option #1 includes enclosing the entire plant in the power plant building, Option #2 provides a more aesthetically pleasing building enclosure (architecturally designed), and Option #3 reduces the enclosure to only include the fuel storage facility, locating the gasification plant outside in shipping containers.

Option #4 is presented to highlight the ability of the design to facilitate future expansion to 1.0 MW_e (500 kW_e addition) and 2.0 MW_e. This approach can also be used when the project starts off, if a larger capacity plant is desired. Please refer to Appendix D, E, F, & G for information regarding the design and opinion of capital cost for the biomass plant options described in the following sub-sections.

2.4.1 Option #1 – Full Building Enclosure – 500 kW_e

To support the development of the business case, and based on the preliminary design described herein, Stantec has prepared a Class IV Opinion of Probable Construction Cost (OoPCC) to install 2 x 250 kW_e wood gasification units supplied by Community Power Corporation (CPC) in Haines Junction. Option 1 OoPCC is based on preliminary planning in a new building in Haines Junction near the existing stand-by diesel substation

2.4.1.1 Scope Summary

The scope of work would include:

- Construction of new 37.4 m x 36.4 m pre-engineered building.
- Construction of new service roads.
- Installation of 2 X 250 kVA wood gasification generators.
- Installation of electrical power equipment, including step-up transformer and switchgear, to connect generator output to the existing 25 kV distribution system.

2.4.1.2 Detailed Project Scope Definition

CIVIL / STRUCTURAL

The civil/structural scope includes:

- Site Work. Clearing and grubbing, site grading, road and parking, building foundation preparation, buried water and sewer services.
- Concrete Work. Building foundations, building slab, door aprons, transformer pad, and elevated slab.
- Pre-Engineered Building (37.4 m x 36.4 m = 1360 m^2). Building steel, insulated walls, insulated roof, doors, openings for louvers and vents.
- Building Internals. Interior rooms (with storage above), chip bin areas, divider wall between chip handling and gasification/generation.

MECHANICAL

The mechanical scope includes:

- A 500 kW_e modular wood biomass CHP system.
- Radiant in-floor heating for entire building using boiler thermal energy as heat source with electric circulation heater backup.
- Combination of wall fans and roof gravity ventilators to provide necessary building minimum ventilation airflow as required by applicable standards for occupancy, oxygen levels, and airborne contaminants such as CO and combustion gases.
- Pressurization air units for the electrical and mechanical rooms.

- Split heat pump system covering the office / meeting room and the lunchroom.
- Small humidifier.
- Plumbing of one washroom and one kitchen sink.
- Fire protection provisions including dry sprinkler, standpipe, fire extinguishers, and pull stations for the entire building. Provision for a manual deluge fire suppression line is also included for each biomass conveyor.

ELECTRICAL

The electrical scope includes:

- Utility power for the building services loads and backup power source for the generator auxiliaries. This includes transformer, fused disconnect, and customer metering. Connections and material up to the meter assumed to be supplied by the utility but an allowance has been made in the estimate to cover the costs associated with this work.
- A 480 V / 400 A power distribution panel (complete with main breaker) feeding utility power to building services loads and aux power to the generators when required.
- Transfer switches at each generator allowing choice of auxiliary power source from either the online generators or the utility feed.
- 480 V switchgear to parallel the outputs of the generators.
- An oil filled 600 kVA step up transformer 480 V / 25 kV to connect generator outputs to the utility line. An oil containment system allowance has been carried.
- Allowance for the utility to connect the generator output from the step-up transformer to the line including fused disconnect.
- Allowance for utility to install revenue metering on the secondary of the step-up transformer.
- Allowance for grounding the building and equipment.
- Building services including low voltage distribution panels, lighting, fire alarms, receptacles, communications, etc.
- Allowance for a contractor to make electrical connection between the shipping splits of Vendor supplied equipment.

- A PLC based control system for miscellaneous building services and heating loop indicators and alarms.
- Communication connections between the Vendor’s supplied equipment, the PLC controller, and a main network switch. This will allow remote monitoring of building and equipment alarms and allow remote configuration and monitoring of the CPC supplied units.
- All power, control, and communications wiring and raceway required to service the units and the surrounding infrastructure.

2.4.1.3 Detailed Basis of Estimate

ENGINEERING

The preliminary engineering allowance is 3.0% of capital, which would include a Class III estimate for project appropriations.

The detailed engineering allowance is 10% of capital for the purposes of this capital estimate. Should the project move forward and Yukon Energy solicit a proposal for further engineering by Stantec, an Opinion of Probable Engineering Costs (OoPEC) would be prepared and included in that proposal. This allows for typical engineering costs for the purposes of budget appropriations.

PROCUREMENT

Major equipment is assumed to be purchased by Yukon Energy and supplied to the installation contractor on site. In this particular study, that would include the switchgear, the step-up transformer, transfer switches, and Vendor supplied generators. This approach is advantageous in that:

- It ensures adherence to the utility standards for equipment where many options and additions are commonly available.
- It does not delegate away the responsibility of expediting these items to site. By maintaining responsibility, the Owner can exercise greater control of delivery on these critical items.
- It avoids the standard contractor markup of ~10% being added to large value line items.

All other items, including cable, cable tray, and all other commodity items required for the installation shall be supplied by the contractor as part of their lump sum installation pricing. This eliminates the need for utility engineers, managers, or consultants to be responsible or concerned with inventory levels of items that are extremely hard to track on a busy construction site.

PRODUCTIVITY FACTORS

Labour factor adjustments have been applied to this estimate based on the following:

- Distance from Whitehorse as it applies to accessing supplies.
- Distance from Whitehorse as it applies to accessing skilled labour.
- Estimated inventory levels at local supply houses.
- Working outdoors or in non-serviced building.

CONSTRUCTION

This OoPCC is based on the following sources of data for labour and materials:

- In-house databases built from historical or manufacturer’s listed prices.
- Direct contact with vendor for switchgear.
- NECA (National Electrical Contractor’s Association) Manual of Labour Units 2011-2012 for specific items covered by that publication.

- Historical labour costs for other items not specifically listed or requiring special consideration.

DIRECT CONSTRUCTION AND INSTALLATION COSTS

Civil / Structural

Site Work

Site work includes clearing and grubbing, site grading for the initial two unit arrangement, preparation of roadway and parking areas by replacement of 1 m of material with compacted pit run gravel, building foundation excavation and backfill, underground water and sewer services, and a fire water loop with two hydrants. For the purpose of this estimate, it has been assumed that water and sewer services exist under the adjacent streets with sufficient supply pressure for building fire protection.

Quantities were calculated and cost opinions were developed using costs from other jobs, with reference to the RS Means cost database, and with partial input from Jon Schmidt of JTS Cost Consulting, Whitehorse.

Concrete Work

Concrete work includes reinforced cast-in-place concrete for building foundations, grade and elevated slabs, door aprons, and transformer pad. Preliminary design has the building on spread footings founded below frost, with a full perimeter wall that extends 2500 mm above grade in the chip handling area to act as chip bins. Grade slab is 200 mm thick both for truck traffic and to support the gasification/generation equipment.

Stantec provided partial quantities and preliminary building layouts to JTS Cost Consulting who developed the cost opinion raw data.

Pre-Engineered Building

The 1360 m^2 building includes a structural steel frame with girts and purlins, wall panels insulated to R30, roof panels insulated to R50, man doors, overhead doors, and openings for louvers and vents. The roof is symmetrically peaked with a 1:12 slope. The east gable end structure has been designed to allow future expansion of the building in this direction.

Quantities and cost opinion for the building was provided by a pre-engineered building supplier (Varco Pruden Buildings).

Building Internals

Building internals include interior rooms for electrical, mechanical, storage, lunchroom, washroom, and administration. As presently proposed, the rooms would be masonry with a concrete roof slab on metal deck to create a storage area above. A wall aligned with the building peak would provide working separation between the chip storage area and the gasification/generation equipment.

Stantec provided partial quantities and preliminary building layouts to JTS Cost Consulting who developed the cost opinion raw data.

General Conditions

JTS Cost Consulting has provided a cost opinion for General Condition items, including:

- Bond, insurance, and permits.
- Temporary office, power, heat, phone, data, fencing, and toilets.
- Safety.
- Layout.
- Clean-up, snow clearing, and waste management.
- Freight and deliveries, materials handling and protection.
- Vehicles and fuel (vehicle and equipment).
- Hoisting, zoom boom, sky reach, and scaffolding.
- Tools.
- Supervision, project management, and foreman surcharge.
- Room and board, including travel.
- Mobilization, and demobilization.
- Close out, as-builts, and manuals.
- Winter works premium.

These items have been included in the civil-structural estimate although they apply to the entire construction activity and sequence.

Mechanical

The mechanical scope for Option 1 includes:

Wood Biomass CHP System

The assumed CHP system size is 500 kW_e nominal electrical and 644 kW_{th} thermal generation capacity.

Equipment cost based on scaling up base budget proposal from CPC for a 100 kW_e system by a factor of four. Efficiencies of scale are gained to achieve the additional output adding up to 500 kW_e total electrical generation capacity.

This system is installed by assembling 14 container type modules which include feedstock handling end, dryer module, gasifier module, genset module, filter module, and controls module.

HVAC

Radiant In-Floor Heating

Allowances cover the entire building concrete floor slab, including ancillary rooms. The primary source of heat for the in-floor heating will be provided by tapping into some of the thermal energy available from the boiler flow supplying the district heating system output from the plant. The fluid will be circulated to the various areas of the building by two circulation pumps (one backup). Control valves will distribute the flow as necessary to maintain the demand requirements of each temperature zone. The design intent is currently to maintain a floor temperature of 1 °C for the fuel delivery and storage building section, 10 °C for the generator house building section, electrical room, mechanical room, and storage room, and 21 °C for the lunchroom, office/meeting room, and washroom.

An allowance for a pair of electric circulation heaters was provided as a source of backup building heat when the boilers are not in operation.

Welded wire mesh for attaching tubing, vapour barrier, and insulation costs carried under civil estimate.

Radiant concrete slab heating cost estimate includes (2) slab temperature sensors for each temperature zone.

Ventilation

The design approach for ventilation of the areas of the building other than the ancillary rooms is to utilize wall mounted ventilation fans with insulated motorized dampers in conjunction with roof mounted low profile gravity ridge natural ventilators with manual chain operators. Those systems would provide necessary building minimum ventilation airflow as required by applicable standards for occupancy, oxygen levels, and airborne contaminants such as CO and combustion gases.

Roof curbs and flashing for the roof gravity ventilators included as part of the civil estimate.

An allowance has been made for the mechanical room and electrical room to have their own pressurization ventilation unit.

An allowance has been made for a small humidifier.

An allowance was made for rental of equipment required to install the HVAC components.

An allowance was made for HVAC related floor / piping penetrations.

An allowance has been made for a ductless split heat pump system covering the office / meeting room and the lunchroom.

Plumbing

A plumbing allowance has been made for a washroom sink, water closet, kitchen sink, water heater, heating system fill line, floor drain in mechanical room, and sewer line inside building.

Potable water supply assumed to be coming from the street.

Sewer piping from building to street covered in the civil estimate.

Fire Protection

For the purposes of determining fire protection requirements for the building, a cursory review of applicable 2010 NBC (National Building Code of Canada) requirements was conducted:

Preliminary building classification per 2010 NBC is high hazard industrial occupancy F-1 for the fuel delivery and storage building section and generator house building sections.

The generator house section is classified as high hazard F-1, as opposed to F-3 normally allowed by code, to avoid the need for a 2 hour rated fire separation, which would normally be required between the fuel delivery and storage section and generator house section as per NBC Section 3.1.3.1.

The reason to classify the entire building as a Type F-1 occupancy is that it is not practical to maintain a 2 hour fire separation at the biomass conveyor penetrations at the wall. The F-1 building falls under Group F Division 1 up to two storeys, under NBC Section 3.2.2.70 which requires sprinklers throughout.

A standpipe system is also required for the F-1 building since its classification does not fall under the exceptions listed under NBC Section 3.2.5.8.

The building requires stations and fire extinguishers.

Fire detection and alarm covered under electrical section.

In addition to specific NBC requirements, conveyors systems handling this amount of combustible material normally require a few manual deluge connections to provide local suppression from a risk mitigation standpoint. The insurer for the plant typically drives this requirement.

Electrical

General Methodology

The power distribution transformer and associated power system components and cabling have been sized for 250 kW_e output from each unit with a worst-case power factor of 0.85. The CPC supplied equipment is shipped to site in several shipping splits. Although the units are prewired by CPC, the installation contractor will make final connection between shipping splits as per CPC instructions.

General Description of Major Products

All new cable tray installed will be aluminum, B-Line series 25, and industrial cable tray. Typical tray grounding and supports are included.

All new power cables up to the low voltage side of the power distribution step-up transformer are 1 kV rated, Teck cable. Allowances have been made to allow the utility to make the 25 kV connections.

Transfer switches are manual type switches with make before break contacts when moving from utility to generator power after the generator has synchronized to the line.

Switchgear is based on GE LV switchgear with one main breaker and two unit breakers. Allocation has been made for two prepared spaces for future expansion.

The power distribution transformer used to connect the generator output to the grid is a liquid filled type installed outside with a containment system.

Electrical Installation Costs

Service Entrance

Allowances have been made for the utility to supply and install a pole mounted transformer and fused disconnect. Allowances have been made for a metered entrance and it is assumed that the utility preforms all work up to the line side of the meter.

A 400 A, 480 V, 3 phase power distribution panel complete with a main breaker will be installed inside the electrical room to supply building services and unit startup power.

Transfer Switches

Transfer switches will be installed to transfer generator auxiliary loads to the utility power feed for start-up. When the generators are online, the auxiliary loads would be switched back to the unit internal power.

Grounding

Allowance has been made to allow typical grounding of the service entrance, the generators, and the building itself.

Building Services

Power Distribution

Allowances have been made for lighting and miscellaneous power requirements for the building. This includes transformers, panels, and wiring for all building services loads.

Heating and Ventilation

Allowances have been made to connect heating and ventilation equipment.

Lighting

Allowances have been made for lighting in all areas of the building. Allowance has been made for the installation of roadway lighting along the service road.

Communications Including Remote Monitoring and Configuration Links

Combination data and telephone outlets are to be in the office area and several telephone outlets throughout the rest of the facility. Everything will be wired back to an incoming line within the electrical room. The CPC system will also be connected to allow remote monitoring, alarming, and configuration from CPC facilities.

Equipment will be installed to allow remote monitoring of indicators and alarms for major equipment in the building. This includes allowance for a small programmable logic controller and network switch. In addition, this connectivity will serve the CPC supplied equipment to allow for monitoring and configuration from their headquarters.

Fire Alarm

A fire alarm system has been included with smoke detectors, thermal detectors, heat detectors and manual pull stations to provide initiating protection. Horn strobes provide audio and visual signaling. There is an allowance for several flow and tamper switches for a sprinkler system. Control relays were also considered with the fire alarm system for equipment shut downs.

Generator Output

The owner-supplied switchgear will be installed by the electrical contractor. Switchgear pricing is based on information received from GE for budgeting purposes. The switchgear includes a main breaker, two unit breakers and two prepared spaces in the pricing. All cabling, including raceway, required from the units to the switchgear have been included.

The electrical contractor will install the step-up transformer on a concrete pad outside the building. Pad to be provided by the civil contractor. Transformer pricing is based on review of pricing of similar transformers normalized to a value per kVA and scaled to 600 kVA.

Allowance has been made for the utility to make all connections beyond the secondary of the step-up transformer including a pole mounted fused disconnect and revenue-metering unit.

Instrumentation and Control

Allowances have been made for several poisonous gas detectors to be installed. Alarms will be relayed through the fire alarm panel.

Connections of the Vendor Supplied Equipment

There is an allowance of two men for one week for each unit intended to cover the interconnection of vendor supplied shipping splits. All material for this work is assumed to be supplied by the vendor.

MISCELLANEOUS CONSTRUCTION DIRECTS

Most construction directs have been accounted for in a blended labour rate. This would include small tools and consumables.

Allowances for required equipment rentals used as part of a normal installation are included in the blended labour rate.

Supervision, crew trailer, and personal PPE are also included.

Freight is included in the material / equipment pricing.

INDIRECT CONSTRUCTION COSTS

Construction Staff & Consultants

An allowance of 2.5% of capital has been carried for an onsite construction manager. An allowance of 1% of capital has been carried for site engineering services to support construction.

Owner's Staff Costs

No allowance has been made for Owner's personnel to support this work.

Commissioning Costs

Commissioning costs are carried as 1.5% of capital. This includes allowances to bring vendor representatives to site.

Escalation Costs

An escalation allowance of 5% has been allowed based on lead-time required before construction begins.

Capital Spares

A capital spares allowance of 5% of the equipment cost has been included.

Indirects Specifically Not Included

The indirect costs associated with the following have not been considered and are assumed to be supplied by Owner. No costs have been assigned to these services that will be associated with this project unless specifically noted in the OoPCC.

- Security.
- Lock-out tag-out (LOTO) coordination.
- Waste removal.
- Snow removal.
- Warehousing and utilities including temporary power supply.
- Temporary lighting.
- Taxes.

- Interest charges during construction.
- Owner's administration costs, including:
  - Legal fees.
  - Insurance.
  - Salaries of Owner's project staff.
  - Allowance for operators hours during training, commissioning, and start up.

Special costs to dispose from site construction waste.

2.4.1.4 Opinion of Probable Capital Cost

The Opinion of Probable Capital Cost for this option is $12.7 M. Table 2.7 provides a breakdown of the probable cost with a detailed line item list included in Appendix C.

Table 2.8 Option #1 Opinion of Probble Capital Cost

Line	Description	Labour Cost	Material Commodity Cost	Equipment Cost	Sub-Contractor Cost	Total Cost
1	**PROJECT TOTAL, BASE SCOPE**					**$12,727,154**
2	Civil - Structural	$562,428	$1,001,238	$195,250	$1,235,200	$3,528,066
3	Mechanical & HVAC	$168,520	$199,500	$5,205,000	$192,476	$5,816,052
4	Electrical	$371,089	$172,531	$238,465	$74,197	$948,827
5	**Sub Total**	**$1,102,037**	**$1,373,269**	**$5,638,715**	**$1,501,873**	**$10,292,945**
6	Preliminary Engineering @ 3% (Class III Estimate)					$152,647
7	Detail Engineering @ 10% Direct Construction Cost					$508,824
8	Construction Management @ 2.5% Direct Construction Cost					$127,206
9	Site Construction Support by Engineering @ 1% Direct Construction Cost					$50,882
10	Commissioning Costs @ 1.5%					$76,324
11	Escalation Allowance @ 5%					$254,412
12	Capital Spares - 5% of CPC equipment cost					$250,000
13	**Sub Total**					**$11,570,140**
14	Contingency @ 10%					$1,157,014

Capital Cost Risk Analysis

No detailed risk analysis has been made on this Class IV OoPCC. A contingency of 10% has been allocated. As per AACE guidelines, a Class IV OoPCC is accurate to a range between -20% and +40%.

2.4.2 Option #2 – Full Architectural Enclosure – 500 kW_e

Option #2 retains the technical and operational characteristics of Option #1, while providing a superior aesthetic presence to the biomass facility to be located in the village.

2.4.2.1 Architectural Details

Accessed from the Alaska Highway the proposed biomass facility forms bold and angular shapes, establishing a powerful icon against the distant mountains. Elevated roof segments and strong, vertical glazing will serve to provide natural daylight and become a 'beacon' at night for travellers along the highway.

Backing on to boreal forest the building is designed to work with the natural surroundings and take advantage of the environmental conditions.

Sustainability and energy efficiency is modeled within LEED criteria and include:

- Use of natural and recyclable materials.

- Energy efficient building systems.
- Abundance of natural day lighting to reduce energy consumption and provision of a pleasant work environment.
- Use of low VOC materials and adhesives.
- Occupancy sensors to control electrical light fixtures operation.
- Rainwater will be diverted back into the soils.
- Combination wood and steel structure for recycling purposes.

Working within close proximity to the Alaska Highway the roadway entry leads into the clearly defined Main Entry for office personnel. As one approaches the building the single sloped roof, in concert with the ‘V’-shaped structure, provides an intriguing form juxtaposed against the dominant, large biomass structure behind. Cladding materials will be a combination of smooth, cementitious, panels and corrugated metal cladding.

The facility is designed to support both the biomass plant function and administrative / office staff in one modern facility that is energy efficient and pleasant to work in. Programmatically the two-storey turbine plant is tucked in behind the one-storey offices and administration spaces. The soaring ceiling, in concert with natural materials, select bright colours and abundance of day lighting provides staff with a strong connection to the natural surroundings. Additionally, the project is designed to allow for future expansion of both specific programs.

Technically the spaces are supported by a thermally superior building envelope complete with coincident air/vapour barrier and polyisocyanurate insulation in the construction assemblies that exceed minimum thermal insulation code requirements.

2.4.2.2 Opinion of Probable Capital Cost

The Opinion of Probable Capital Cost for this option is $13.5 M. Table 2.8 provides a breakdown of the probable cost with a detailed line item list included in Appendix D.

Table 2.9 Option #2 Opinion of Probble Capital Cost

Line	Description	Labour Cost	Material Commodity Cost	Equipment Cost	Sub-Contractor Cost	Total Cost
1	**PROJECT TOTAL, BASE SCOPE**					**$13,494,160**
2	Civil - Structural	$617,073	$1,094,838	$203,150	$1,631,800	$3,528,066
3	Mechanical & HVAC	$168,520	$199,500	$5,205,000	$192,476	$5,816,052
4	Electrical	$371,089	$172,531	$238,465	$74,197	$948,827
5	**Sub Total**	**$1,156,682**	**$1,466,869**	**$5,646,615**	**$1,898,473**	**$10,292,945**
6	Preliminary Engineering @ 3% (Class III Estimate)					$169,654
7	Detail Engineering @ 10% Direct Construction Cost					$565,514
8	Construction Management @ 2.5% Direct Construction Cost					$141,378
9	Site Construction Support by Engineering @ 1% Direct Construction Cost					$56,551
10	Commissioning Costs @ 1.5%					$84,827
11	Escalation Allowance @ 5%					$282,757
12	Capital Spares - 5% of CPC equipment cost					$250,000
13	**Sub Total**					**$12,267,418**
14	Contingency @ 10%					$1,226,742

Capital Cost Risk Analysis

No detailed risk analysis has been made on this Class IV OoPCC. A contingency of 10% has been allocated. As per AACE guidelines, a Class IV OoPCC is accurate to a range between -20% and +40%.

2.4.3 Option #3 – Fuel Handling Enclosed – 500 kW_e

Option #3 retains the technical and operational characteristics of Option #1, but attempts to reduce costs by only enclosing the fuel handling area. This option would only be available for the CPC and Proton Power units as they are self-contained in standard shipping containers (CPC units depicted in the rendering).

2.4.3.1 Opinion of Probable Capital Cost

The Opinion of Probable Capital Cost for this option is $11.4 M. Table 2.9 provides a breakdown of the probable cost with a detailed line item list included in Appendix E.

Table 2.10 Option #3 Opinion of Probble Capital Cost

Line	Description	Labour Cost	Material Commodity Cost	Equipment Cost	Sub-Contractor Cost	Total Cost
1	**PROJECT TOTAL, BASE SCOPE**					**$11,402,782**
2	Civil - Structural	$399,213	$714,346	$167,750	$846,626	$3,528,066
3	Mechanical & HVAC	$205,634	$117,600	$5,204,000	$84,301	$5,816,052
4	Electrical	$463,036	$151,271	$238,235	$85,447	$948,827
5	**Sub Total**	**$1,067,883**	**$983,217**	**$5,609,985**	**$1,016,374**	**$10,292,945**
6	Preliminary Engineering @ 3% (Class III Estimate)					$122,831
7	Detail Engineering @ 10% Direct Construction Cost					$409,438
8	Construction Management @ 2.5% Direct Construction Cost					$102,359
9	Site Construction Support by Engineering @ 1% Direct Construction Cost					$40,944
10	Commissioning Costs @ 1.5%					$61,416
11	Escalation Allowance @ 5%					$204,719
12	Capital Spares - 5% of CPC equipment cost					$250,000
13	**Sub Total**					**$10,366,165**
14	Contingency @ 10%					$1,036,617

Capital Cost Risk Analysis

No detailed risk analysis has been made on this Class IV OoPCC. A contingency of 10% has been allocated. As per AACE guidelines, a Class IV OoPCC is accurate to a range between -20% and +40%.

2.4.4 Option #4 – Options for Expansion – 500 kW_e, 1000 kW_e, & 2000 kW_e

A potential path forward for the project is to first install a 500 kW_e plant as a proof-of-concept demonstration for the North, and then expand the facility in the near future. The design described for Option #1 facilitates the expansion of the power plant by an additional 500 kW_e without the need for added auxiliary services (i.e., sufficient space mechanically and electrically have been left to support the expansion). Beyond the 1.0 MW_e capacity, additional building services will be required. From a cost perspective, the first incremental 500 kW_e expansion will see cost savings compared to the initial installation, whereas achieving a 2.0 MWe would be equivalent to double the cost of the 1.0 MW_e plant. This is depicted in Figure 2.3.

To expand the plant in 500 kW_e blocks without incurring increased costs (i.e., each expansion costs the same) is possible, but would require a higher upfront capital cost to ensure the auxiliary services could support three future expansions. The owner needs to weigh the benefit of having the added infrastructure installed upfront for an expansion that may not take place.

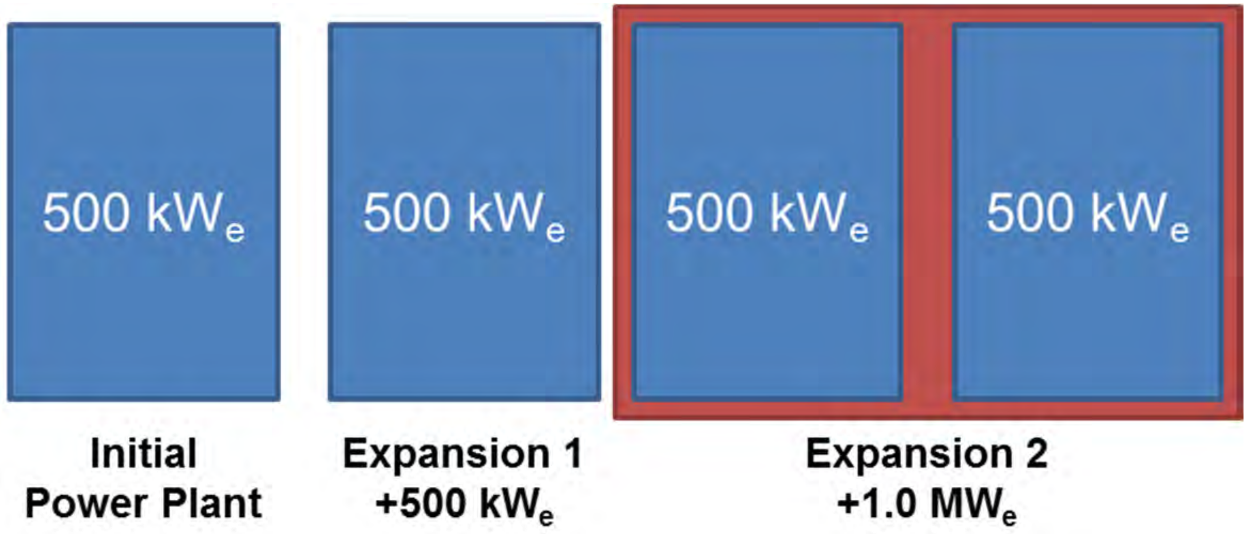


Figure 2.3 Expansion Incremental Costing

2.4.4.1 Opinion of Probable Capital Cost

The Opinion of Probable Capital Cost for this option is an additional $9.8 M on top of the base plant cost to achieve a total 1.0 MW$_e$ capacity, or $22.5 M if 1.0 MW$_e$ is installed initially. To achieve a 2.0 MW$_e$ capacity, the combined figure would double to $45.0 M. Based on equipment costing for the gasification systems, to start the plant with a 2.0 MW$_e$ capacity would be approximately the same budget, $45.0 M.

Table 2.10 provides a breakdown of the probable cost with a detailed line item list included in Appendix G.

Table 2.11 Option #4 Opinion of Probble Capital Cost

Line	Description	Labour Cost	Material Commodity Cost	Equipment Cost	Sub-Contractor Cost	Total Cost
1	**PROJECT TOTAL, BASE SCOPE**					**$22,484,173**
2	Civil - Structural	$648,841	$1,226,438	$229,250	$1,390,000	$3,528,066
3	Mechanical & HVAC	$408,694	$376,500	$10,210,000	$302,428	$5,816,052
4	Electrical	$658,369	$283,829	$320,748	$101,033	$948,827
5	**Sub Total**	**$1,715,905**	**$1,886,767**	**$10,759,998**	**$1,793,461**	**$10,292,945**
6	Preliminary Engineering @ 3% (Class III Estimate)					$368,538.46
7	Detail Engineering @ 10% Direct Construction Cost					$1,228,461.54
8	Construction Management @ 2.5% Direct Construction Cost					$307,115.39
9	Site Construction Support by Engineering @ 1% Direct Construction Cost					$122,846.15
10	Commissioning Costs @ 1.5%					$184,269.23
11	Escalation Allowance @ 5%					$614,230.77
12	Capital Spares - 5% of CPC equipment cost					$250,000
13	**Sub Total**					**$20,440,157**
14	Contingency @ 10%					$2,044,016

Capital Cost Risk Analysis

No detailed risk analysis has been made on this Class IV OoPCC. A contingency of 10% has been allocated. As per AACE guidelines, a Class IV OoPCC is accurate in a range between -20% and +40%.

2.5 OPERATING COST

The operation and maintenance estimated cost is based on the use of an outside Operation & Maintenance (O&M) contractor. Operations and maintenance costs for the biomass plant consists of several components:

- Labor.
- Maintenance and materials.
- Major Equipment Repair reserve fund.
- Annual Environmental Testing.
- Consumables and chemicals.

- Miscellaneous supplies.

The items included in each category are explained below:

- **Labor** - The labor component, excluding fuel cost and renewal fund, is the largest cost in an O&M budget. It consists of the salaries and benefits for the operators and admin staff. The size of the staff can vary significantly depending on the size and complexity of the plant. For a 0.5 MW_e biomass plant, the operation will consist of five (5) full-time operators. Staff will have one plant manager and four (4) operators. The staffing compliment could be lower if based on CPC's operator requirements of two (2) trained operators.

- **Maintenance and Materials** - The cost for maintenance and materials reflects normal daily, weekly, monthly costs for regular plant maintenance.

- **Major Equipment Repair Reserve Fund** - The major equipment in a biomass power plant needs to be overhauled and repaired on a regular basis in accordance with the vendor's recommended procedures. This fund is primarily associated with the gasifier and engine but also includes other major pieces of equipment, particularly rotating equipment and heat exchangers. A reserve fund is established so that money is available to cover the significant costs of the equipment overhaul several years in the future. This cost is carried separately in the business case as the Capital Renewal Annual Rate, see Table 4.14.

  In lieu of planning and reserving for major equipment overhauls and inspections, owners sometimes establish a Long Term Service Agreement (LTSA) with the vendor. The LTSA provides annual performance guarantees from the suppliers as well as responsibility for all repairs and overhauls for a fee. The term of the LTSA can vary from 10 to 15 years. Note this approach was not taken for this O&M estimate.

- **Environmental Testing** - Most environmental operating permits require annual testing for any air, water or wastewater discharges from a plant to verify compliance with the permit conditions.

- **Consumables and Chemicals** - The cost of lubricants, oils, chemicals and misc. consumables used during normal plant operation is included in this line item.

- **Misc. Supplies** - This item covers the general administrative cost of running the power plant. It includes phones, office supplies, computers, etc.

2.5.1 Opinion of Probable O&M Costs

The following table, Table 2.11, is a summary of estimated O&M costs for the two biomass plants:

Table 2.12 Opinion of Probable Conventional Biomass O&M Costs

Description	0.5 MW	2 MW
Labor	$200,000	$350,000
Maintenance & Materials	$50,000	$200,000
Environmental Testing	$15,000	$25,000
Consumables & Chemicals	$15,000	$45,000
Misc. Supplies	$5,000	$10,000
Total O&M Estimated Cost	**$285,000**	**$630,000**

The estimate cost for O&M reflects the estimated average annual cost. It does not include cost normally incurred by the owner. These costs include fuel; insurance; property taxes or asset management fees.

2.6 FEEDSTOCK CHARACTERIZATION (AGFOR)

In order to develop an understanding of the potential for local feedstock for the plant at any capacity, several aspects need to be considered. Of primary interest is the current level of harvesting around Haines Junction, Yukon. Second is the industry the current harvest is serving, and potential synergies with the proposed biomass facility. Finally an assessment of the available fuel characteristics (moisture content, heating value), quantities available/required by the plant, and preliminary costing are provided.

2.6.1 Harvesting and Existing Industries

Overall harvest activity is low with little economy of scale; most equipment is bought used to keep costs down. Harvesting is regulated by permit based on experience and capacity.

New personal use entrants with no harvesting track record are issued permit volumes up to 25 m^3 within specified location in a common area; successive permits can be issued upon successful completion of a permit. Harvesting is by chainsaw and a variety of small scale forwarding equipment from manual, ATV, and snowmobile to pick-up truck.

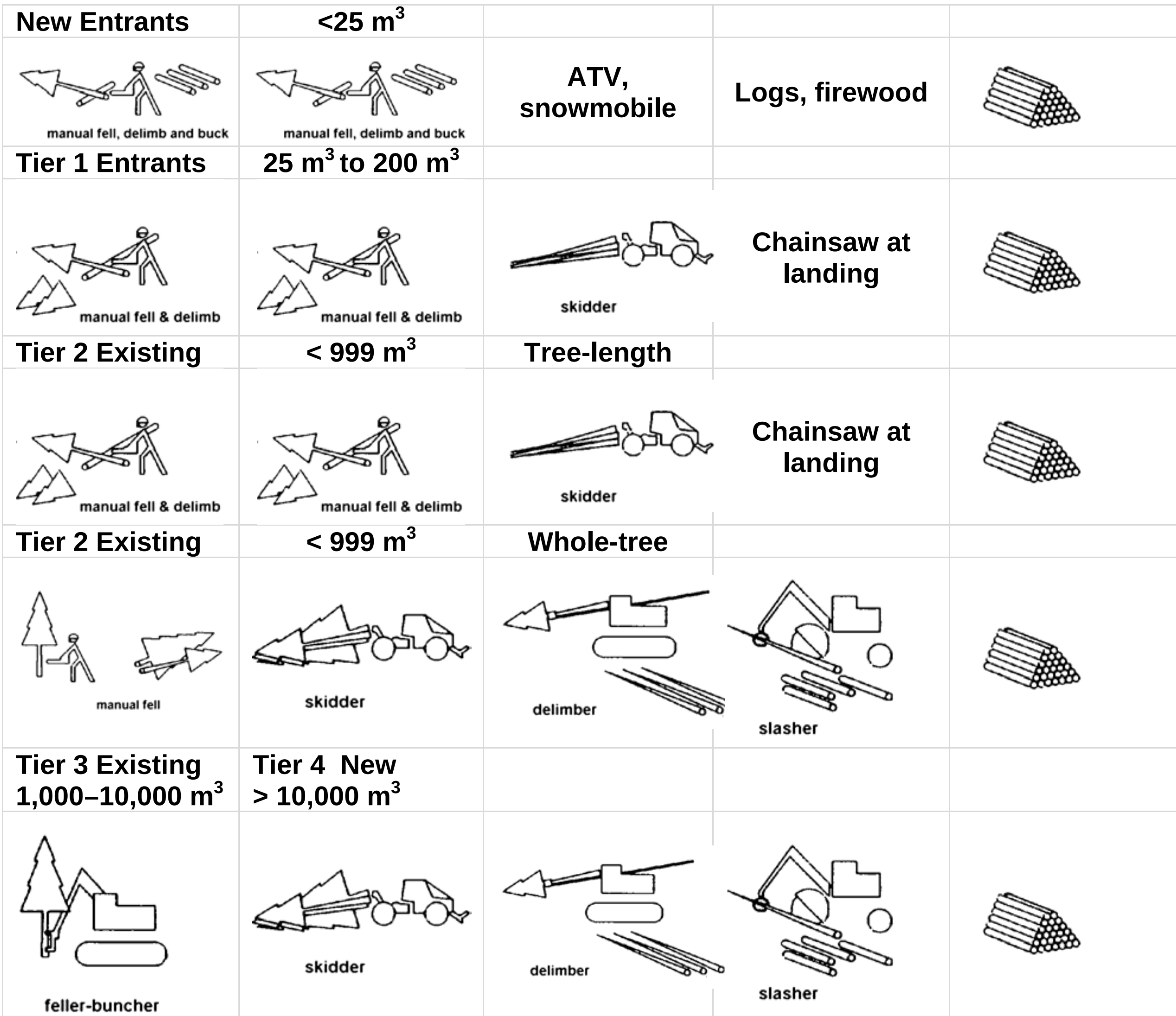
Commercial harvesting activities listed in the Wood Allocation Strategy for Haines Junction are presented in four (4) tiers as follows and depicted in Figure 2.6 on the following page.

Tier 1 – New entrants with no recent Yukon harvest experience (in the past three years) are issued permit volumes from 25 m^3 to 200 m^3. This Tier is for operators who aspire to a Tier 2 permit. Successive permits can be issued. Ten Tier 1 opportunities are made available for a given time period. Harvesting is by chainsaw and a variety of small scale forwarding equipment such as ATVs, snowmobiles, farm tractors and skidders.

Tier 2 – Operators with recent Yukon harvest experience are provided with two years wood supply permits up to 999 m^3 per year within a three-year license period; successive permits can be issued upon successful completion of the current permit. Operators are encouraged to participate in the license design and YESAB screenings. Harvesting is mainly is by chainsaw and a variety of small scale forwarding equipment such as farm equipment and skidders.

Tier 3 – Existing operators with recent Yukon harvesting history (in the past three years) are provided with 1,000 m^3 to 10,000 m^3 per year permits for a maximum of a four-year supply within a five-year period. Operators are required to complete the license design and YESAB screenings. Harvesting is by mechanical felling and bunching, forwarding is by grapple skidder, delimbing ranges from operational limbing (breakage and chainsaw) to cut-to-length processor to produce delimbed logs at the landing ready for loading; alternatively, this is done with chainsaws and or a firewood processor.

Tier 4 – Initiatives requiring significant investment are usually issued a harvest volume greater than 10,000 m^3 per year linked to a capital investment. A five to 10-year term may be considered, depending on availability and the annual allowable cut (AAC). The operator would be responsible to prepare the Timber Harvest Plans (THPs), license area design assessment and YESAB screening and follow the entire process to completion of harvest. Harvesting is by mechanical felling and bunching, forwarding is by grapple skidder, delimbing ranges from operational limbing (breakage and chainsaw) to cut-to-length processor to produce delimbed logs at the landing ready for loading; alternatively, this is done with chainsaws.



Source: AGFOR Inc.

Figure 2.4 Harvesting Tiers

During the course of the FEED, in addition to desktop level assessments, AGFOR spent eleven (11) days (during two separate trips) in the Yukon meeting with key individuals in the Yukon forestry sector including harvesters, sawmill operator, other forest professionals, and Forestry Management Branch staff.

Initially AGFOR met with the three principal harvesting operators in the region. For each operation, AGFOR sought to gain an appreciation of the following:

- Harvest volume of shipped product (firewood, sawlogs) in the recent year – all tenures considered.
- The quantity of wood left standing after harvest excluding regulatory requirements, expressed as percentage of volume of product shipped - as a precautionary measure, AGFOR reduced the volume left standing by 50% to ensure that the requirement to leave 25% of the original standing volume is not compromised.
- The quantity of wood left lying in the harvest block – all species, expressed as percentage of volume of product shipped.
- The quantity of wood left at the landing after product has been shipped – all species expressed as percentage of volume of product shipped.

The same questions were asked of the forestry professionals familiar with the harvesting practices in the Haines Junction area; responses were consistent with those of the operators. For the most part, their answers were comparable with responses in other jurisdictions (AGFOR in-house).

In the Yukon, there are two principle uses of biomass feedstock: firewood and two small sawmills (one in Dawson and one near Haines Junction). The Haines Junction firewood and sawmill industries are serviced by three principal harvesters who collectively harvest and deliver approximately 25,000 m^3 per year, all tenures considered (>90% of the Haines Junction harvest).

For the sawmill, it was important to estimate bark, sawdust, and shavings left after sawing merchantable lumber, and the mill's current recovery factor (m^3 of logs per thousand board feet – MFBM). Subtracting the sawn lumber volume from the gross log volume delivered to the sawmill allowed for an approximation of the sawmill recovery and residuals

Estimated residues, in green metric tonnes (GMT), for each of the above assessment (i.e., sawmill residues, biomass left standing, left lying in block, and left lying at the landing) are summarized in Table 2.12; these are the forest harvesting residuals after product is shipped and the sawmill residuals from producing lumber – they reflect local practices and conditions.

Table 2.13 Opinion of Probable Harvest and Sawmill Residues (GMT)

Known Sources :	Tonnes/year
Sawmill residues	2,000
Left at landing (slash)	1,450
Left in block (slash)	1,750
Left Standing (- Reduced by 50%)	2,400
Total	**7,600**

2.6.2 From the Forest

With estimates of the potential residues and standing residuals from the three larger forest harvesters in the region and the sawmill totaling approximately 7,600 tonnes/year, it should be possible to supply the biomass to a generating facility capacity of approximately 1 MW_e. The business case for the three larger harvesters should be explored to ensure the validity and longevity of any commitment. The business case for other smaller harvesters and possible new entrants should also be explored to provide forest residuals adding a layer of security of capacity and of supply.

As the biomass plant capacity begins to exceed this level of existing supply (>1 MW_e), it becomes important to appreciate the availability of the required feedstock in relation to the forest resource. A plant capacity larger than 1 MW_e will require green stands to be harvested.

Some of the forest characteristics provide a first indication of the resource:

- Age class distribution and stage of development: Age class distribution is the area of the forest for each age class (10, 20, 30 age classes). This is a gross portrait of the forest landscape and its age. Approximately 40% of the Forest Resource Management Zone (Green Zone) is between 100 and 200 years of age (source: Forest Management Branch data).
- The gross volume (cubic meters of wood per hectare) of timber typically available at each age class is found on a yield curve.
- A significant portion of the forest is mature. Forest stand maturity shifts to over-maturity at just over 200 years when the stand volume begins to decrease. The January 17, 2013 flight over the Haines Junction area suggested that there are no great areas of significant stand volume decrease. The preliminary conclusion is there is mature standing timber.

- A focus on forest stands in the Forest Management Zone (Green Zone) that have more than 75 m^3 per hectare (the lower end of economic operability for many operators) provide the known operable standing volume. This where the requirement should be met. A new forest inventory will provide a better idea of the harvest potential and its geographical distribution.

The first three bullets provide an indication that the overall forest should support the harvest of a small volume of forest biomass. While the final bullet provides an idea of the operable inventory and its location, it should be noted that the current harvest levels with the additional biomass would be below the 2006 temporary salvage harvest. The salvage annual allowable cut ends in 2016. The new Timber Supply Review should identify new areas of potential supply

2.6.3 Moisture Content

Moisture content is a weight-based value; wood from operations is typically quantified on the volume basis, usually by the cord. That means that costs are constant for a given volume regardless of the moisture content. The lower the moisture content, the less wood needs to be harvested. This is operationally significant and contributes to maintaining the overall landscape.

AGFOR heard anecdotal comments of low moisture contents, especially in standing dead trees; a moisture meter reading at the sawmill in October 2012 seemed to confirm that. Reports from other jurisdictions also suggested low moisture contents.

AGFOR undertook to have the moisture contents of wood samples from both freshly harvested live and dead trees. The samples were taken on January 17, 2013. The Yukon Research Centre did the moisture content determinations in their laboratories. The results, shown in Table 2.13 for the dead trees were consistent with expectations, although the results for the live trees were higher than expected.

Table 2.14 Feedstock Moisture Content

Attribute	Moisture Content
Dead spruce	14.8%
Live spruce	47.0%

Chipping to size and moisture content are two key components. The challenge will be the green moisture content and the availability of standing dead (dry) trees. There are indications that the inventory and salvage of standing dead trees will begin to drop with time - when the supply of dead standing spruce becomes unattractive to the firewood business, a move to standing green trees with higher average moisture content is necessary. Moisture content (MC) of 35% is used for standing green trees. When this change occurs during the life of the plant more green wood will enter the feedstock and other pre-processing techniques and measures should be considered. Calculations are based on AGFOR's original assumptions, which are 15% for residues and 35% for standing green wood.

Several factors could affect moisture content at the time of harvest and sampling. Regular moisture content sampling of harvested dead and green trees over a year on different site conditions could provide a better appreciation of the variability.

Measures to reduce moisture content should be explored during the detailed feedstock study following the FEED study; as such, measures could offset the apparent higher than expected moisture content of a limited sample from a few sites. Based on the unit performance outlined previously and 15% moisture content of the immediate feedstock, the feedstock requirements at the bookend capacities are presented in Table 2.14

Table 2.15 Summary of Feedstock Requirement

Scenarios:	0.5 MW_e	2 MW_e
Oven dry tonnes	3,000	15,900
With15% moisture	3,789	20,081
Cubic meters (m^3)	7,293	38,652
Cords	3,241	17,178
Cords per week	62	330
Truck loads/week	2-3 /week	11-15/week

The cubic meter is a solid measure that excludes air spaces and is equivalent to a solid volume of wood one meter wide, one meter high and one meter long

The cord is an apparent volume of stacked bolts of wood including the air spaces between bolts, hence apparent volume. A cord is 128 cubic feet, often described as a pile of wood measuring four feet wide, four feet high and eight feet long or some variation that equals 128 cubic feet.

2.6.4 Feedstock Cost

Feedstock costs are based on the local operating conditions and products that form the operator's business case.

Harvesting Cost

From each operator, AGFOR obtained an indication of their charge-out rate for each function/piece of equipment. This is the cost of harvesting equipment including labour, profit and overhead. In the absence of a charge out rate, AGFOR obtained the roadside selling price of firewood at the forest-roadside landing. From that, the current applicable stumpage and fees are deducted to arrive at a value that approximates their equipment costs with labour, profit and overhead. These are values used on local operations. They were compared to earlier reference studies and to AGFOR in-house studies and cost models.

Transportation and Handling

Where possible AGFOR obtained local rates and found that they were similar to other sources. They were compared to earlier reference studies and to AGFOR in-house studies. Distances where adjusted to reflect average haul distances over time at 50 km for the sawmill residues and 70 km for the forest harvesting residues and dedicated feedstock harvest. The new forest inventory will provide a better idea of the harvest potential and geographical distribution.

Loading and handling costs rely on in-house data with some adjustment to reflect the small scale of the project. These would need to be validated once the siting and feedstock delivery logistics begin to firm-up during the detailed feedstock analysis.

Chipping costs need to be confirmed. There are approaches, such as roadside (landing) storage and chipping, which could provide value to the plant. These would need to be validated once the amount of feedstock, siting and delivery logistics are finalized.

The costs are competitive by many standards. The extent to which these might be considered will occur in a detailed feedstock procurement exercise.

It is anticipated for either scenario (0.5 MW_e or 2 MW_e), that 50% of the winter harvest would be put into inventory for approximately six months at a storage yard eight kilometers away and then reclaimed for consumption. Interest charges would have to be added to that half of the feedstock. Alternatively, the feedstock could be chipped at roadside and delivered directly to the plant.

Several measures should be explored during the final site selection and feedstock procurement to mitigate the extra handling and inventory costs of an off-site intermediate off-site log yard:

- Explore the possibility of a summer harvest to reduce inventory, and provide work for the harvest crew during the summer – this would need the CAFN/Forest Management Branch’s approval and any roads would trigger a review process.
- Store wood at the harvest landing and only reclaim it during the summer for immediate processing and consumption – this would need CAFN/Forest Management Branch’s approval and any roads would trigger a review process. We would expect the wood to dry while in storage.
- Using a mobile chipper at the harvest landing and chipping whole trees has significant advantages:

    - Logging cost will be reduced because no limbing or limited limbing would be involved; if chainsaws and skidders are used there is a significant reduction in the risk of injury.

- While the trees are in storage, the moisture content should reduce, and possibly offset the extra handling and storage costs.
- There is a gain in volume/weight by not topping the tree.

Both chipping and whole tree chipping (or with intermediate limbing) at the landing would require the CAFN/Forest Management Branch's approval and likely require regulatory approval.

SCENARIO 1 - 0.5 MW_e

Scenario 1 produces 0.5 MW_e and requires approximately 3,789 GMT at 15% moisture content (green basis). The sources are sawmill residues, logging debris at the landing (slash) and debris left in the harvest block. Little or no standing live trees are anticipated in this scenario. Should dead standing spruce no longer be available at a future date, a shift to standing live trees would occur. Note that residues make up the majority of the Scenario 1 feedstock which are at 15% MC, which aligned with the assumed moisture content required for use of the CPC system (denoted as 'as fired').

Scenario 1 - 0.5 MW_e	
GMT 'as fired'	**GMT @ 15% MC**
3,000	3,789

The following are the combined delivered and chipped costs of sawmill residues, harvest residues at the landing, and in the harvest block.

Scenario 1 costs as fired (bin)		
	$ GMT as fired	**GMT @ 15%**
(a) Direct to plant	Omitted	Omitted
(b) With secondary yard	Omitted	Omitted

Scenario 1(a), 0.5 MW_e, has an expected direct delivery wood cost of ($ Omitted) per GMT at 15% MC as fired (in the bin) without transitioning through an off-site log yard.

Scenario 1(b), 0.5 MW_e has an expected wood cost via an off-site storage yard eight kilometers away of ($ Omitted) per GMT at 15% MC as fired (in the bin).

SCENARIO 2 – 2.0 MW_e

Scenario 2 produces 2 MW_e and requires approximately 20,081 GMT at 15% MC (green basis). The sources are sawmill residues, logging debris at the landing (slash) and debris left in the harvest block and the harvest of standing live trees in this scenario. Should dead standing spruce no longer be available, the harvest of standing live trees would increase to possibly 78%

of the feedstock; this percentage is used in the Scenario 2 cost estimate with wood at 35% MC. This level of harvest would likely require regulatory approval.

Scenario 1 – 2.0 MW_e	
GMT 'as fired' @ 35% MC	**GMT @ 15% MC**
24,610	20,081

The following are the combined delivered and chipped costs of sawmill residues, harvest residues at the landing and in the harvest block, the harvest of standing residuals and the harvest of live trees for feedstock.

Scenario 2 costs as fired (bin)		
	$ GMT as fired	**GMT @ 15%**
(a) Direct to plant	Omitted	Omitted
(b) With secondary yard	Omitted	Omitted

Scenario 2(a), 2 MW_e, has an expected direct delivery wood cost of ($ Omitted) per GMT at 15% MC and ($ Omitted) per GMT as fired (in the bin) without transitioning through a log yard eight kilometers away.

Scenario 2(b), 2 MW_e, has an expected delivered wood cost via a storage yard of ($ Omitted) per GMT at 15% MC and ($ Omitted) per GMT as fired (in the bin).

2.6.5 Pre-Processing Implications of Biomass Properties

Costs (harvesting, handling, transport and chipping) are essentially constant regardless of moisture content as harvesters are paid on a volume basis. The facility operates in green metric tonnes (GMT) and benefits from any reduction in moisture content. The use of sawmill and harvest residues of dead wood is currently an advantage for all of Scenario 1 feedstock requirements and a portion of the Scenario 2 feedstock requirement. The remainder of the Scenario 2 feedstock will rely mostly on live trees (green). Opportunities to reduce the moisture content of live trees needs to be explored and integrated into the procurement practices.

It is anticipated that 50% of the winter harvest would be put into inventory for approximately six months at a storage yard eight kilometers away (assuming the experimental farm is used) and then reclaimed for consumption. Yard inventories of drier dead spruce and the green live spruce should be kept apart and dated for inventory control. The green live spruce should be reclaimed on a first in first out basis to capitalize on any moisture content reduction. Interest charges would have to be added.

Two off-site storage (inventory) opportunities should be explored:

- Leave the wood decked at the roadside landing in the woods that is accessible to a truck year-round, especially in the summer months, and remove for consumption as needed. This would need to be developed in the next phase (during the detailed feedstock analysis) and would likely require regulatory approval.
- Transport wood to an intermediate off-site yard and then reclaim for processing and consumption. This is the current Scenario 1b and 2b.

The first opportunity involves less handling and is less costly than the second.

A minimum operating feedstock inventory equivalent to two or three weeks supply should be sought. Off-site storage is needed for weekly deliveries of wood during the regular season and in the off-season months. The storage area needs to accommodate basic site access infrastructure and right-of way access for trucks and equipment to and from the piles all year including during the spring break-up. The site should have good drainage to support the traffic all year.

The approximate area required is presented below:

Scenario	Storage Capacity (m^3 - cords)	Area (hectares - acres)
1b	3,122 m^3 (1,388 cords)	0.9 hectares (2.1 acres)
2b	18,302 m^3 (13,700 cords)	5.2 hectares (13 acres)

Harvest of Green Trees (Scenario 2)

Harvest and delivery costs (as-fired) of green trees currently left standing and as a dedicated harvest including harvest, transport to plant and chipping are presented below (rounding differences occur).

In Scenario 2(a) direct delivery (no intermediate storage yard) to the plant for Live Trees - are as follows:

$ / m^3 @ 35% MC	GMT @ 35%	$/GMT @ 35%	Factor to 0%	$ /ODT
Omitted	0.639	Omitted	1.76	Omitted

In Scenario 2(b) indirect delivery via an off-site yard for Live Trees - are as follows:

$ / m³ @ 35% MC	GMT @ 35%	$/GMT @ 35%	Factor to 0%	$ /ODT
Omitted	0.639	Omitted	1.76	Omitted

Potential Employment

Looking at the potential impact to existing employment, either scenario will require an increase both harvesting by local contractors and new employment to support the plant. Based on the fuel quantities expected, the breakdown for added employment is outlined in Table 2.15. This high-level assessment shows the need for increased activity by the local harvesters (Contractor) and the biomass facility (New Corporation (NEWCO)).

Table 2.16 Employment Impacts from Biomass Plant

Employment / Scenario	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b
Person Days	265	343	1464	1612
Person Years Total	1.20	1.56	6.65	7.33
Contractor* Person Yrs	0.70	0.70	4.57	4.57
NEWCO Person Yrs + yard-site maintenance	0.50	0.86	2.08	2.76

*Scenario 2 includes part-time conventional chainsaw and skidder volume

3.0 Environmental Assessment and Permitting

3.1 REGULATORY APPROVALS STRATEGY

A draft Environmental and Socio-economic Impact Assessment (IA) has been prepared based on information currently available on the Project and existing conditions in the area. This report includes an overview of the effects assessment and regulatory regimes associated with permitting the Project, scoping of the assessment to include relevant Valued Components (VC), summaries of baseline conditions for each VC and expected effects and proposed mitigation. Determination of significance has been based on residual effects after implementation of mitigation. Adaptive management and monitoring activities are also outlined where deemed applicable. The environmental and socio-economic impact assessment report draft completed to date is attached as Appendix F.

As the plant site has not yet been confirmed, collection of data to provide an understanding of baseline conditions associated with the plant site has been done at a high level for Haines Junction and the surrounding area. Data available at a desktop level indicate that there are no major environmental constraints on the preliminary site (used in the FEED study). Field studies are required to confirm findings once the site has been selected and are suggested to include (but may not be limited to) heritage resource assessment, vegetation and wildlife surveys and an existing sound pressure level survey. Targeted meetings or interviews with CAFN members and the public should also be held to confirm the plant site should not cause any significant effects on traditional and current land use and culture.

The Project team has drafted the effects assessment thus far with the intent to meet the requirements of an Executive Committee level screening. This route was chosen as the full scope of the Project is not yet confirmed, and thus the volumes of harvesting required are not known. These depend on the plant size and the outcome of the preliminary feedstock harvesting study (now complete). The client has also indicated it is likely that an Executive Committee submission is required based on initial consultation with YESAB. At this time, it is important to note that the level of submission required under Yukon Environmental and Socio-economic Assessment Act (YESAA) has not been confirmed with YESAB. The YESAA trigger for Executive Committee assessment of this Project is based on harvesting of 20,000 m^3 or more of standing or fallen trees. If a plant size of 500 kW_e is chosen it is estimated to consume 10,500 m^3 per year with existing harvesting areas having the potential to supply all of this volume (6,000 m^3 in logging residues from current harvesting operations and 4,500 m^3 (2,200 GMT) of sawmill residues not currently being used). Therefore, this size of plant could potentially be permitted through a Designated Office (DO) level submission (assuming DO level proposals are submitted separately by existing operators for ongoing harvesting). This would reduce the level of detail required in the assessment and importantly the potential timelines for approval. These potential timelines for approval (to receive a Decision Document) of an

Executive Committee proposal are 1 to 2.5 years, whereas the DO process timeline is less than 1 year. Note that on occasion, regulators may require an assessment for a project that is otherwise exempted (although this mechanism has never been applied). There is also a possibility that a Project requiring a DO level submission (as per the requirements of YESAA) could be referred to the Executive Committee at either the onset or following initial review of the DO submission. This referral would primarily be based on the potential for adverse effects even with proposed mitigation as well as stakeholder concerns or use of unknown technologies. Therefore, consultation with YESAB is required to confirm the Project's stream and scope of assessment. This strategy is further discussed in Section 4.3.

3.2 DESKTOP FEEDSTOCK HARVESTING ANALYSIS

Key potential environmental and socio-economic issues associated with using beetle kill and potentially green feedstock in the Yukon have been described in the draft IA (Appendix F). Mitigation options have been identified based on the preliminary information available. The feedstock harvesting environmental analysis included consideration of:

- Long-term sustainability of supply (discussion of the overall sustainability of supply for expansion of biomass use).
- Responsible treatment of ecosystem and environment.
- Legislative and regulatory requirements for the timber resources.
- Fire Management.
- Respect of other uses and users of forests.

Some consideration for Traditional Activities and Culture as well as social, recreational, and commercial use has been included however, this is recommended as an area for further study, now that volumes of required harvest are better understood. For the smaller plant, these are not critical considerations in the event that existing harvesting activities are contracted to supply the Project. Very limited documentation exists to support this type of socio-economic assessment at a desktop level and the social aspect requires consultation to ensure current values and uses are considered.

Supply for a 500 kW_e plant has been determined to be sustainable with no change over existing harvest areas expected. The additional requirement for a 2 MW_e plant is also a low percentage of the overall resource; in consideration of the Green zones as denoted in the Integrated Landscape Plan, the current use and the Timber Harvest Level for the Champagne and Aishihik Traditional Territory (2006). Both the availability of supply and the harvest level are subjects for review as part of the new forest inventory of dead and live forests.

Key guiding documents and plans are highlighted as follows:

2004 – Strategic Forest Management Plan for the Champagne and Aishihik Traditional Territory (CATT) provides direction to the planning process presenting the values and objectives for the CATT necessary to ensure sustainability in the broadest terms and reflecting the traditional and non-traditional values and objectives of the community. It provides the indicators and the processes for involvement of the community in the planning process. It addresses the entire land base in the study area.

2006 - The Timber Harvest Level for the Champagne and Aishihik Traditional Territory spells out the harvest level determination of spruce bark beetle affected forest stands and timber harvesting opportunities. This agreement set a harvest ceiling of 1,000,000 m^3 annually for the spruce beetle affected forest over a ten-year period. The harvest level is being updated with the in progress forest inventory.

2007 – Integrated Landscape Plan for the Champagne and Aishihik Traditional Territory (CATT) originally made available publically in March 2006. It is a subordinate plant to the 2004 Strategic Forest Management Plan (SFMP) and introduces land use Zones and availability for forest harvesting. These zones include both CAFN Settlement Lands and non-Settlement Land. Three Zones are presented:

- Forest Management Zone shown in green (aka the Green zone – 93,700 ha) is the zone currently considered for Timber Harvest Project Planning. Most of the wood harvesting would be in this zone with accommodation for site-specific wildlife and habitat.
- Provisional Forest Management Zone (aka the Yellow Zone – 70,000 ha) is not currently targeted in Timber Harvest Project Planning.
- Conservation Forest Management Zone (aka the Orange Zone – 83,150 ha) in which no commercial harvesting is currently allowed. Significant amendments to the SFMP and the ILP would be required to allow harvesting in this zone.

These documents provide the forest planners with the scope for planning and wood supply analysis, their rules of engagement and are referenced in the *Forest Resources Act* 2008 (FRA) which came into effect in 2011 along with the regulations. The FRA applies to non-Settlement Land where as CAFN Settlement Land falls under the authority of CAFN and is regulated via the *Traditional Activities and Protection Act*.

During this time, inventory estimates were developed to allow a level of forest harvesting activity to occur in the Green Zone. The background data used in this timber supply analysis stemmed from earlier photo interpretation to provide a rough and broad estimate of standing timber. The Timber Harvest Level for the Champagne and Aishihik Traditional Territory is a binding agreement on the allowable salvage harvest that was established in 2006 based on this analysis.

Spruce Bark Beetle, Yukon Forest Health – Forest Insect and Disease Bulletin 19 provides a recent history of the spruce bark beetle infestations and its dynamics - The most recent outbreak began in 1990 caused significant yet unquantified mortality. Large tracts of dead and dying mature white spruce were observable while the infestation was in progress. The harvest/salvage of this wood was made possible with a time limited salvage harvest (10-year period from 2006 to 2016). The extent that this salvage will continue to be available is now a key question as the standing dead trees are beginning to fall.

A Timber Supply Review or new forest inventory is in progress based on recent aerial photo interpretation at a finer resolution. This will provide better data on the volumes, distribution and condition of both dead and live trees.

2009 – Forest Health Report, Yukon Energy Mines and Resources uses a risk based approach to forest health; 2009 is the first year of publication. It provides an expanded history of various forest health issues. The spruce bark beetle is the most damaging forest pest targeting mature spruce in the Yukon. The Yukon outbreak began in 1990 and is (at the time of the report) still underway “It is by far the largest and longest lasting spruce beetle outbreak ever recorded in Canada.” “The intensity and duration of the current infestation are related directly to climatic stress …by the significant increase in temperature during the late 1980s and into the 1990s.

2012 Champagne and Aishihik - Yukon Forest Management Implementation Agreement “reaffirms the provisions included in the Strategic Forest Management Plan for the Champagne and Aishihik Traditional Territory and the Integrated Landscape Plan for the Champagne and Aishihik Traditional Territory (CATT) confirming guidance to the new Timber Supply Review.

The new Timber Supply Review will provide useful information on both dead and live trees and will be the object of public engagements before a revised final annual allowable cut (AAC) is set. The AAC will then be apportioned according to the types of use and license categories in accordance with the objectives of the Forest Management Implementation Agreement. Public consultation would also be conducted before allocations are made.

Current interim allowable harvest volume estimates are based on the earlier inventory and the salvage of dead white spruce. The allocations on non-Settlement Lands follow the process outlined in the **Wood Allocation Strategy (see Operational Policy Procedure June 2012 – Wood Allocation Strategy for Haines Junction):**

- A License is issued and provides the rights to a volume in the licensed area.

- A Timber Harvest Plan (THP) is prepared in accordance with the Act and is approved by Forest Management Branch.
- A Timber Cutting Permit is issued in accordance with the Act.
- YESAA applies to areas over 1,000 m^3 and is engaged.
- A site plan is prepared in accordance with the above and in accordance with the Act.
- A Cutting Permit is issued with the terms and conditions specifying time frames, stumpage and fees and reporting and completion requirements.
- A post assessment conducted by the Compliance Branch provides Closure to the license.

  On Settlement Lands, the *Traditional Activities and Protection Act, The Timber Harvest Level for the Champagne and Aishihik Traditional Territory, the Forestry Implementation Agreement* as well as the SFMP and ILP provide some framework and legislation for harvesting activities. CAFN is currently in the process of developing additional forest policy framework, scheduled to be in place by 2015. This was one of the key objectives of the 2012 Forestry Implementation Agreement. (Per. Comm. Roger Brown CAFN 2013).

3.3 RISK MANAGEMENT STRATEGY FOR ENVIRONMENTAL/SOCIO-ECONOMIC AND REGULATORY APPROVALS

This risk management strategy for environmental and socio-economic regulatory approvals builds on the preliminary work undertaken as part of the environmental assessment and permitting phase. The objective is to define environmental and regulatory approval risks to the project. A summary of gaps and uncertainties and recommendations for further study and potential approvals schedules are provided.

Based on our preliminary work, we consider the overall risk to the Project to be low in relation to attainment of environmental/socio-economic regulatory permitting requirements.

3.3.1 Gaps and Uncertainties

Although some information from the FEED Study has been made available to the environmental team prior to release of the draft study, the effects assessment completed to date (January 31) does not incorporate the information provided in the draft FEED Study or the findings of the preliminary feedstock assessment as these activities were conducted and finalized concurrently. As these studies have been conducted concurrently, some updates to the effects assessment are required to reflect the conclusions of these studies (such as the plant site area, construction periods and activities, volumes of waste generated, water consumed). Further updates are likely to be required depending on the decision of the steering committee on whether to proceed with the Project and at what size or scale.

At this stage (as directed by the Project team), no directed consultation with the Yukon Environmental and Socio-economic Assessment Board (YESAB) has been conducted. It is recommended that potential strategies and timelines be reviewed with YESAB prior to financial and board decisions to move forward so that their input can be considered.

Assessment of cumulative effects has not been completed in detail, as the Project will not be registered with YESAA until a decision to move forward is made by the steering committee and those providing financial support to the Project. Additional activities or projects could be initiated prior to that time. Based on preliminary review, no other activities or projects currently exist that would combine with this Project to cause a significant adverse environmental or socio-economic effect. Further study in relation to socio-economic effects on existing forest harvesting and traditional and current land use, activities and culture may be warranted, depending on the magnitude of harvesting proposed.

Further study of noise/sound quality effects from chipping should be completed once this activity's location and equipment/technology are defined. A set back from the nearest residence or other sensitive receptor (such as the school) of 500 m to 1,000 m is expected to be required to avoid annoyance from noise due to this operation. The preliminary air quality assessment indicates that the Project should comply with regulatory requirements, however this will need to be confirmed based on the emissions profile of the Project from the selected vendor.

3.3.2 Feedstock Harvesting

With regards to moisture content of green trees, limited samples were taken during a one-day field visit on January 17, 2013. The preliminary moisture contents of the green wood determined based on this sampling were higher than expected; these findings should be considered preliminary in nature. More volume of harvest would be needed to supply the feedstock using green wood; this has been partially adjusted in calculations presented in this report by assigning a 35% moisture content to all standing trees left in a block (to be harvested to meet the 2.0 MW_e feedstock needs). Further in-season moisture content analysis should provide a better indication of variability. Moisture content reduction strategies have also been identified for further study.

This is considered a concern as fewer large areas of standing dead wood (beetle kill) may be economically available over time than previously suspected. The new forest inventory of dead and live forests is intended to address that issue. In the event that current harvesters agree to supply the required feedstock for a 500 kW_e facility, minimal planning on the part of the Proponent would be required in harvesting operations. While harvesting for a 500 kW_e facility requires detailed planning of wood harvesting, storage and chipping location and activities to ensure compliance with procedures and continuous feedstock availability, the contracted harvesters could be expected to manage the majority of this planning. Depending on the methods for hauling, storage and chipping, the effects assessment would be revised accordingly.

Harvesting feedstock for a plant larger than 500 kW_e would require an increase in harvesting, beyond current levels. Further study should be undertaken to define the activities and timelines for this harvesting (*e.g.*, types of equipment, blocks required annually and planned field studies, seasonality of harvesting required, wood storage and chipping locations). Once the activities and areas are defined, the additional scope of assessment of socio-economic and environmental effects will be modified.

The assumption that existing fuel wood harvesting will continue to operate as per the status quo and thus could supply the Project as part of this activity presents some risk. The risk to this assumption is that current harvesters could leave the Haines Junction area once the dead wood is depleted. Risk to supply may also increase as the dead wood is depleted, as the economic efficiency of using greenwood volumes is known to be less due to the requirement for drying. This has been accounted for in calculations by assigning a 35% moisture content to all standing trees left in a block and trees to be harvested to meet the 2.0 MW_e feedstock needs. A review of the harvester's business case and of operational moisture content reducing strategies are noted for further study.

3.3.3 Next Steps

The following steps are provided under the assumption that a decision to go forward with the Project is made. No environmental constraints have been identified in the desktop review. Preliminary consultation has indicated that there is community interest and support for the Project.

In consideration of the plant site itself, no environmental constraints are expected for the range considered (500 kW_e to 2.0 MW_e) that would result in denial of approval of the Project for environmental or socio-economic reasons. When the feedstock harvesting activities are combined with the plant operation, there is more uncertainty with the larger plant size in terms of scope of assessment and timeline for completion. However, as the requirements are still a small fraction of the previously estimated forest resource and when combined with current harvest levels, are well within the 2006 Timber Harvest Level for the Champagne and Aishihik Traditional Territory, the inclusion of the forest harvesting activities in the overall assessment is not expected to result in significant adverse environmental effects that cannot be mitigated (for the sizes of plant being considered).

It is recommended that the plant size be selected in consideration of FEED results (economics and technical constraints) and input from consultation with First Nations and the public as well as the expected timelines for permitting of the facility under different scenario (500 kW_e to 2.0 MW_e). Field studies should be defined for this site, as required, in order to finalize the impact assessment in relation to the plant.

Confirmation of the emissions profile and dispersion modeling should be completed during the vendor selection process. Modeling may need to be redone if emissions are higher than those estimated based on Community Power Corporation's (CPC) proposal or stack parameters are substantively different (much lower stack or lower velocity would result in worse ambient air quality predictions).

A strategy for regulatory permitting, which should allow for more timely consumption of beetle-killed wood, is to proceed with permitting of a 500 kW_e facility with minimal additional analysis of environmental issues associated with feedstock harvesting (assuming existing forest harvesting operations can provide the required feedstock and YESAB agrees to a DO level proposal for the plant). This may be justifiable and agreeable to YESAB and the public for the following reasons:

- In accordance with the CAFN strategic plan, CAFN is interested in pursuing regional economic development within its Traditional Territory by exploring opportunities in all economic sectors. CAFN has been actively investigating Biomass potential for 18-months prior to this FEED study.
- The Public and First Nations have not communicated any concerns that cannot be resolved and mitigated through planning.
- Some members of the community and CAFN leadership have expressed their desire to use the beetle killed wood before a catastrophic forest fire occurs or the resource loses its usefulness due to rot (although it is understood that not all members of the community may align with this view).
- Based on the FEED study, the feedstock supply for a 500 kW_e plant should be attainable through existing harvesters without increasing annual harvest area (by using waste from sawmill operations, slash being left in the blocks and at the landing).
- CAFN and the Yukon Government have developed a Strategic Forest Management Plan and Integrated Landscape Management Plan, which is applicable to Settlement and non-Settlement Lands. These plans as well as the Yukon *Forest Resources Act* and the Haines Junction Wood Allocation Strategy Operational Policy and Procedures (non-Settlement Lands) would be followed in harvesting for the Project.
- CAFN does not consider current regulatory/legislative tools to be sufficient to adequately manage forest resources on Settlement Lands and is thus in the process of developing a forest policy framework, scheduled to be in place by 2015. This was one of the key objectives of the 2012 Forestry Implementation Agreement. (pers. Comm. Roger Brown CAFN 2013).

As explained in the FEED study, modular designs are available for the plant. Following the installation and operation of the 500 kW_e plant, sufficient time would be allowed to monitor operational issues related to the plant and/or feedstock acquisition (either operational or environmental/socio-economic). Subsequent to this, a proposal could be submitted to the DO

for expansion. Assuming operation of the initial 500 kW_e plant is shown to cause no significant effects, permitting of an expansion may be relatively straightforward.
Additional studies surrounding feedstock-harvesting activities should be defined in consultation with the Forest Management Branch, Environment Yukon, The Alsek Renewable Resource Council (ARRC), CAFN and YESAB. Based on our work to date, we suggest the following may be warranted:

- Review of Heritage Resource Assessment process currently being undertaken in association with forest management.
- Development of a Heritage Resource Assessment plan for the life of the Project.
- Focused public, stakeholder and Aboriginal and First Nations consultation to discuss existing land use, traditional activities and culture, and local knowledge of the areas in terms of ecological and heritage resources (in relation to potentially harvestable areas).
- Bird surveys should be designed in consultation with Canadian Wildlife Service, Environment Canada, Environment Yukon, and ARRC. Multiple surveys may be required to target various bird species (e.g., Common Nighthawk, owls, early surveys for woodpeckers, breeding bird surveys).
- Rare plant surveys should be designed in consultation with Environment Yukon, multiple surveys may be required to ensure that early ephemeral species are captured as part of the survey.
- Additional wildlife surveys may be required depending on consultation with Environment Yukon. Surveys targeting bats and/or small mammals may be required.
- Fish and fish habitat surveys may be required depending on the location of the feedstock sites. Design of the survey would be conducted in association with input from regulatory agencies.

3.3.4 Preliminary Field Study and Permitting Schedule

Consultation with YESAB is recommended prior to a go decision on size of plant. This will help to ensure that any input from the regulators on required scope of assessment can be considered in the decision process. The schedule from that point is dependent on the required permitting path. Consultation with CAFN and the community of Haines Junction to confirm plant siting should be completed prior to finalizing the site. Site field surveys for wildlife and vegetation should be completed in 2013. Certain species (such as Woodpecker and owl surveys) are done early in the spring (likely May) while the regular breeding bird surveys would be done in June. Depending on the level of detail required by the regulators, some of the plant surveys may need to be done early in the spring to catch early ephemeral species. All wildlife and plant surveys and their timing depend on consultation with the regulators to confirm required scope.

Timing for a field heritage resource assessment could be as early as spring 2013, provided assessments are conducted in snow-free conditions. Following completion of these activities and assuming a DO proposal is possible, the initial proposal could be submitted by mid-2013. If additional environmental and socio-economic study of feedstock harvesting is required by YESAB (likely for 2.0 MW_e plant, may be required for smaller plant), these studies should be scoped and initiated following a go decision on the Project and are expected to take 6 to 12 months to complete depending on the scope. The overall schedule and YESAA process is summarized in Figure 3.1.

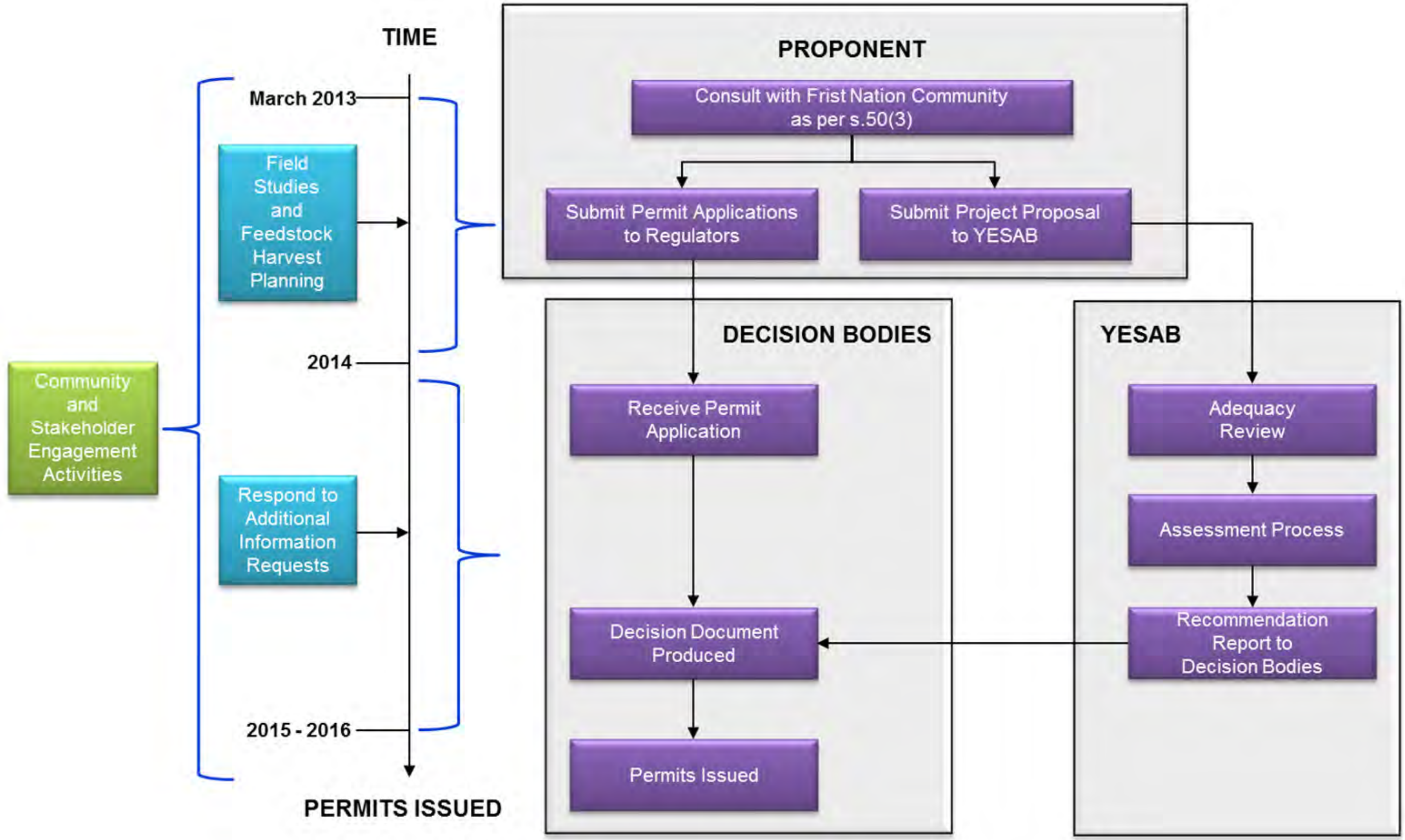


Figure 3.1 YESAA Simplified Process Flow Diagram for 2.0 MW Capacity

4.0 Risk, Financial & Operations Analysis

The Risk, Financial, and Operations Analysis section of the FEED focused on three critical areas, including: sources for project financing/funding, options for different business models for the formation of the new company (NEWCO), and financial assessment of the biomass plant (ROI, NPV, and sensitivities). Each of these topics is presented in the following subsections.

4.1 SOURCES OF PROJECT FINANCING

As part of the Phase 5 – Project Financing task, Stantec has conducted preliminary research into potential sources for project funding. At the kick-off meeting in Whitehorse on September 19, one potential source of funding discussed was Sustainable Development Technology Canada (SDTC). Stantec reviewed the workshop presentation for SDTC with the following comments.

4.1.1 Sustainable Development Technology Canada

SDTC operates two funds intended to stimulate investment in sustainable technologies. The first fund is the “SD Tech Fund™” which is 10 years old and aimed at development of emerging clean technologies. The key here is the word “emerging”. To be eligible, the Yukon biomass would have to be considered “unproven”[1].

The second fund managed by SDTC is the “NextGen Biofuels Fund™”. This fund is aimed at “large demonstration-scale facilities for next-generation renewable fuels and co-products.

Both of these funds were discussed with Paul Austin (SDTC, Vancouver office), to determine potential eligibility for the Yukon project.

Unfortunately, this project is likely to not qualify for either funding. The SD Tech Fund is strictly for new technologies or innovative use of clean technologies, and a proven biomass technology / waste heat application is not what SDTC is looking for in new applications. With regard to the NextGen Fund, it is for “first of a kind” type biofuel projects already in a continuous operation mode.

4.1.2 The ecoENERGY Innovation Initiative

“The ecoENERGY Innovation Initiative (ecoEII) received funding in Budget 2011, the Next Phase of Canada’s Economic Action Plan, for a comprehensive suite of research and development (R&D) and demonstration projects. The program’s objective is to support energy technology innovation to produce and use energy in a cleaner and more efficient way. This

[1] SDTC states in the presentation materials under the heading “SOI Don’ts” – Proven Technology = no need for SDTC

Initiative is a key component of the Government of Canada's actions to achieve real emissions reductions, while maintaining Canada's economic advantage and its ability to create jobs for Canadians. The ecoEII will also help in the search for long-term solutions to reducing and eliminating air pollutants from energy production and use."[2]

This funding source is currently engaged under the 'demonstration' division to support this FEED study. Continued funding from NRCan on the next phases of this project is possible and negotiations are ongoing.

4.1.3 Potential Funding Sources

Research indicates that there are other funding programs that may be applicable to the project. These will require direct follow-up with the applicable government agencies to determine if it is worthwhile to apply. Furthermore, once (if) a waste heat option is finalized, this may also lead to other funding opportunities.

From the Canadian Northern Economic Development Agency, there are the following programs:

4.1.3.1 Strategic Investments in Northern Economic Development (SINED)

SINED has been allocated $22 million funding per Territory for the years 2009-2014 as part of its Targeted Investment Program (TIP). The four areas of focus for TIP are building the knowledge base, enhancing the economic infrastructure base, capacity development, and economic diversification. It is possible that the Yukon project could qualify for funding as an economic diversification plan.

4.1.3.2 Community Economic Opportunities Program (CEOP)

The CEOP and CEDP funding provides project-based support and core operational support for First Nation communities for projects that lead to more community employment, greater use of land and resources, enhanced community infrastructure etc. The Yukon biomass project certainly will provide these economic benefits and may be a good candidate for this funding.

4.1.3.3 Community Infrastructure Improvement Fund (CIIF)

The CIIF program provides up to $1 million in funding for projects that improve community infrastructure. Recipients of the program must be not-for-profit entities, local/territory governments or First Nations. Infrastructure must be directly accessible to the public (i.e. district heating) and must be materially completed by March 31, 2014. There is some question whether the Yukon project would qualify due to restrictions pertaining to commercial activities.

[2] http://www.nrcan.gc.ca/energy/science/2003

Natural Resources Canada (NRCan), who is funding this Yukon feasibility study via its ecoEnergy Initiatives Program, may also have possible funding availability under grant programs as follows.

4.1.3.4 Aboriginal Economic Development in Forestry

The Canadian Forest Service (CFS) has been mandated by AFI to provide knowledge and facilitate coordination of federal support programs for Aboriginal economic forestry development, of which bioenergy is a priority focus. Limited multi-year funding may be available from AFI where it is determined that critical gaps exist in support from other programs that may pose a risk to project success. There is no formal application process involved. Instead, any funding will be subject to the CFS identifying the need and strategic value of the project as well as availability of the funding from AFI.

4.1.3.5 Biomass for Energy Program

Established in 2000, the Biomass for Energy Program focuses on research and development related to technologies used in the growing, harvesting and transportation of biomass feedstock. The program is also funded through the Canadian Forest Service.

The federal government Office of Energy Research and Development (OERD) offers another potential research and development grant program focusing on biomass technologies.

4.1.3.6 Bio-based Energy Systems and Technologies (BEST) Program

This program supports the research and development of technologies used to improve the supply, conversion and utilization of both existing and new biomass feedstock supply.

Finally, for taxable entities, accelerated Capital Cost Allowance provisions are available for capital assets used in the production of energy using renewable fuel sources. The provisions allow for an increased depreciation of equipment at a rate of 30% annually.

4.2 NEWCO BUSINESS MODELS

The purpose of this subsection is to provide a risk and qualitative analysis of the options available to NEWCO (Champagne and Aishihik First Nations, Yukon Energy and the Village of Haines Junction (VHJ)) for the ownership and operations of a 0.5 - 2.0 MW_e biomass energy system. The analysis is provided separately for both the feedstock harvesting (e.g. feedstock storage yard/wood chipping and logging) operations and the biomass plant operations.

Options:

Three ownership and operations options have been considered for each of the feedstock yard/logging operation and the biomass plant operation, resulting in a combined total of six options. These six possible options are provided in the following table.

Table 4.1 Business Model Options Analysis

	Feedstock Yard/Logging		**Biomass Plant**	
	Ownership	Operations	Ownership	Operations
Option 1	NEWCO	CAFN	NEWCO	NEWCO
Option 2	NEWCO	ISP	NEWCO	NEWCO
Option 3	NEWCO	CAFN	NEWCO	ISP
Option 4	NEWCO	ISP	NEWCO	ISP
Option 5	ISP	ISP	NEWCO	NEWCO
Option 6	NEWCO	CAFN	ISP	ISP

CAFN Champagne and Aishihik First Nations
ISP Independent Service Provider
NEWCO CAFN/Yukon Energy/Village of Haines Junction (a private entity)

Assumptions:

As part of this analysis, specific base assumptions have been made as follows:

- For options where an ISP is the owner, it is assumed that NEWCO will retain an option to acquire all assets at fair market value after a twenty-year period.
- For options where an ISP is the owner, it is assumed they will also be the primary operator. CAFN members will be used to the greatest extent possible and trained for eventual assumption of full operations over a maximum twenty-year period.
- Yukon Energy will hold a minority interest in NEWCO. They are interested in the plant operations but are not interested in the operations of the logging business.
- The Village of Haines Junction will hold a minority interest in NEWCO but will not participate in any of the operations.

4.2.1 Risk Analysis

The risk analysis used has been developed to show areas where actual results may differ from predicted. The risk analysis is semi-quantitative, with lower scores signifying a lower probability of occurrence and a lower severity of risk. Risk criteria have been broken out into two life-cycle categories reflecting the periods before and after the assets are placed into operations. The two categories are the "*design and construction period*" and the "*operations and transfer period*". The feedstock yard/logging operations and the biomass plant operations have been evaluated separately due to the distinctiveness of each of these project components.

Scoring:

The risk assessment considers both the probability of the risk occurring and the severity of impact if the risk does occur. The scoring uses a scale where 1=Low, 2= Medium and 3=High which can generally be interpreted as follows:

Table 4.2 Scoring Structure

Score	Probability	Severity
1 (Low)	*Unlikely* to occur for this project	Low impact unlikely to result in a loss that cannot be easily mitigated
2 (Medium)	*Possible* to occur for this project	Medium impact where the loss can mostly be mitigated
3 (High)	*Likely* to occur for this project	High impact where the loss may be significant

The total risk for each option is calculated as: **Total Risk = Probability x Severity**.

4.2.1.1 Feedstock Yard/Logging Analysis

The total risk scores for the feedstock yard/logging operations are:

Table 4.3 Risk Score Summary – Feedstock Yard/Logging

	NEWCO Owns/ NEWCO Operates	NEWCO Owns/ ISP Operates	ISP Owns/ ISP Operates
Design and Construction Period	16	18	14
Operations and Transfer Period	16	11	19
Total Risk Score	**32**	**29**	**33**

With the lower score reflecting lowest risk, Option 2 is the lowest risk option for feedstock yard/logging.

The following table shows the detailed scoring for the feedstock and logging ownership and operations options followed by a short narrative of the scoring rationale for each criterion.

Table 4.4 Risk Assessment – Feedstock Yard/Logging

FEEDSTOCK YARD / LOGGING RISK ASSESSMENT (Low-1 , Medium - 2 , High - 3)	OPTIONS								
	NEWCO / CAFN			NEWCO / ISP			ISP / ISP		
	Prob-ability	Sever-ity	Risk	Prob-ability	Sever-ity	Risk	Prob-ability	Sever-ity	Risk
DESIGN & CONSTRUCTION PERIOD									
Under or over designed (changes required to meet performance criteria or capex higher than necessary)	1	1	**1**	1	1	**1**	1	1	**1**
Constructability	2	2	**4**	2	2	**4**	1	1	**1**
Insufficient interest in RFP to stimulate competitive forces	1	3	**3**	1	3	**3**	1	3	**3**
Complexity of processes leading to increased time and cost	1	2	**2**	2	2	**4**	3	2	**6**
Permit/zoning risks	1	1	**1**	1	1	**1**	1	1	**1**
Scope / schedule creep	2	2	**4**	2	2	**4**	1	1	**1**
Default/breach of T&C's by consultants/contractors	1	1	**1**	1	1	**1**	1	1	**1**
Average Score			**16**			**18**			**14**
OPERATIONS & TRANSFER PERIOD									
Operational reliability standards not met	3	2	**6**	1	2	**2**	1	2	**2**
Operating cost variances	3	2	**6**	1	2	**2**	1	2	**2**
Electricity demand risk	1	1	**1**	1	2	**2**	1	2	**2**
Energy cost (feedstock) variation	0	0	**0**	0	0	**0**	0	0	**0**
Default/breach of T&C's by operator	1	1	**1**	1	3	**3**	1	3	**3**
Required maintenance not performed, diminishing value of asset	1	1	**1**	1	1	**1**	2	2	**4**
Market conditions change, increasing market value of the assets	1	1	**1**	1	1	**1**	3	2	**6**
Average Score			**16**			**11**			**19**
TOTAL RISK SCORE (**Lower** is better)			**32**			**29**			**33**

Following is an explanation of scoring for each life-cycle category:

Design and Construction Period:

The three options have close risk levels pertaining to the design and construction period. The risk of over or under designing the required facilities is quite low for all options primarily due to the requirements being low complexity. This is also true for overall constructability. Regarding tendering, the potential risk of there being insufficient interest in the project is again low as most consultants and contractors should have adequate capability to provide design and construction requirements. The risk level does differ between options when considering the complexity of processes. This is due primarily to the asset transfer back to NEWCO after twenty years if an ISP is owner, which can significantly increase time for contractual negotiations compared to a more standard arrangement. This option does, however, provide the lowest overall risk to NEWCO during the construction phase. Although permitting risk is not likely to be any different, the risks associated with scope and scheduling are lower where an ISP is owner. As the ISP is ultimately responsible for most construction risks, NEWCO will be effectively sheltered from this risk. Although there is possibly increased risk from a breach of terms and conditions by an ISP as an owner and/or operator, the fact that the project represents a longer term project with larger cash flows effectively makes it less likely that an ISP would default or breach contract than would a contractor in a design-build option with less at stake.

Operations and Transfer Period:

During the operating stage, the most significant period in the life cycle, the options where ISP is operator provide a lower risk exposure for NEWCO. The operating risk is primarily attributable to the entity responsible for operating the logging and feedstock operations. With NEWCO as operator, the lack of experience in these areas represents a high risk. The risk of electricity demand is low regardless of who is the owner. However, the severity of this risk will be greater where the ISP is operator as there is likely to be some form of contractual guarantee by NEWCO such as a take-or-pay agreement. This is not likely to be high however, due to the ability to keep workers active and stockpile feedstock if necessary. Other areas where an ISP operator provides a greater risk to NEWCO is the possibility, although small, that an ISP could default and/or breach the terms and conditions of the operating agreement. Although the operating agreement would most certainly contain recourse protection if a default or breach were to occur, the problems and lost time by key NEWCO personnel could be significant. Accordingly, this risk is likely to have serious impact if it were to occur.

Where the ISP is owner, it is assumed that the asset will be transferred back to NEWCO at fair market value (assumed net book value) after twenty years of operations. Due to potential, inaction, or uncontrollable market conditions, the eventual fair market value is likely to be different from predicted. The probability of this occurring is high, however the impact is considered only moderate at worst, especially if taking into consideration the impact in today's dollars. The condition of the asset at transfer is also highly dependent on the capital renewal and maintenance plan of the ISP. The greater influence that NEWCO has over these areas, the more likely the asset condition will maintain a higher value. Therefore, where the ISP is owner (and NEWCO has least control) the risk will be greatest.

4.2.1.2 Biomass Plant Analysis

The total risk scores for the biomass plant operations are:

Table 4.5 Risk Summary – Biomass Plant

	NEWCO Owns/ NEWCO Operates	NEWCO Owns/ ISP Operates	ISP Owns/ ISP Operates
Design and Construction Period	24	24	15
Operations and Transfer Period	13	12	20
Total Risk Score	**37**	**36**	**35**

With the lower score reflecting lowest risk, Option 3 is the lowest risk for the biomass plant. The following table shows the detailed scoring for the logging and feedstock ownership and operations options followed by a short narrative of the scoring rationale for each criterion.

Table 4.6 Risk Assessment – Biomass Plant

BIOMASS PLANT RISK ASSESSMENT (Low -1 , Medium - 2 , High - 3)	OPTIONS								
	NEWCO / NEWCO			NEWCO / ISP			ISP / ISP		
	Prob-ability	Sever-ity	Risk	Prob-ability	Sever-ity	Risk	Prob-ability	Sever-ity	Risk
DESIGN & CONSTRUCTION PERIOD									
Under or over designed (changes required to meet performance criteria or capex higher than necessary)	2	3	**6**	2	2	**4**	1	1	**1**
Constructability	2	2	**4**	2	2	**4**	1	1	**1**
Insufficient interest in RFP to stimulate competitive forces	2	3	**6**	2	3	**6**	1	3	**3**
Complexity of processes leading to increased time and cost	1	2	**2**	2	2	**4**	3	2	**6**
Permit/zoning risks	1	1	**1**	1	1	**1**	2	1	**2**
Scope / schedule creep	2	2	**4**	2	2	**4**	1	1	**1**
Default/breach of T&C's by consultants/contractors	1	1	**1**	1	1	**1**	1	1	**1**
Average Score			**24**			**24**			**15**
OPERATIONS & TRANSFER PERIOD									
Operational reliability standards not met	2	2	**4**	1	2	**2**	1	2	**2**
Operating cost variances	2	2	**4**	1	2	**2**	1	2	**2**
Electricity demand risk	1	1	**1**	1	2	**2**	1	2	**2**
Energy cost (feedstock) variation	1	1	**1**	1	1	**1**	1	1	**1**
Default/breach of T&C's by operator	1	1	**1**	1	3	**3**	1	3	**3**
Required maintenance not performed, diminishing value of asset	1	1	**1**	1	1	**1**	2	2	**4**
Market conditions change, increasing market value of the assets	1	1	**1**	1	1	**1**	3	2	**6**
Average Score			**13**			**12**			**20**
TOTAL RISK SCORE (**Lower** is better)			**37**			**36**			**35**

Following is an explanation of the scoring for each life-cycle category:

Design and Construction Period:

The options where NEWCO is owner has a considerably higher risk level than does the ISP as owner option. This is primarily attributable to NEWCO having minimal knowledge and experience related to biomass generation systems. Although Yukon Energy has generation expertise, they do not have specific biomass experience. This fact impacts the risk that the project is over or under designed and constructability of the project. It is also quite likely that risk pertaining to insufficient interest in the RFP tender will be higher where NEWCO is operator. Where an ISP is owner, the project represents a longer term project with larger cash flows making it more attractive. Where the risk level is higher for an ISP owned project is regarding the complexity of processes, due primarily to the asset transfer back to NEWCO after twenty years. This can significantly increase the time required and complexity of contractual negotiations compared to a more standard arrangement. Where the risk associated with scope and scheduling is concerned, the ISP owned project is much less risky due to the ISP having the responsibility for most construction risks. There is however the possibly with an ISP operated project that they breach some terms and conditions. However, as the project is of a longer term nature, and with larger overall cash flows (as owner and operator), it is less likely that an ISP would default or breach contract.

Operations and Transfer Period:

Converse to the design and construction period, the option where ISP owns the biomass plant is riskier than where NEWCO is owner. This is largely a result of the requirement for the plant to be transferred back to NEWCO after twenty years, and the uncertainty regarding the condition and value of the asset at that time. Potential, action or inaction, or uncontrollable market conditions, can cause the eventual fair market value of the plant to be different from predicted. The probability of this occurring is high, however the impact is considered only moderate especially considering the impact in today's dollars. With the condition of the asset at year twenty being highly dependent on capital renewal and maintenance of the plant, the more control NEWCO has over these areas, the more likely the asset condition will maintain a higher value, making an ISP owned project riskier than a NEWCO owned project. Other areas where an ISP owner/operator provides a greater risk to NEWCO is regarding a potential default and/or breach of the terms and conditions of the operating/transfer agreements. Although the agreements would most certainly contain recourse protection for NEWCO, a default or breach could still create problems and lost time by key NEWCO personnel.

The option where the ISP is the operator does provide a lower risk exposure for NEWCO where operational reliability and cost variances are concerned attributed to the ISP greater knowledge and experience with biomass systems. The risk of electricity demand is low regardless of who the owners is, due mainly to the small size of generation output. However, the severity of this risk will be greater where the ISP is operator as there is likely to be some form of contractual guarantee by NEWCO such as a take-or-pay agreement.

4.2.2 Risk Analysis Summary

The following table combines the three feedstock yard/logging and three biomass plant risk scores into a summary of the six possible options considered for these operations and ranks each option in terms of lowest risk.

Table 4.7 Risk Summary

	Feedstock Yard/Logging		Biomass Plant			
	Owner	Operator	Owner	Operator	TOTAL	RANKING
Option 1	NEWCO	CAFN	NEWCO	NEWCO		5
Risk Score	32		37		69	
Option 2	NEWCO	ISP	NEWCO	NEWCO		2
Risk Score	29		37		66	
Option 3	NEWCO	CAFN	NEWCO	ISP		4
Risk Score	32		36		68	
Option 4	NEWCO	ISP	NEWCO	ISP		1
Risk Score	29		36		65	
Option 5	ISP	ISP	NEWCO	NEWCO		6
Risk Score	33		37		70	
Option 6	NEWCO	CAFN	ISP	ISP		3
Risk Score	32		35		67	

Based on the analysis, Option 4 has the lowest risk profile. This option combines the benefits of NEWCO ownership control with the ISP industry specific operational expertise. Following very closely is Option 2, which substitutes NEWCO as operator for the biomass plant.

The deviation in scoring between the lowest and highest scores is five points (roughly 7%) suggesting that the risk profile deviation is not significant. Because of this, decision-making should be based on two criteria:

- Criteria 1 - The ability to control/mitigate the risks.
- Criteria 2 - The scale of the operation (0.5 MW versus 2.0 MW).

Referring back to the risk score summary previously provided in Table 1, it is clear that the risk profiles for NEWCO versus ISP as operator differ greatly between the design and construction and the operations and transfer periods. Where NEWCO is operator the greatest risk is during the design and construction stages while with an ISP as operator the greatest risk is during the latter (and longer) operations and transfer stages. The greatest risks for NEWCO in the design and construction stage are the unfamiliarity with both the feedstock yard/logging and biomass requirements whereas the greatest risks where an ISP is operator are primarily due to not having control over operations. Much of the design and construction risk can be effectively mitigated by contracting the project and construction management to consultants with specific expertise. However, countering this is the increase in operations risk, which occurs as the scale of the operations increase. For example, with a smaller scale 0.5 MW operation the risks of NEWCO operating the plant is relatively low whereas for a larger scale 2.0 MW plant this risk is much higher. For the feedstock yard and logging operations, where NEWCO has no experience, the risk is high regardless of the plant size.

4.2.3 Financial and Operational Analysis

The qualitative financial and operations analysis used has been developed as a complimentary extension of the risk analysis to highlight NEWCO/CAFN and ISP specific strengths or weaknesses in knowledge and experience that are important to both the feedstock yard/logging operations and the biomass plant operations. The analysis is

Scoring:

The financial and operations criteria are scored using a simple scale from 1 to 3 as follows:

1 = *Low* level of knowledge and/or experience.

2 = *Medium* level of knowledge and/or experience.

3 = *High* level of knowledge and/or experience.

A separate evaluation was done for both the feedstock yard/logging operations and for the biomass plant operations due to the distinctive nature of each. Both evaluations used the same seven criteria as follows:

- Design and construction experience.
- Operations and maintenance experience.
- Industry and regulatory experience.
- Environmental and sustainability experience.
- Access to experienced labor.
- Administrative requirements (impact on NEWCO).

- Management and control (impact on NEWCO).

4.2.3.1 Feedstock Yard/Logging Analysis

The total qualitative financial and operations score for the feedstock yard/logging operations are:

Table 4.8 Financial and Operations Analysis – Feedstock Yard/Logging

FEEDSTOCK YARD / LOGGING FINANCIAL AND OPERATIONS ANALYSIS	OPTIONS Score (Low -1 , Medium - 2 , High - 3)		
	NEWCO / CAFN	NEWCO / ISP	ISP / ISP
Design and construction experience	1	2	3
Operations and maintenance experience	1	3	3
Industry/regulatory experience	2	3	3
Environmental/sustainability experience	1	3	3
Access to experienced labor	1	3	3
Administrative requirements (to NEWCO)	3	2	1
Management and control (to NEWCO)	3	2	1
TOTAL SCORE (**Higher** is better)	**12**	**18**	**17**

Following is an explanation of the scoring for each criterion:

<u>Design and Construction Experience:</u>

Design and construction of the feedstock yard/logging is an area where a slight advantage is held by the ISP due to their significant knowledge and experience specific to the industry. Although NEWCO will procure the design and construction from outside sources, they will still be required to ultimately oversee and approve design and construction. Where the ISP is operator but not owner, there could be benefit with them providing their experience as part of the design stage, but likely not during construction.

<u>Operations and Maintenance Experience:</u>

The ISP, with specific industry knowledge and experience will have a very significant advantage over NEWCO/CAFN who has minimal knowledge and experience in logging and biomass feedstock operations.

Industry Regulatory Experience:

The ISP, with specific industry knowledge and experience will have a significant advantage over NEWCO/CAFN who has minimal knowledge and experience in regulations pertaining to logging.

Experience in Environmental/Sustainability:

The ISP, with specific industry knowledge and experience will have a significant advantage over NEWCO/CAFN who have very minimal knowledge and experience in environmental and sustainability matters related to logging. Knowledge and experience in environmental and sustainability matters is fast becoming a critical requirement for businesses of all types.

Access to Experienced Labor:

The ISP, due to their presence in the feedstock yard/logging industry will also have good access to experienced labor while it is very unlikely that NEWCO/CAFN will have access to this type of skilled labor. Having access to skilled operators and maintenance staff is critical to reliability and efficient operations of the logging and feedstock operations. An advantage for a large ISP will be access to their own overall labor pool which may be deeper and more specialized. This provides added assurance where training, specialization and emergency staff replacement requirements are concerned.

Lower Administrative requirements (to NEWCO)

A disadvantage to outsourcing operations to an ISP is the increased administration burden required to oversee initial negotiations and the ongoing management of the contractual terms and conditions and the general relationship with the ISP. For the NEWCO owns and CAFN operates option there is minimal partnering so this is not a big issue. Where NEWCO owns and an ISP operates there is added administration for the ISP operating agreement. Where the ISP both owns and operates the transfer of assets back to NEWCO will require the most administrative resources for NEWCO.

Management and Control (to NEWCO):

The more ownership and responsibility for operations that NEWCO undertakes, the more management and control they will have. For the ISP own and operate option, NEWCO has little or no control over the physical assets and operations, however they do have contractual control inherent in the terms and conditions of the operations and transfer back agreements.

4.2.4 Biomass Plant Analysis

The total qualitative financial and operations score for the biomass plant operations are:

Table 4.9 Financial and Operations Analysis– Biomass Plant

BIOMASS PLANT FINANCIAL AND OPERTIONS ANALYSIS	OPTIONS Score (Low -1 , Medium - 2 , High - 3)		
	NEWCO / CAFN	NEWCO / ISP	ISP / ISP
Design and construction experience	1	2	3
Operations and maintenance experience	1	2	3
Energy industry/regulatory experience	2	3	3
Environmental/sustainability experience	2	3	3
Access to experienced labor	1	2	3
Administrative requirements (to NEWCO)	3	2	1
Management and control (to NEWCO)	3	2	1
TOTAL SCORE (**Higher** is better)	13	16	17

Following is an explanation of the scoring for each criterion:

Design and Construction Experience:

Design and construction of the biomass plant is an area where a slight advantage is held by the ISP due to their significant knowledge and experience specific to the biomass industry. Although NEWCO has generation experience and will procure the design and construction from outside sources, they will still be required to ultimately oversee and approve design and construction. In the option where NEWCO owns and an ISP operates there could be some benefit with an ISP providing their experience as part of the design stage, but likely not during construction. Under Option 3, an ISP who has designed and constructed numerous biomass plant systems to satisfy many different requirements undoubtedly will have greater advantage and can be relied on to “get it right” with little to no risk.

Operations and Maintenance Experience:

NEWCO has good in-house capabilities via Yukon Energy but biomass systems would be new to the existing team. An ISP will draw on their significant capabilities to provide greater knowledge, innovation and solutions to problems that may arise.

Energy Industry/Regulatory Experience:

NEWCO has no energy and regulatory experience but is assisted by having Yukon Energy as a partner. The option where an ISP partners with NEWCO adds additional experience. Finally, an ISP, with specific biomass knowledge and experience is best equipped in specific biomass matters.

Experience in Environmental/Sustainability:

Knowledge and experience in environmental and sustainability matters has become a critical requirement for businesses of all types. In the utilities sector, an ISP brings the breadth and depth of knowledge and experience in these areas that NEWCO has only by way of the partnership with Yukon Energy. Adding the ISP experience to NEWCO would provide a similar level of expertise as an ISP can offer in these important areas.

Access to Experienced Labor:

Having access to skilled operators and maintenance staff is critical to reliability and efficient operations of utility systems. NEWCO has a well-trained staff via Yukon Energy. An advantage for an ISP will be their access to their own overall labor pool which may be deeper and more specialized, especially with biomass systems. This provides added assurance where training, specialization and emergency staff replacement requirements are concerned.

Lower Administrative Requirements (to NEWCO):

A disadvantage to outsourcing operations to an ISP is the increased administration burden required to oversee initial negotiations and the ongoing management of the contractual terms and conditions and the general relationship with the ISP. For the NEWCO owns and CAFN operates option there is minimal partnering so this is not a big issue. Where NEWCO owns and an ISP operates there is added administration for the ISP operating agreement. Where the ISP both owns and operates the transfer of assets back to NEWCO will require the most administrative resources for NEWCO.

Management and Control (to NSUH):

The more ownership and responsibility for operations that NEWCO undertakes, the more management and control they will have. For the ISP own and operate option, NEWCO has little or no control over the physical assets and operations, however they do have contractual control inherent in the terms and conditions of the operations and transfer back agreements.

Financial and Operations Analysis Summary:

The following table combines the three feedstock yard/logging and three biomass plant financial and operations analysis scores into a summary of the six possible options considered for these operations and ranks each option in terms of lowest risk.

Table 4.10 Financial and Operations Summary

	Feedstock Yard/Logging		Biomass Plant			
	Owner	Operator	Owner	Operator	TOTAL	RANKING
Option 1	NEWCO	CAFN	NEWCO	NEWCO		6
Score	12		13		25	
Option 2	NEWCO	ISP	NEWCO	NEWCO		2
Score	18		13		31	
Option 3	NEWCO	CAFN	NEWCO	ISP		5
Score	12		16		28	
Option 4	NEWCO	ISP	NEWCO	ISP		1
Score	18		16		34	
Option 5	ISP	ISP	NEWCO	NEWCO		3
Score	17		13		30	
Option 6	NEWCO	CAFN	ISP	ISP		4
Score	12		17		29	

Similar to the risk analysis, Option 4 places highest with Option 2 again being second. This is a confirmation of the importance of having industry experience specific to the feedstock yard/logging and biomass industries. Overall the deviation in scoring between the lowest and highest scores is ten points (roughly 29%) indicating that the industry experience is very critical to success. The difference between Option 4 and Option 2 is a much lower three points (8%) which indicates that NEWCO operating the biomass plant is less critical than having an ISP operate the feedstock yard/logging operations. This is logical as NEWCO has power generation knowledge, which, although not biomass specific, is at least beneficial where a smaller 0.5 MW operation is concerned, but would be less so where the plant size increases to 2.0 MW.

4.2.5 Summary of Analyses

Option 4 (NEWCO owns/ISP operates) ranks first in both the risk analysis (Table 5) and the financial and operations analysis (Table 8). However, following closely is Option 2 where NEWCO operates the plant. This is especially applicable where a smaller 0.5 MW plant is concerned.

The risk and financial and operations analysis demonstrates that “control”, “experience” and “scale” have the greatest impacts on risk and ultimately project success. NEWCO benefits greatly where they have most control over operations. However, total control also comes at the expense of not having the benefit of the ISP industry experience. Option 4 provides a trade-off where the lack of experience is addressed via an ISP. However, if the operation will be a smaller scale 0.5 MW plant, the benefit of an ISP operating the plant will not be as great, meaning that NEWCO should be able to operate the plant without much risk.

4.2.6 Conclusion

Applying this analysis to the size and scale of the biomass operation, the following ownership and operations models are the most appropriate for a smaller (0.5 MW) and larger (2.0 MW) plant operation.

Table 4.11 Recommended Owner/Operator Model

	Feedstock Yard/Logging		Biomass Plant	
Plant Size	**Owner**	**Operator**	**Owner**	**Operator**
0.5 MW	NEWCO	ISP	NEWCO	NEWCO
2.0 MW	NEWCO	ISP	NEWCO	ISP

As stated in the assumptions earlier in the report, where the ISP is the operator, the intention would be to increasingly employ workers from CAFN and provide training over a set period of time (i.e. 20 years).

4.3 FINANCIAL ANALYSIS

Using the preliminary engineering designs, financial analyses were prepared to determine the financial viability of the various installation scenarios. The results of these analyses are presented and explained in the following tables and charts.

It is important to note that the financial analyses do not currently include the capital cost for the district heating network. The capital cost for the installation of the network has been assumed to be covered under a separate project to be completed in conjunction with the biomass plant. The financial analyses do account for the O&M and revenue from operating the biomass plant in conjunction with the network (i.e., selling heat through the network)

The financial analyses were performed on multiple scenarios based on biomass plant size, building architecture, and vendors. Although only four options have been outlined in previous sections, ten different options were investigated for the financial analyses. Options #1 through #6 are all based on the technology offered by Community Power Corporation using the preliminary engineering parameters discussed previously. The details of Options #1 through #6 are detailed below:

- Option #1 – Full Building Enclosure – 500 kW_e (Community Power Corp.).
- Option #2 – Full Architectural Enclosure – 500 kW_e (Community Power Corp.).
- Option #3 – Fuel Handling Enclosed – 500 kW_e (Community Power Corp.).
- Option #4 – Options for Expansion – 1 MW_e (Community Power Corp.).
- Option #5 – Options for Expansion – 2 MW_e (Community Power Corp.).
- Option #6 – Options for Expansion – 3 MW_e (Community Power Corp.).

Due to the savings in capital costs, the equipment provided by Proton Power was also analyzed, as described in Options #7 through #10 below. Options #7 through #10 are based on the replacing the CPC equipment with that provided by Proton Power. It should be noted that Proton Power has indicated it has the ability to provide containerized systems, but has not completed a project using this format to date (see Figure 4.1).

- Option #7 – Full Building Enclosure – 500 kW_e (Proton Power).
- Option #8 – Full Architectural Enclosure – 500 kW_e (Proton Power).
- Option #9 – Fuel Handling Enclosed – 500 kW_e (Proton Power).
- Option #10 – Options for Expansion – 2 MW_e (Proton Power).

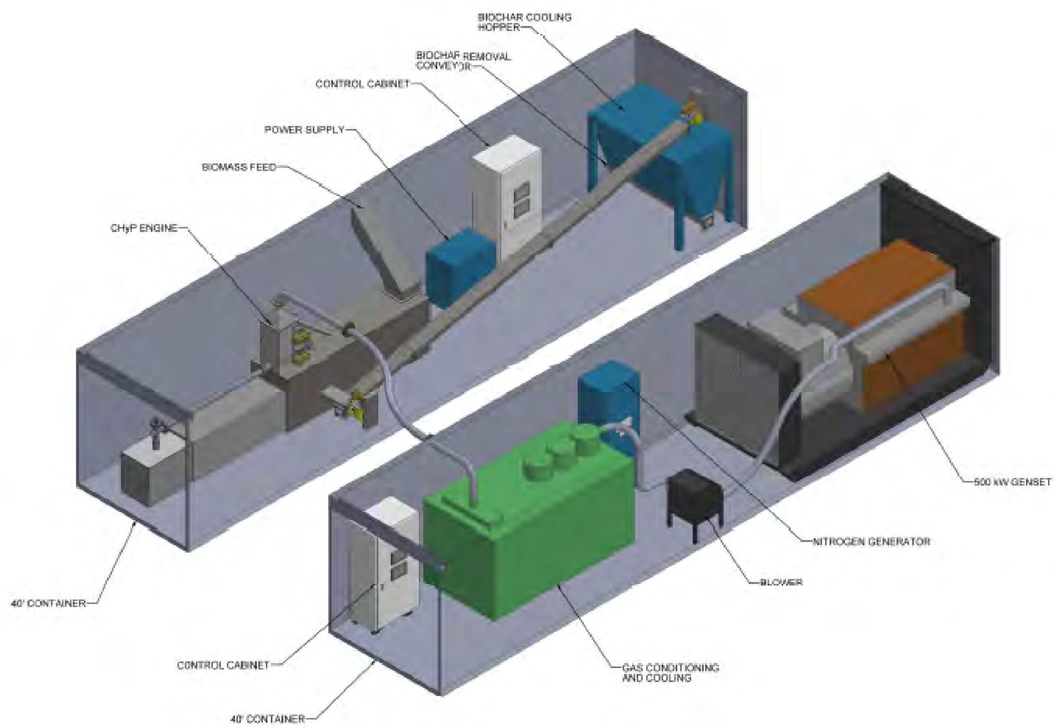


Figure 4.1 Potential Proton Power Containerized 500 kW_e Units

The primary difference between the inputs associated with CPC (Table 4.12) and those associated with Proton Power (Table 4.13) are the equipment costs and capacity factors (CPC has an 80% factor, Proton 92.5%). All other inputs remain the same, though in reality some variances may occur regarding the O&M costs.

Table 4.12 Financial Inputs: Options #1 - #6

Item	Option #1 500 kW_e	Option #2 500 kW_e	Option #3 500 kW_e	Option #4 1000 kW_e	Option #5 2000 kW_e	Option #6 3000 kW_e
CAPEX ($ Million)	$12.7	$13.5	$11.4	$22.5	$45.0	$67.5
Annual Fuel Consumption (ODT/yr)	3,000	3,000	3,000	6,000	12,000	18,000
Power (MWh/yr)	3,500	3,500	3,500	7,000	14,000	21,000
OPEX ($)	$285,000	$285,000	$285,000	$400,000	$630,000	$800,000

Table 4.13 Financial Inputs: Options #7 - #10

Item	Option #7 500 kW_e	Option #8 500 kW_e	Option #9 500 kW_e	Option #10 2000 kW_e
CAPEX ($ Million)	$8.5	$9.2	$7.3	$26.6
Annual Fuel Consumption (ODT/yr)	3,472	3,472	3,472	13,888
Power (MWh/yr)	4,052	4,052	4,052	16,208
OPEX ($)	$285,000	$285,000	$285,000	$630,000

In order to complete the financial analysis, several financial parameters needed to be defined. The financial assumptions outlined in Table 4.14 were employed to support this study. Assumptions for amortization, tax rate, and escalation are made on a consistent basis for all scenarios to facilitate comparison (Table 4.14). NEWCO's discount rate and electricity purchase price were assumed for the study.

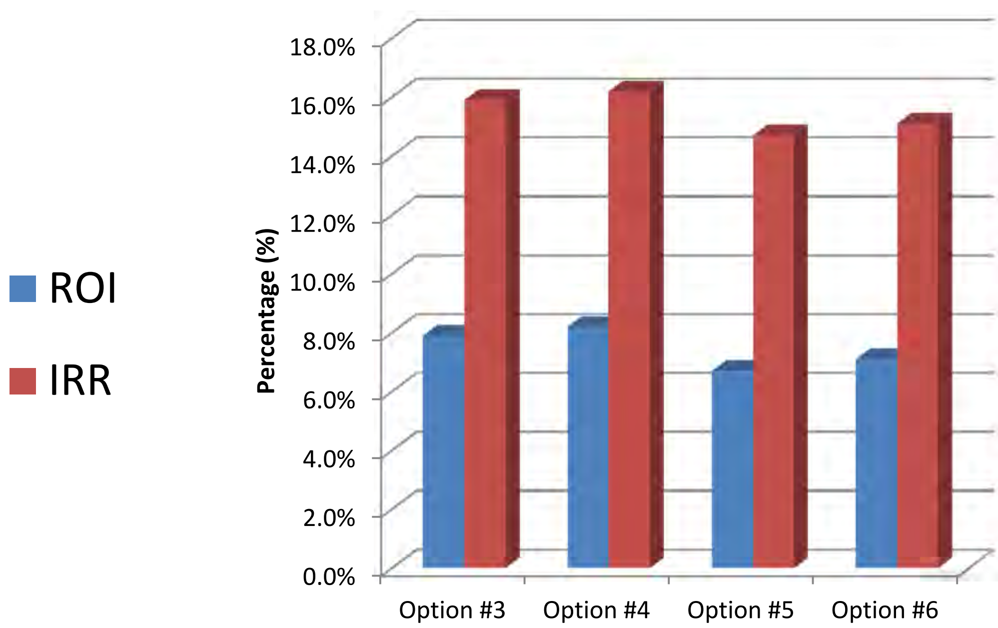
Using the base financial assumption, none of the ten (10) options proves viable. Each has ROE/ROI/NPVs that are negative. The main opportunity explored to make the options viable was to add a capital subsidy with could be achieve through funding grants. The amount of capital subsidy was taken as a percentage of total project costs to conduct this sensitivity.

Table 4.14 Financial Assumptions

Financial Assumptions			
Amortization:	Declining Balance:	20	Years
	Plant:	50.0	% (w/accelerated CCA class 43.2)
	Buildings:	4.0	% (w/CCA class 1)
	Equipment:	30.0	% (w/CCA class 43)
Capital Renewal Annual Rate:	Plant:	4.0	%
	Buildings:	2.0	%
	Equipment:	6.0	%
Weighted Average Cost of Capital:	WACC:	8	%
Inflation:	Annual Escalation:	3.0	%
	Feedstock Inflation Rate:	1.0	%
Equity:	NEWCO:	30	%
Long Term Debt :	Interest Rate :	5	%
Capital Subsidy (as % of Total Project):			
	Funding Low:	0	%
	Funding High:	80	%
Base Fuel Pricing:			
	Biomass:	Omitted	$/GMT
Biomass Power Sale Price:			
	Base:	$200	$/MWh
Biomass Heat Sale Price :			
	Base:	$185	$/MWh

The results of the financial analysis are provided in Table 4.15 in graphical and tabular form. The values of ROI and IRR were estimated using an assumed feedstock price of $50/GMT, 80% capital subsidy and an electricity selling price of $0.20/kWh, for a select number of options.

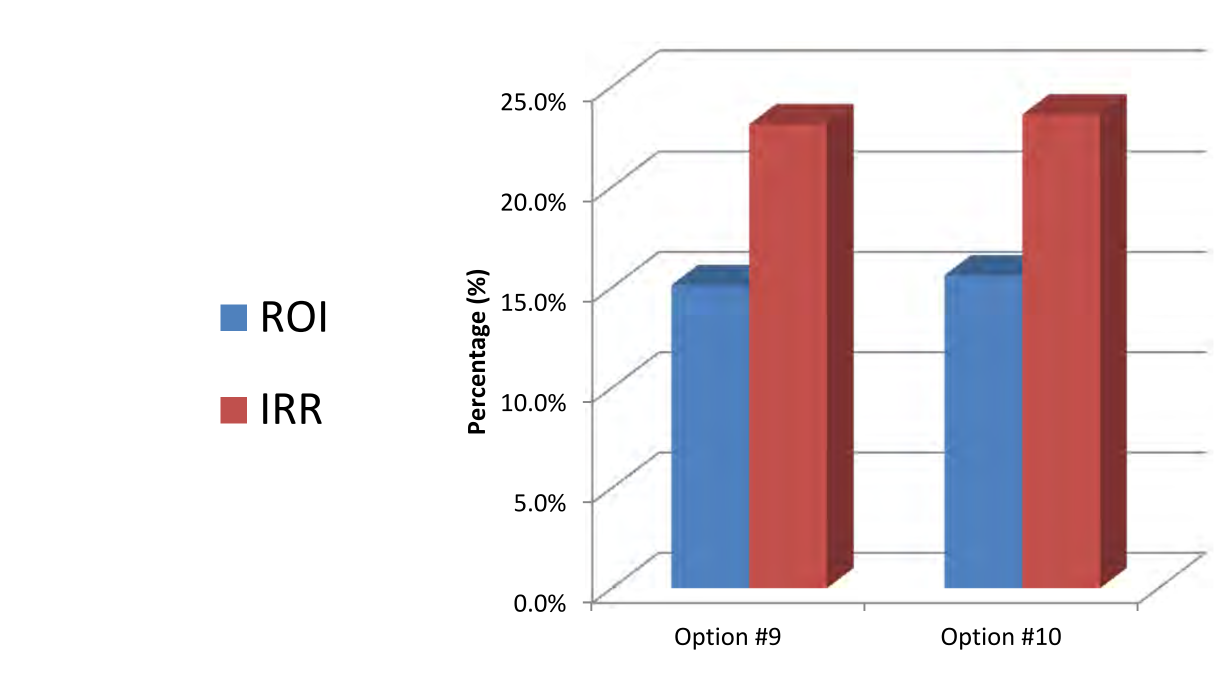
Table 4.15 Biomass Plant Return on Investment Performance: CPC



500 kW$_e$	**Item**	**Option #3 – 500 kW$_e$ Fuel Enclosed** **$50/GMT, $200/MWh, 80% Capital Subsidy**
	Return on Investment (ROI)	7.9%
	Internal Rate of Return (IRR)	15.9%
1.0 MW$_e$	**Item**	**Option #4 - 1 MW$_e$ Fully Enclosed** **$50/GMT, $200/MWh, 80% Capital Subsidy**
	Return on Investment (ROI)	8.2%
	Internal Rate of Return (IRR)	16.2%
2.0 MW$_e$	**Item**	**Option #5 - 2 MW$_e$ Fully Enclosed** **$50/GMT, $200/MWh, 80% Capital Subsidy**
	Return on Investment (ROI)	6.7%
	Internal Rate of Return (IRR)	14.7%
3.0 MW$_e$	**Item**	**Option #6 - 3 MW$_e$ Fully Enclosed** **$50/GMT, $200/MWh, 80% Capital Subsidy**
	Return on Investment (ROI)	7.1%
	Internal Rate of Return (IRR)	15.1%

Similar to the CPC ROI performance, the Proton Power could also reach positive ROIs with capital subsidy, although require significantly less due to their lower capital cost (note that only the 2 MW_e system was investigated for Proton Power and not 1 MW_e or 3 MW_e).

Table 4.16 Biomass Plant Return on Investment Performance: Proton Power



	Item	Option #9 – 500 kW_e Fuel Enclosed $50/GMT, $200/MWh, 67% Capital Subsidy
500 kW_e	Return on Investment (ROI)	15.1%
	Internal Rate of Return (IRR)	23.1%
2.0 MW_e	**Item**	**Option #10 – 2000 kW_e Fuel Enclosed $50/GMT, $200/MWh, 67% Capital Subsidy**
	Return on Investment (ROI)	15.6%
	Internal Rate of Return (IRR)	23.6%

As seen in the following two figures (Figures 4.2 and 4.3), the most viable options from each vendor in terms of ROE at the 0.5 MW_e capacity are CPC's Option #3 and Proton's Option #9. These refer to the plants with only fuel enclosure which have the lowest capital cost for this capacity. Therefore, the sensitivity analyses will only concentrate on these two options as book ends for project viability.

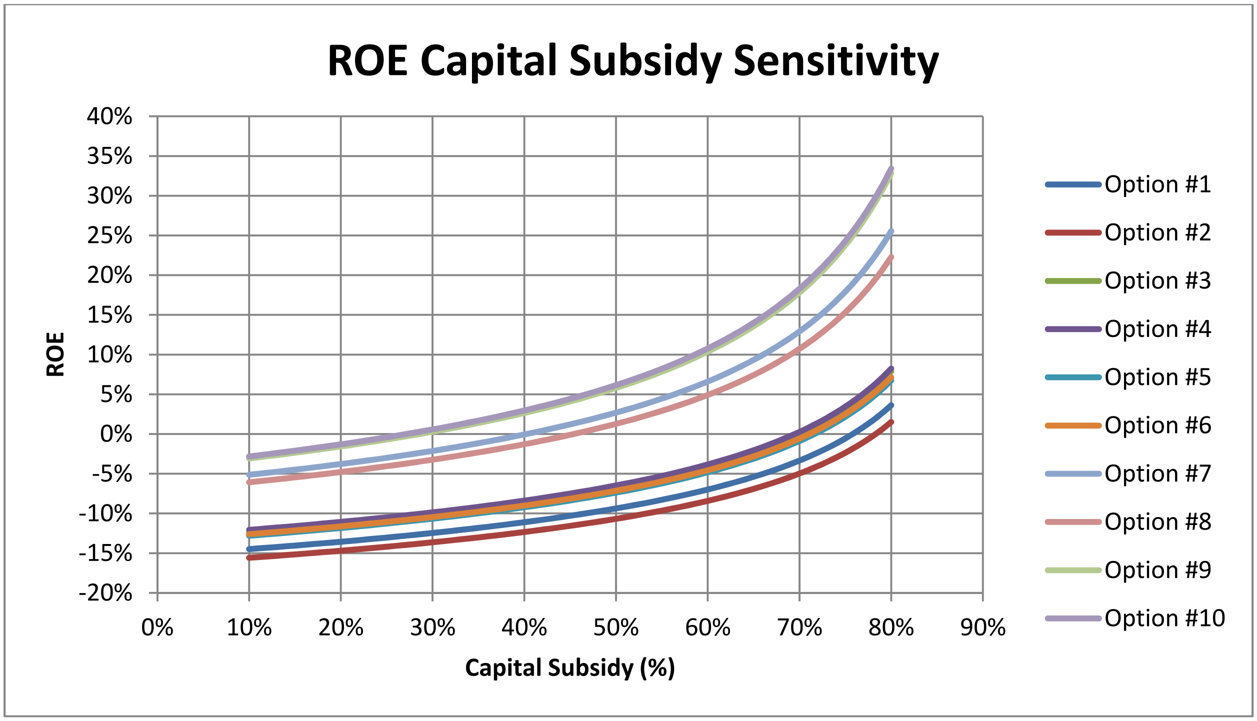


Figure 4.2 ROE Capital Subsidy Sensitivity

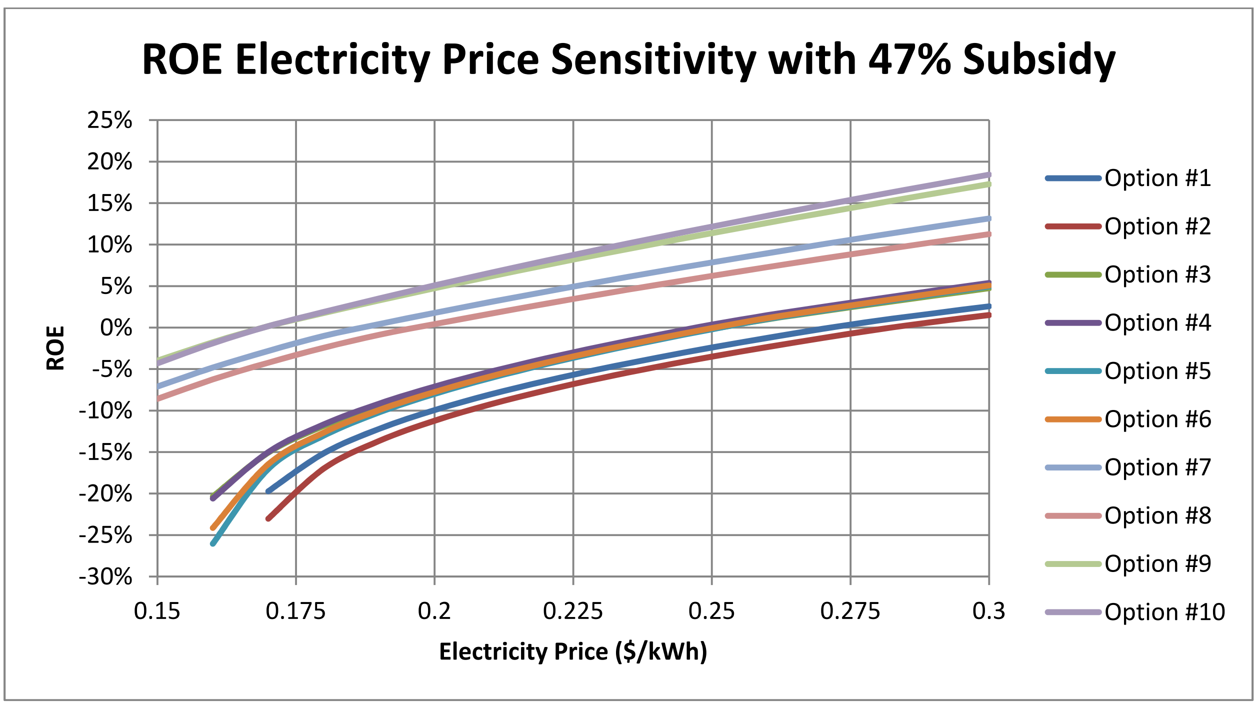


Figure 4.3 ROE Electricity Price Sensitivity

The previous figures also indicate the level of capital subsidy and/or electricity sale price required to achieve a desired ROE of 15%. In Figure 4.2, each option has no capital subsidy, and each option shows its lack of an ROE. As subsidies are increased, the Proton Power options pass over the 0% ROE mark with 30-40%subsidy, and achieve a 15% ROE at 67% for Option #9 and #10. The CPC options only start into positive ROE territory beyond the 70% subsidy mark.

In Figure 4.3, a combination of capital subsidy and increase in electricity sale price are considered to achieve a 15% ROE. The curves are based on the project achieving a 47% capital subsidy, and highlighting the impact of increasing the electricity sale price. For the best case scenario with Proton Power's Option #9, the electricity sale price would have to increase from $200/MWh to $280/MWh, to achieve the 15% ROE. For CPC, the project would only achieve a 5% ROE with 47% subsidy and a $300/MWh sale price.

4.3.1 Sensitivity Analyses

Four (4) additional variables affecting the success of biomass plant are fuel costs, O&M costs, district heating sales, and the district heating sale price. In order to understand the impact of these four (4) variables on the successful outcome of the installation, a range for each was considered and plotted based on impact to ROI and NPV. Each sensitivity analysis is presented in the following sub-section by variable, for each vendor.

4.3.1.1 Feedstock Price

For the two cases with fuel enclosures, Figure 4.4 was prepared to highlight the ROI and NPV for fuel costs from $50/GMT to $175/GMT. Fuel costs are market driven and subject to change outside the control of the facility design.

Similar to capital subsidy and electricity pricing, the project viability is strongly related to the feedstock pricing. Although there is no feedstock price that helps any option achieve a better financial viability, an increase to feedstock prices higher than would be available from existing operations (low end of the sensitivity, $50/GMT) would be detrimental to any gains from capital subsidy – doubling feedstock cost reduces ROE of Proton Power by half, to 7.5%.

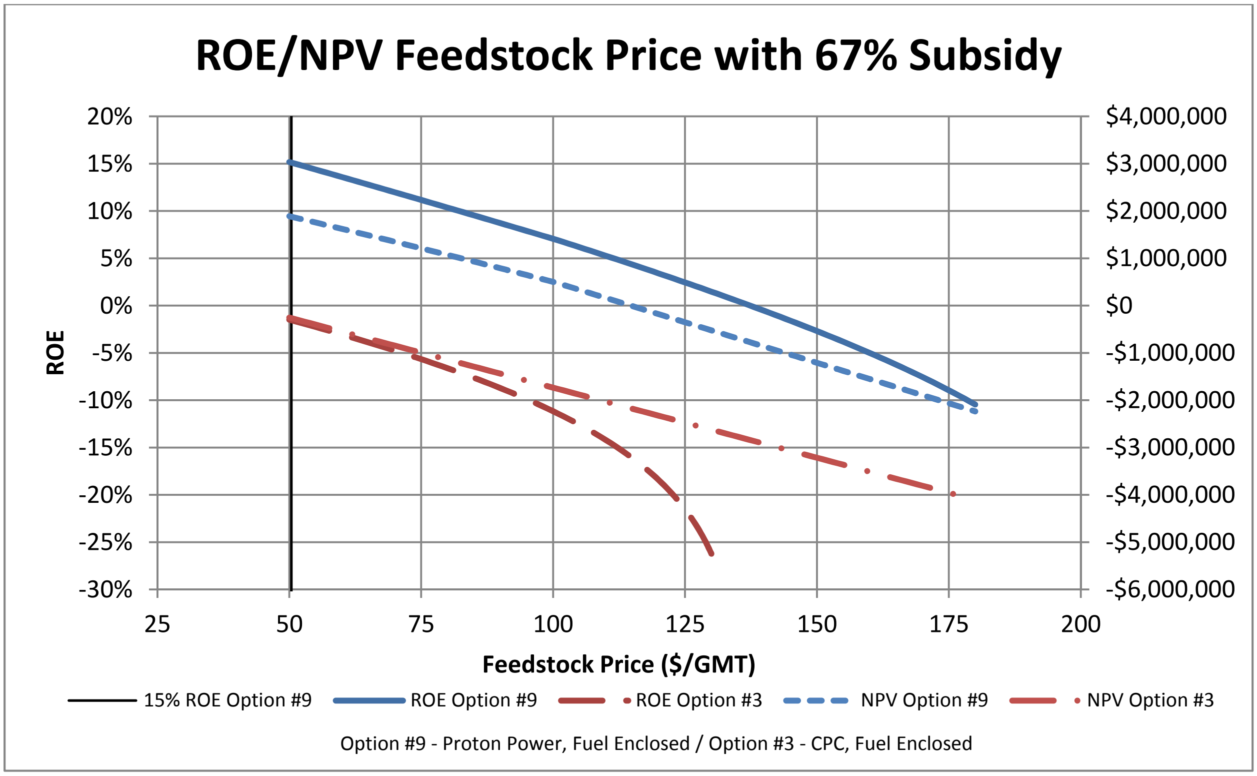


Figure 4.4 ROE/NPV Feedstock Price Sensitivity

4.3.1.2 Other Variables

For the two cases with fuel enclosures, Figure 4.5, 4.6, and 4.7 were prepared to highlight the ROI and NPV for plant O&M costs from $125,000 to $500,000 annually, district heating sales from 1,000 to 2,000 MWh annually, and district heating sale price from $110 to $250 / MWh. This variable are subject to change based on the facility/network design and vendor selected. The O&M costs in Figure 4.5 focuses on O&M specific to operating the biomass gasification system, O&M for the DH network and ORC are not considered.

Variations in O&M costs will affect the project's ROE by approximately 2.5% for every $50,000 annual. Similarly, an increase in DH sales by 500 MWh per year would increase the ROE by 2.5%. As the DH network is only projected to sell 1280 MWh/year, and the gasifier rejects over 5,000 MWh/year, the opportunity exists to expand the network in the future for increased sales.

The DH sale price in Figure 4.7 shows the impact of a variation in the sale price for 1,280 MWh per year. Currently valued based on the CTCG report at $185/MWh, this price will likely need to be indexed based on diesel fuel prices when the project is implemented. Current price offers a 2% savings over diesel.

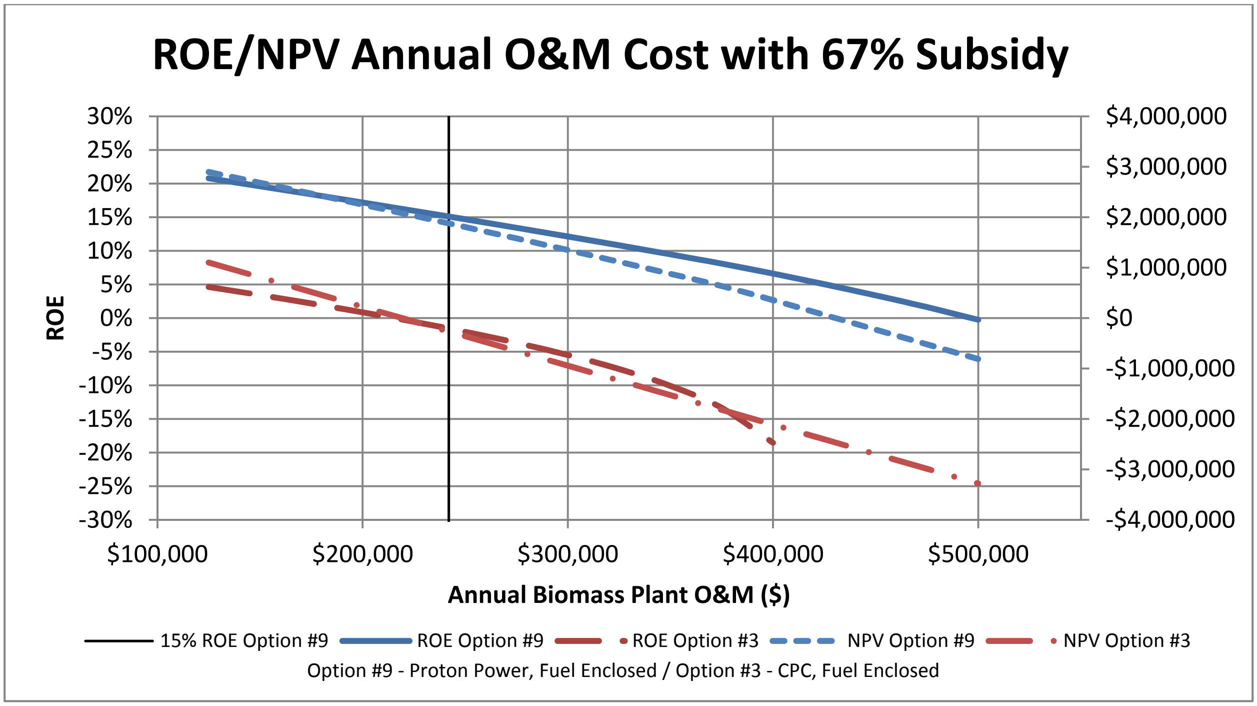


Figure 4.5 **ROE/NPV Annual Plant O&M Price Sensitivity**

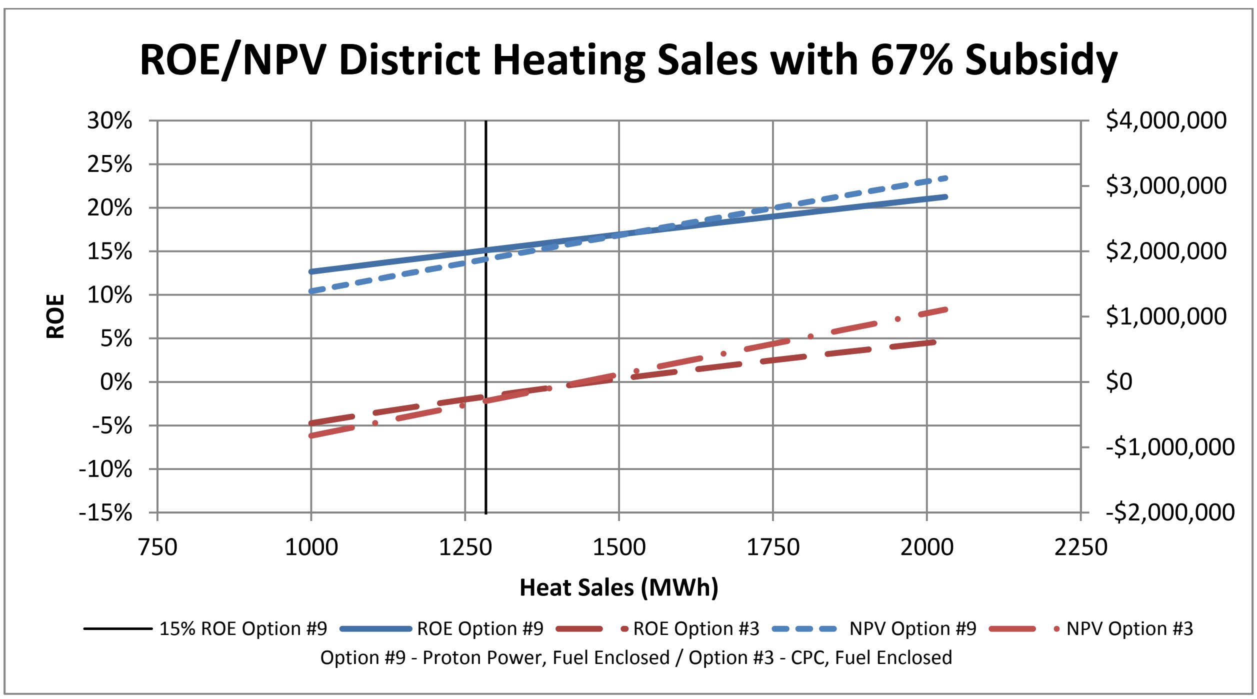


Figure 4.6 **ROE/NPV District Heating Sales Sensitivity**

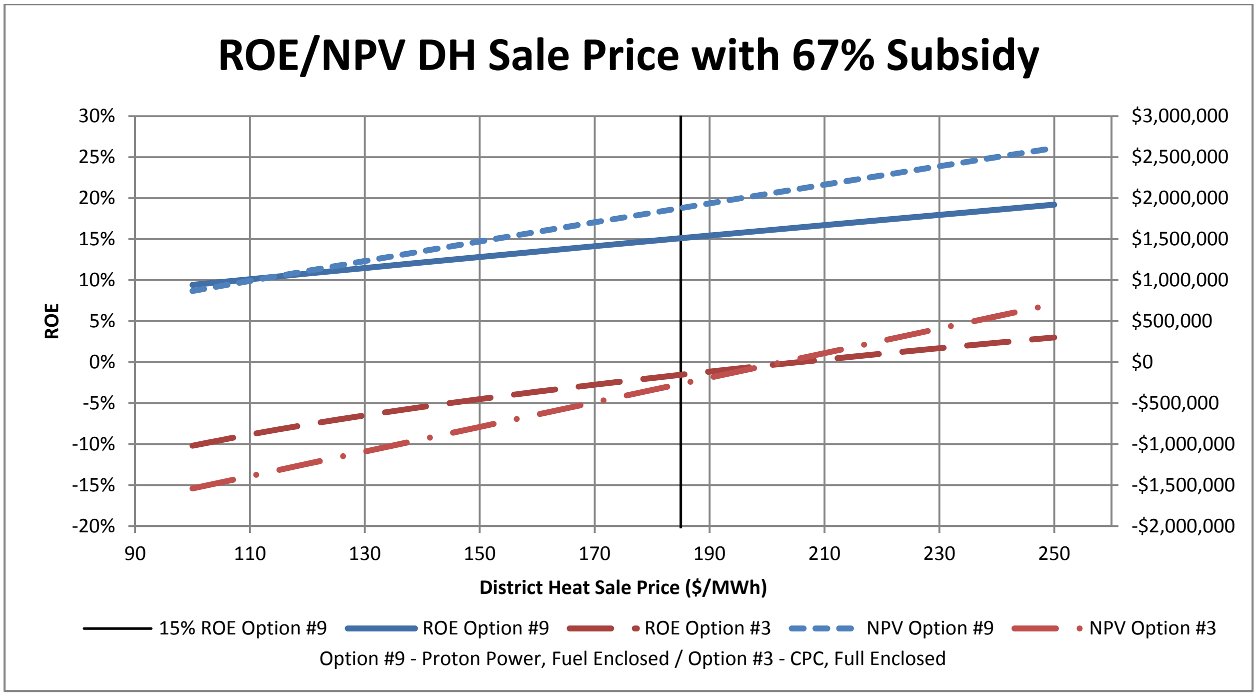


Figure 4.7 ROE/NPV District Heating Sale Price Sensitivity

4.3.1.3 Tornado Diagram

The figure on the following displays the impact of these key variables in a different manner. Figure 4.8 shows the results of independently adjusting the seven (7) key variables by ± 20% on the project ROE. The centerline of the graph represents the 15% ROE set point for Option #9 with 67% subsidy, while each bar is indicative of the positive or negative change in ROE resulting from a ± 20% change in a given variable. Table 4.17 shows the corresponding change in NPV for each variable as well as the specific ROE percentage. The variables are arranged from the most significant to the least significant based on the magnitude of their impact.

It is evident from Figure 4.8 that the most significant variable on the success of the project is the amount of capital subsidy provided, followed by electricity price potential, both discussed previously. Following these two factors, by decreasing influence, are project capital cost, plant O&M cost, district heat sale price, district heat annual sales and feedstock price.

The results of this analysis suggest that during the next level of study it will be vital to secure capital subsidies and or increases to the electricity sale price, as these are the greatest deciding factors in the outcome of the project. Further project definition through engineering can aid in acquiring a definitive value for capital and operating costs, as well as support firming up the DH system design and waste heat sale potential.

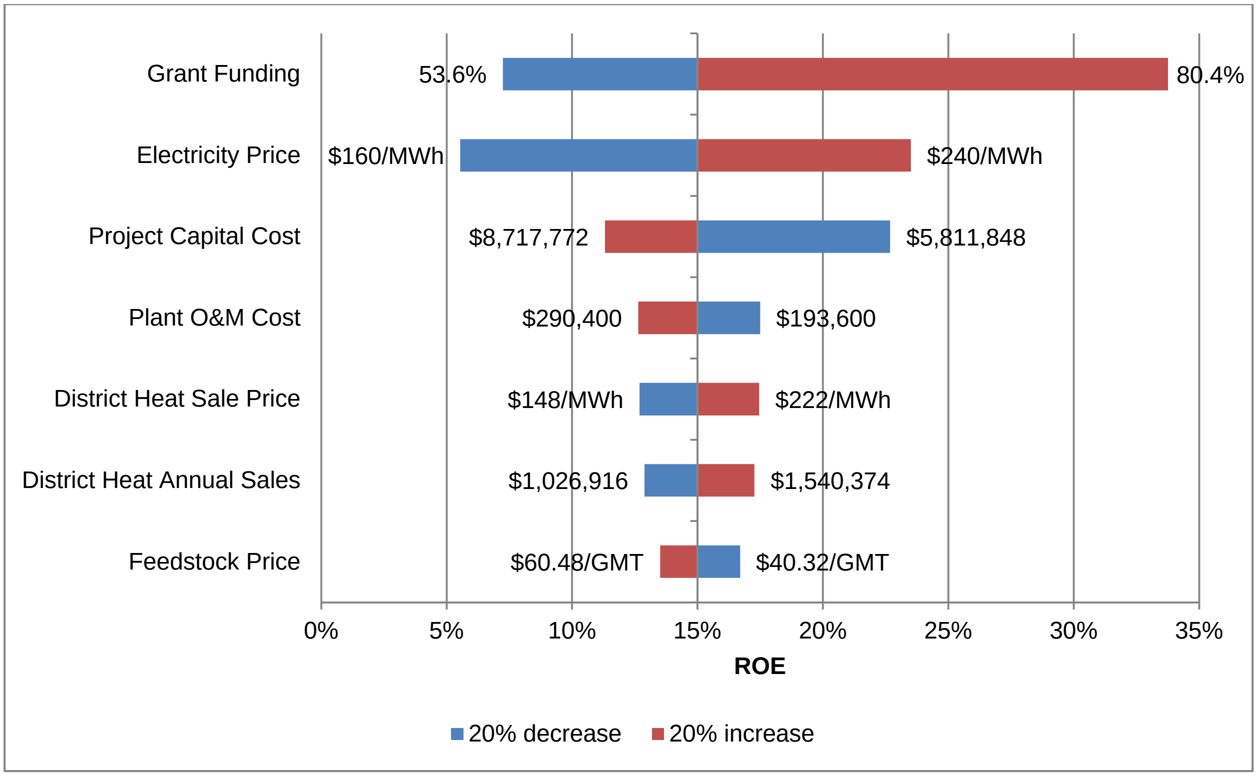


Figure 4.8 ROE/NPV District Heating Sale Price Sensitivity

Table 4.17 Tornado Diagram Results

	Variation	ROE	NPV
Grant Funding	+20%	33.76%	$2,804,710
	-20%	7.24%	$953,761
Electricity Price	+20%	23.51%	$3,233,005
	-20%	5.54%	$309,701
Project Capital Cost	+20%	11.31%	$1,548,366
	-20%	22.68%	$2,306,406
Plant O&M Cost	+20%	12.64%	$1,439,168
	-20%	17.50%	$2,306,886
District Heat Sale Price	+20%	17.46%	$2,298,968
	-20%	12.69%	$1,447,476
District Heat Annual Sales	+20%	17.27%	$2,312,515
	-20%	12.89%	$1,435,633

5.0 Next Steps

The FEED report outlines a series of challenges that exist for the project to be successful, whether it is feedstock security, technology risk or cost, or the need for financial support to bring the project to a reality. No project is without its challenges and, if financial support can be found, mitigation strategies could be developed to address requirements of regulators, enhanced policies (feedstock procurement) and the technical risks associated with the demonstration nature of the project.

Should the project partners decided to pursue the project to the next level of development to realize the potential for biomass gasification in the Yukon, the following sub-section outlines general tasks that would be required and a project implementation schedule.

5.1 NEXT LEVEL OF DEVELOPMENT

Looking beyond the conclusion of the FEED study, considered to be Phase 1 of the project, each area of the FEED will require additional work to bring greater definition and certainty to the project viability and requirements for support. With the completion of the FEED study, the project definition began to take shape but additional work and refinement needs to take place. To support bringing the project definition to the next level of study, work in each area of the project needs to be completed. The following statement of work includes, but is not limited to, phases of study to be completed ahead of detailed engineering and construction.

Phase 2 – Feedstock

Initial indications from the FEED show the potential to source feedstock from local sawmill and harvesting operations. The feedstock supply logistics and business models for this supply will have to be further refined in order to make the decision to proceed with detailed engineering.

- Procurement Logistics and Strategy.
    - Supplier Business Model.
    - Storage location options and retrieval*.
    - Chipping options and locations*.
    - Site Visits to Existing Operations.
    - Input to design.
    - Develop moisture content strategies*.
    - Alternative sources.

- Regulatory.
  - Security of supply w FMB*.
  - Confirm Strategy (who needs to be up to speed)*.
  - Regulatory approvals before EOI*.
- Procurement.
  - Expression of Interest (EOI) to Supply 500 kWe Plant*.
  - EOI Preparation*.
  - EOI Issued*.
  - Letters of Interest (LOI) Returned*.
  - LOIs Reviewed*.
  - Feedstock Assessment & Costing.
  - Procurement Plan.
  - Private Shortlisted Request for Proposal.
  - Formal Firm Proposals.
  - Procurement Contracting.

** Short-term items to support business case development (Phase 4)*

Phase 3 - Environmental Permitting

Based on the FEED study assessments completed, the current expectation is for a DO level assessment by YESAB. This needs to be confirmed and the proper impact assessment completed accordingly (including field studies, public consultation).

- Scoping Meeting with YESAB*.
- Field Surveys and Technical Analyses.
  - Wildlife and Wildlife Habitat (migratory birds, bats).
  - Wetlands and Vegetation.
  - Land Use/Traditional Use Consultation in Community (siting).
  - Archaeological and Heritage Resources.
- Impact Assessment Report.
  - Prepare Draft DO Proposal for Internal Review.
  - Client Review Period.
  - Preparation of Regulatory Draft DO Proposal.
  - Adequacy Review.
  - Respond to Information Requests from Adequacy Review.
  - DO Reviews Responses.

- Seeking Views and Information (public consultation).
- DO Reviews input from SVI.
- Potential further Information Requests.
- DO Prepares/Issues Recommendation or Referral.

- Permit Applications.

    - Community and Stakeholder Engagement*.
    - Prepare other Applications and Submit to Decision Bodies.
    - Decision Bodies Receive Recommendation from DO.
    - Review and Consideration by Decision Bodies.
    - Decision Bodies Issue Permits.

** Short-term items to support business case development (Phase 4)*

Phase 4 - Bridging Engineering & Business Case

The engineering and business case assessment completed as part of the FEED study provide direction on project approach and defined the project to the extent possible. With the knowledge gained, the next level of study can be completed ahead of detailed engineering to provide a Class 3 opinion of probable capital and operating costs as well as associated business case.

- Project Management & Local Support.

Bridging Engineering

- Engineering Design to support Waste Heat Integration.

    - Identification of buildings for the district heating network.
    - Contact building owners/operators to determine hook-up potential and assessment of current heat loads.
    - On-site assessment of buildings to determine building infrastructure requirements for energy transfer stations.
    - Heat load assessment to determine system sizing and which building to include in the network.
    - Prepare system design including but not limited to:
        - Main, distribution, and branch line sizing.
        - System control and metering infrastructure.
        - Energy transfer station sizing for each building.
    - Drawing and design package to support the development of a AACE Class 3 opinion of probable capital and operating cost for the system.

- Engineering Design to support Facility Design:
  - Gasification technology:
    - Develop and issue firm Request-for-Proposal for 500 kWe gasification technology.
    - Conduct bid comparison and select vendor for engineering design.
    - Plant design to support technology, grid interconnection, district heating interconnection, and fuel receiving.
  - Finalize site location:
    - Dependent on heating network design and feedstock storage requirements.
    - Conduct open house to solicit public input.
    - Select location, determine infrastructure requirements (grid interconnection, water/sewer), confirm land ownership and tax implications.
  - Materials Handling:
    - Confirm on-site/enclosed feedstock storage requirements.
    - Finalize fuel storage and reclaim method (loaders/bin, walking floor, other).
    - Support design, sizing and tie-in with selected technology vendor.
  - Plant Auxiliaries:
    - Confirm building/room sizing and infrastructure tie-in requirements.
    - Building services (lighting, HVAC).
  - Drawing and design package to support the development of an AACE Class 3 opinion of probable capital and operating cost for the system.
  - Project implementation schedule through to commercial handover.

Business Case

- Project support to develop business case, including:
  - Input into owner's applications for funding.
  - Determine model for heat sales and draft heat sale contract.
- Finalize business model and case as engineering is concluded, including:
  - Ownership model.
  - Sensitivity analyses.

Phase 5 - Detailed Engineering and Procurement

Phase 6 & 7 - Construction, Commissioning, Start-up, Commercial Handover

5.2 IMPLIMENTATION SCHEDULE

If the decision were made to proceed with the next level of development, three of the phases outlined above would need to start in 2013. Feedstock assessment will need to be further defined and support the requirements of the YESAB submission for the project. In future years, the feedstock procurement strategy and final supply contracts will be critical project components. Environmental permitting will also need to begin in 2013 with a consultation with YESAB to ensure the project can proceed with a D.O. level screening and establish requirements for field studies, modelling, and other areas deemed critical. The environmental team will also support the public and First Nations consultation process on an on-going basis. The main driver for project refinement in 2013 will be the bridging engineering and business case refinement. This work, outlined above, will provide greater clarity to the facility design (looking at firm vendor quotes and cost savings measures) to arrive at a Class 3 opinion of probable capital cost. On the business case side, it will be necessary to secure draft heat contracts and power purchase pricing to provide greater certainty to future revenue streams. Confirmation of the potential revenue, along with plant and feedstock costing will facilitate the development of a more sound business case.

A high-level implementation schedule is presented in Table 5.1 for consideration. A more detailed potential implementation schedule (Gantt Chart) is presented in Appendix K.

The schedule in Appendix K represents a fast track schedule to indicate the scope of each phase and its earliest possible completion. Table 5.1 relaxes the need to complete more detailed feedstock activities and environmental permitting tasks (field studies) until 2014 instead of 2013. This reduces upfront costs, and facilitates further refinement of the business model ahead of proceeding with detailed engineering and ordering of equipment.

Table 5.1 Implementation Schedule

Phase	Task Description	2013	2014	2015	2016
2	Feedstock				
3	Environmental Permitting-DO Level				
4	Bridging Engineering & Business Case				
5	Detailed Engineering and Procurement				
6	Construction				
7	Start-up & Commissioning				

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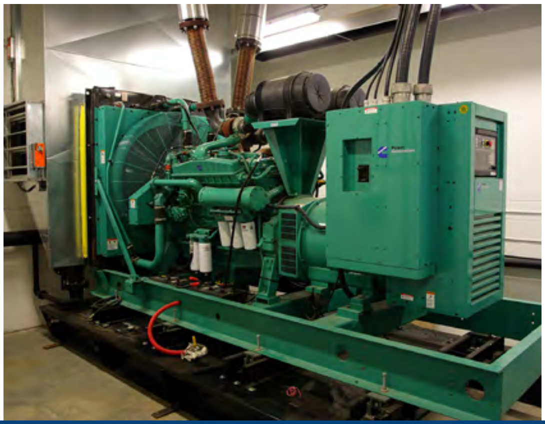
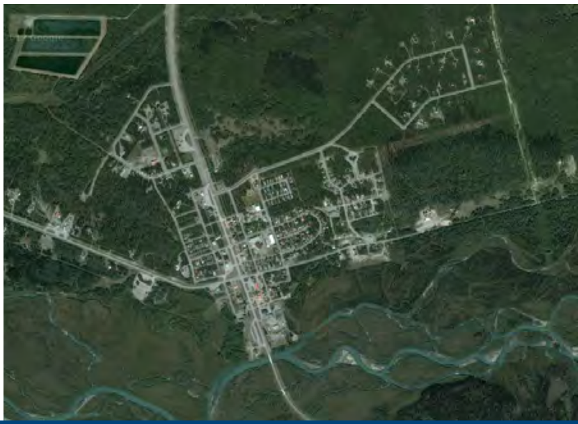
7.0 Appendices

APPENDIX A	**INTERIM REPORT # 1**
APPENDIX B	**INTERIM REPORT # 2**
APPENDIX C	**VENDOR PACKAGES**
APPENDIX D	**BASIS OF ESTIMATE – OPTION # 1**
APPENDIX E	**ARCHITECTURAL UPGRADE - OPTION # 2**
APPENDIX F	**BASIS OF ESTIMATE – OPTION # 3**
APPENDIX G	**500 kWe EXPANSION – OPTION # 4**
APPENDIX H	**IMPACT ASSESSMENT**
APPENDIX I	**ENGAGEMENT PLAN**
APPENDIX J	**FINANCIALS**
APPENDIX K	**IMPLEMENTATION SCHEDULE**



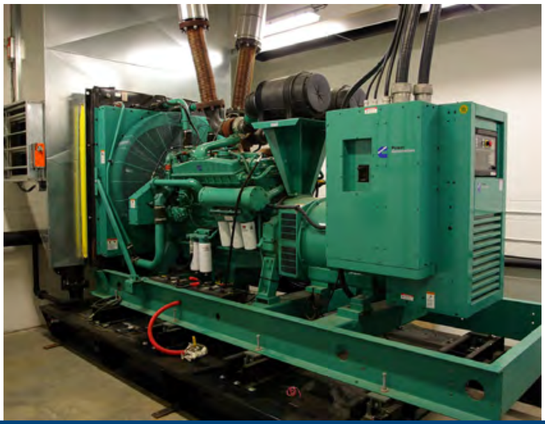


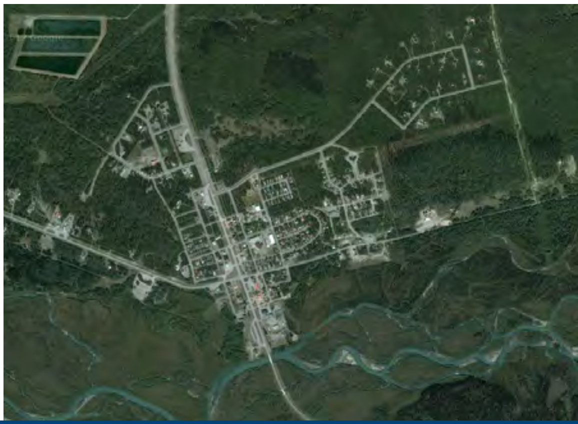
APPENDIX A

Interim Report #1

Front End Engineering Design (FEED) Study
Yukon Bioenergy Demonstration Project
in Haines Junction, Yukon

Yukon Energy Corporation
2 Miles Canyon Road, Whitehorse, YT Y1A 6S7



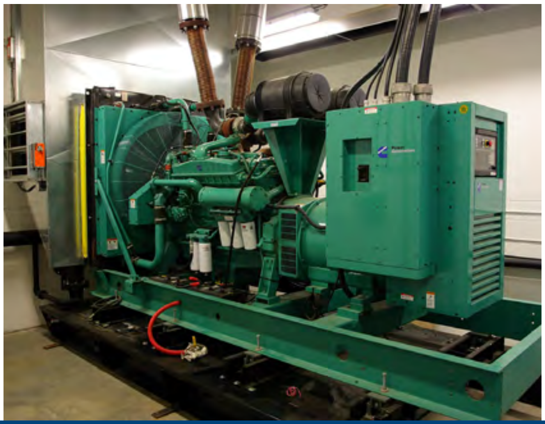


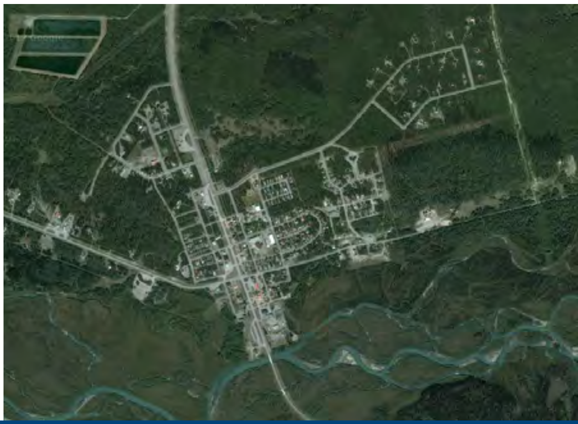
APPENDIX B

Interim Report #2

Front End Engineering Design (FEED) Study
Yukon Bioenergy Demonstration Project
in Haines Junction, Yukon

Yukon Energy Corporation
2 Miles Canyon Road, Whitehorse, YT Y1A 6S7





APPENDIX C

Vendor Packages

Front End Engineering Design (FEED) Study

Yukon Bioenergy Demonstration Project
in Haines Junction, Yukon

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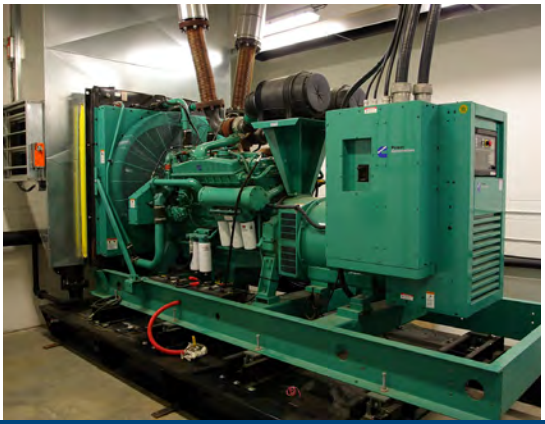
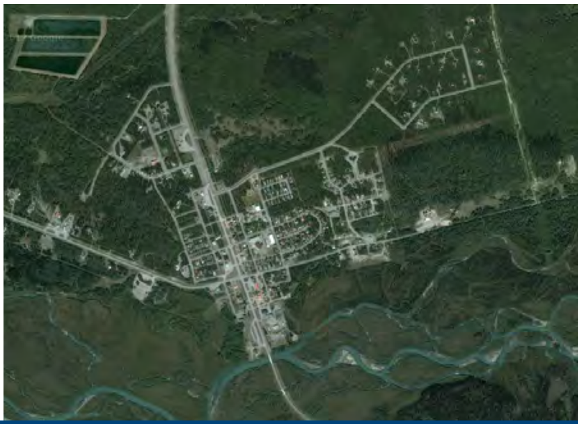
2 Miles Canyon Road, Whitehorse, YT Y1A 6S7





APPENDIX D

Basis of Estimate - Option #1

Front End Engineering Design (FEED) Study
Yukon Bioenergy Demonstration Project
in Haines Junction, Yukon

Yukon Energy Corporation
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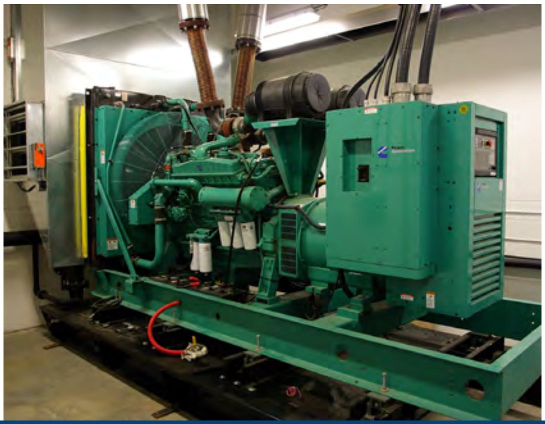

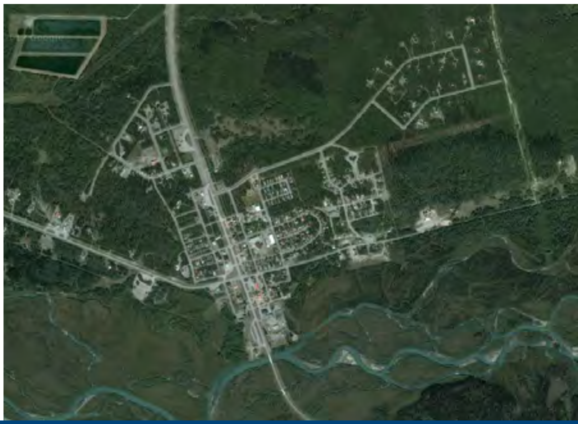

APPENDIX E

Architectual Upgrade - Option #2

Front End Engineering Design (FEED) Study

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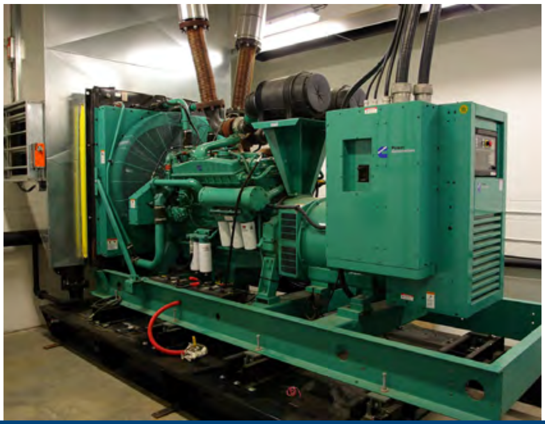

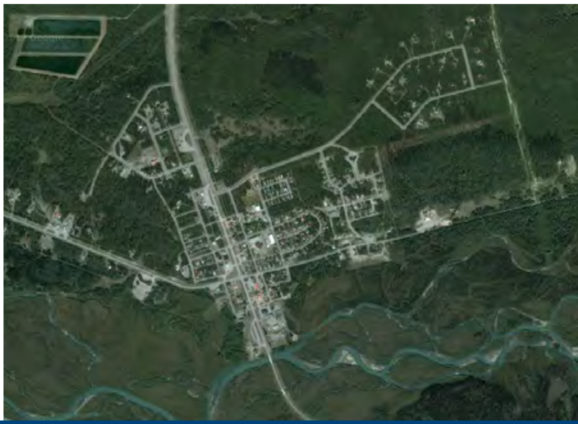

APPENDIX F

Basis of Estimate - Option #3

Front End Engineering Design (FEED) Study
Yukon Bioenergy Demonstration Project
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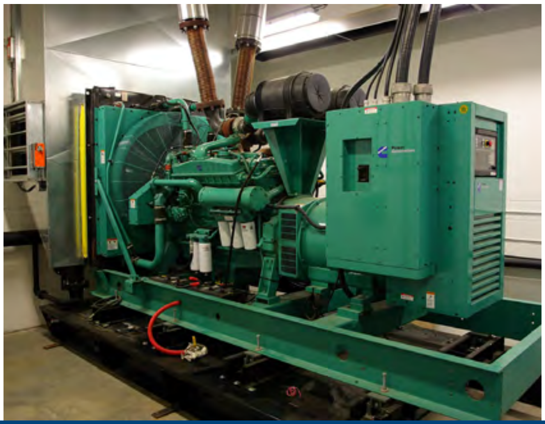

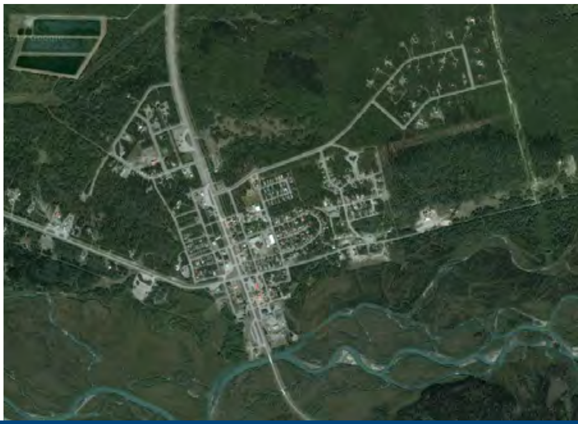

APPENDIX G

500 kWe Expansion - Option #4

Front End Engineering Design (FEED) Study

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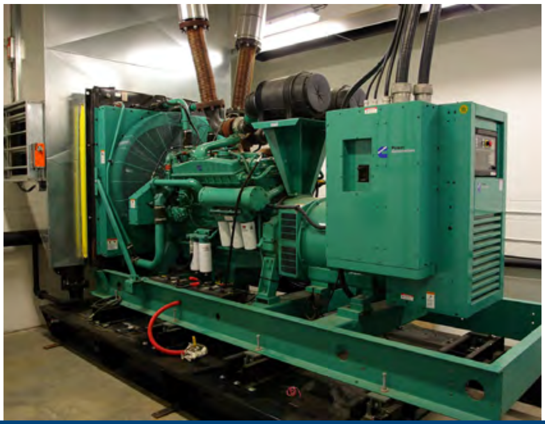

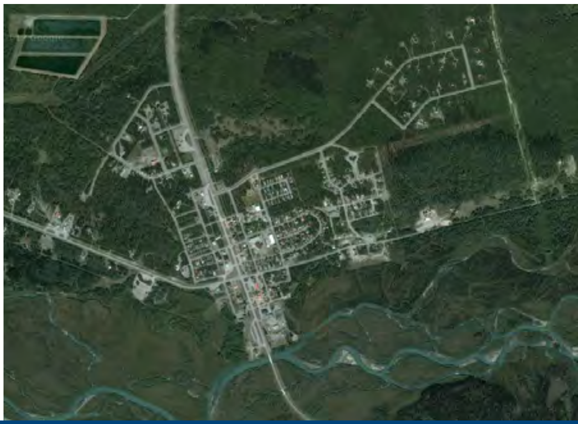

APPENDIX H

Impact Assessment

Front End Engineering Design (FEED) Study
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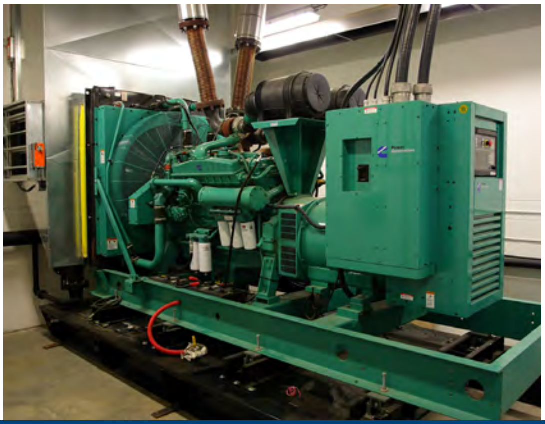

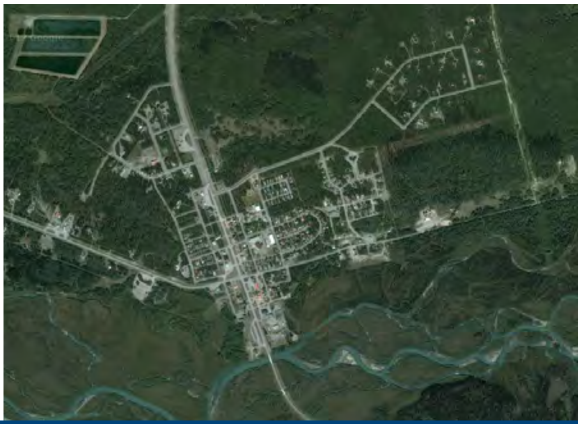

YUKON ENERGY

APPENDIX I

Engagement Plan

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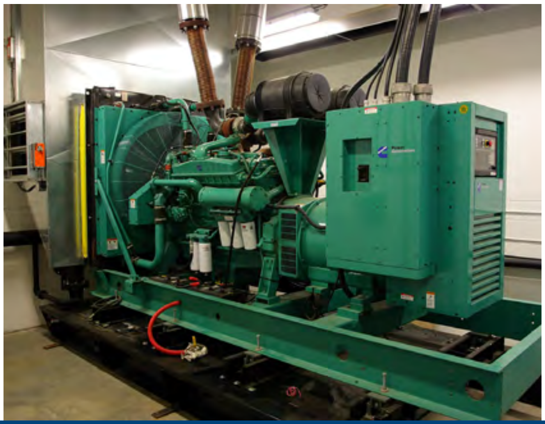

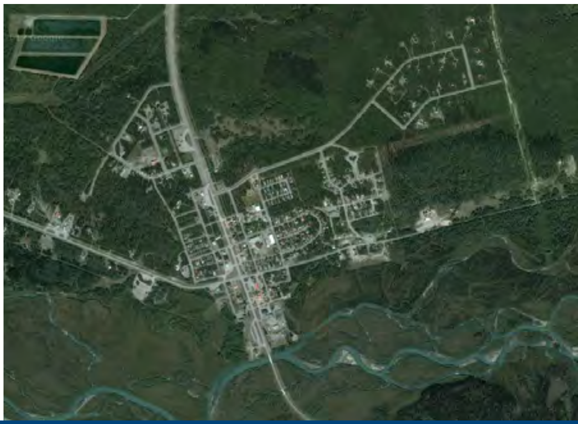

APPENDIX J

Financials

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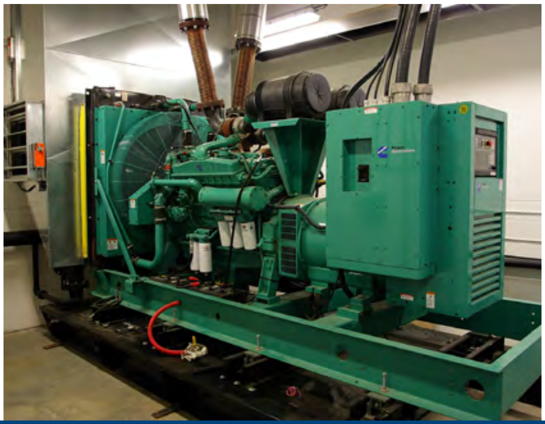

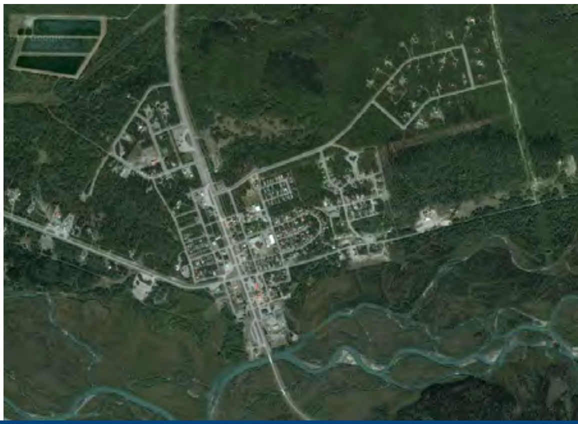

APPENDIX K

Implimentation Schedule

Front End Engineering Design (FEED) Study
Yukon Bioenergy Demonstration Project
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