Biomass Feedstock Supply

required for
1.2 MW Combined Heat and Power System

Pre-feasibility Analysis

Prepared for:
The City and Borough of Yakutat, Alaska
Yak-tat Kwaan Inc.
September 7, 2010

Prepared by:
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Executive Summary

The City and Borough of Yakutat (Yakutat) and Yak-tat Kwaan Inc. (Kwaan) require 10,000 to 20,000 tons of biomass per year as combustion feedstock to generate energy with a combined heat and power plant. Bionera Resources Inc. (Bionera) was engaged by the Kwaan to conduct a three day site visit in July 2010 and consider options for biomass supply. This included a cursory review of the land base with respect to overall size, climate, topography, soils, vegetation, history and community culture, and ecological values. The Yakutat Salmon Board provided an overview of the fisheries resource, which is a fundamental aspect of Yakutat, Alaska and is its primary economic driver.

Bionera was then engaged to determine volume and cost of sustainable biomass sources and the viability of an energy crop. By combining systems that share some of the equipment, and selecting equipment options in scale with available volume, a cost of $52 per ton can be achieved for a supply of 10,000 tons per year. The addition of energy crops could lift the potential to 20,000 tons per year provided that future testing indicates a sufficient growth rate. The requirement to clear land for agriculture and an anticipated slow growth rate contribute to a high cost per ton for energy crops, at around $61 per ton. This increases the overall average cost for the 20,000 ton option to an average of $56 per ton. Summary results follow:

Yakutat Biomass Supply Blend of sources; +/- 25%; green tons				
Biomass Sources	**Tons**	**Cost/ton**	**Total**	**Remarks**
Waste material	356	$24	$8,393	sustainable indefinitely
Forest thinnings	5,414	$46	$249,212	harvest known volume over 20 years; supplement with re-growth and thinning contracts
	152	acres per year		
Logging debris (logyard)	**500**	**$50**	$25,000	available for 5 - 10 years
Logging debris (cutblocks)	**250**	**$60**	$15,000	Available for 20 years, except on areas established with energy crops
Roadside willow and alder	1,467	$58	$85,370	sustainable indefinitely
In-block willow and alder	1,467	$58	$85,370	sustainable indefinitely, except on areas established with energy crops
Energy crops	1,046	**$75**	$78,415	sustainable indefinitely
	523	acres		
Sums and Averages	**10,000**	**$52**	**$521,762**	
Energy crops	11,046	$61	$678,472	sustainable indefinitely
	5,523	acres		
Sums and Averages	**20,000**	**$56**	**$1,113,425**	

Bionera was also asked to estimate the cost to address a diligent range of issues and questions that should be covered before proceeding with a biomass feedstock program of this size. The total cost to achieve comfort with sustainable biomass volume and delivered cost is $179,000 including all due diligence aspects identified to date. This includes $73,000 for equipment and testing of logging debris and stump harvest along with a second energy crop trial plot. The total also includes $67,000 that can be deferred until results from prior due diligence are available.

An alternate first stage option is included in Appendix A for your consideration. The goal of this part of the investigation was to assess whether or not a 1,000 ton system could provide an adequate financial return, useful productivity data, and also fit into the larger overall project.

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Background

Electricity in Yakutat is currently provided by diesel fired generators. Much of the Kwaan's land base has been logged sporadically over the last 60 years and left to natural regeneration, with variable results. Much of the land is not regenerated to forest. The community desires a lower cost source of energy, provided that this can be done without risk to the fisheries resource or the ecological recovery of the land base generally.

On approximately 3,000 acres, forest regeneration is dense. Thinning is underway to improve forest health and wildlife habitat.

Yakutat sought information about alternative energy and subsequently formed a subgroup on alternative energy, including the Kwaan. The two groups are working cooperatively toward a sustainable energy alternative.

Bionera is engaged in energy crop establishment, and is a wholly owned subsidiary of Pacific Regeneration Technologies Inc. (PRT), which operates 12 seedling nurseries in North America, and has been engaged in Short Rotation Intensive Culture (SRIC) of woody species since 1999.

Sources used for this document

In the interest of time and cost, citations are not included in this document. References can be found in the working papers. Citations and a bibliography can be added upon request.

Working papers accompanying this report:

Pre-feasibility analysis 2010-09-14.xls
Yakutat Visit Summary 2010-08-02.pdf

Biomass Sources, Volume and Cost

A variety of biomass options were considered and calculations were performed based on available information, including tests performed to date and various independent sources of information. Summary results follow:

Yakutat Biomass Supply Blend of sources; +/- 25%; green tons										
Biomass Sources	**Term**	**First 3 years**			**Year 4 - 20**			**Year 21+**		
	Yrs	**Tons**	**Cost/ton**	**Total**	**Tons**	**Cost/ton**	**Total**	**Tons**	**Cost/ton**	**Total**
Waste material	99	356	$24	$8,393	356	$24	$8,393	356	$24	$8,393
Forest thinnings	99	5,414	$46	$249,212	5,414	$46	$249,212	5,414	$46	$249,212
		152	acres per year		152	acres per year		152	acres per year	
Logging debris (logyard)	5	**500**	**$50**	$25,000						
Logging debris (cutblocks)	20	**250**	**$60**	$15,000	**250**	**$60**	$15,000			
Roadside willow and alder	99	1,467	$58	$85,370	1,467	$58	$85,370	1,467	$58	$85,370
In-block willow and alder	99	1,467	$58	$85,370	1,467	$58	$85,370			
Energy crops	99				1,046	**$75**	$78,415	2,763	**$70**	$193,397
					523	acres		1,381	acres	
Sums and Averages		**9,454**	**$50**	**$468,347**	**10,000**	**$52**	**$521,762**	**10,152**	**$52**	**$527,979**
Energy crops	99				11,046	$61	$678,472	12,763	$61	$783,956
					5,523	acres		6,381	acres	
Sums and Averages					**20,000**	**$56**	**$1,113,425**	**20,000**	**$56**	**$1,118,538**

Numbers in blue/bold are entered directly in this table, and are not substantiated by sampling or feasibility calculations

At	**$52**	**per ton &**	**10,000**	**tons / yr**	**$521,762**	**per year**

At	**$56**	**per ton &**	**20,000**	**tons / yr**	**$1,113,425**	**per year**

Biomass Source Discussion

Municipal Solid Waste

Combustible municipal waste is assumed to include only wood, paper, cardboard and yard trimmings, yielding 30 tons per month. It is assumed that this can be comminuted in one half-day per month by the same equipment used for other sources of biomass. Volumes are based on national data for generation of municipal solid waste per capita.

Forest Thinnings

The cost of collecting, comminuting and hauling forest thinning material was calculated based on the average of six methods. Considerable information was available both from test work done in Yakutat, and because of a wide range of slash reduction work underway in the western US to reduce forest fuel loads. The Yakutat project is unrelated to fire risk reduction, however similar productivity can be achieved. This work could be performed over a period of 20 years to achieve a productive level of equipment utilization.

The most cost-effective option explored includes the Fecon Bio-Harvester and estimates suggest a cost range of $36 to $51 per ton. If a lower capital cost option is needed, the work could be performed by contractors required to thin and forward the material to roadside. In this case, grinding and hauling equipment would be purchased and operated locally to deliver the biomass. A variety of sources were used to assess this option, suggesting a range of $43 to $56 per ton. Available residues were estimated at 42 tons per acre with 85% of the material recoverable.

There are currently 3,300 acres of forest that can be thinned, with a total of at least 110,000 tons of recoverable woody biomass. By utilizing this fuel over 20 years (~5,500 tons per year), skills development and employment will be more stable, and there will be time for under-story forest growth in other areas to provide a long term sustainable harvest. Biomass project operations can include thinning work on lands under the jurisdiction of other agencies, thereby supplementing total volume and long term sustainability.

Logging Debris and Stumps

Logging debris in the abandoned logyard, along with logging debris from cutblocks being converted to energy crops can be harvested for biomass. An estimate of $50 to $60 per ton is used for the time being. In order to get more accurate costs, small scale yarding and splitting tests will be required.

One study was reviewed to estimate the cost of stump utilization. This study provided valuable information on recoverable stump volume, however productivity figures were derived from an ideal and high cost set of equipment being utilized year-round in a second-growth harvested stand. At 2.5 times the costs achieved, this study suggests a delivered cost of $63 per ton. Recovery and costs can be assessed for Yakutat as part of the small scale yarding and splitting tests described above.

Utilization of in-block material has the potential to significantly reduce energy crop establishment costs. Debris logs and stumps will need to be removed to establish the energy crop, so if this source can be used to cost-effectively deliver biomass feedstock as part of that task, energy crop economics will be improved.

Roadside and in-block willow and alder

Costs presented assume that roadside and in-block willow and alder will be harvested with the same equipment set (Fecon Bio-Harvester, high dump wagon and chip truck) as will be used for thinning. Volume is based on samples collected from roadside re-growth and the assumption that in-block willow and alder can contribute a similar amount. This estimate also includes an allowance for enhancement of the in-block areas with seeding and cuttings to increase the area occupied by Sitka alder, cottonwood and willow over time.

More ground will need to be covered with this option than for thinning, however the chip van can be located closer to the material, so costs are expected to be the same as the cost for the thinning operation. Most of the cost is associated with grinding the biomass. Roadside and in-block willow and alder is smaller in diameter than forest thinnings, requiring less input energy to process.

Energy crops

Energy crops of some kind will be required to increase yield beyond 13,500 tons per year. Three alternatives appear worthy of consideration: native Sitka alder, willow and/or cottonwood row crop, hybrid willow row crop, and enhancement of in-block biomass by increasing the area occupied by Sitka alder.

The first two options require land clearing to enable agricultural row-crop production, raising the cost as compared to a crop grown on cleared but otherwise under-utilized land.

Energy crop yield can not be estimated within an acceptable range. For the purpose of this report, it is assumed that a growth rate of 4 tons per acre can be achieved, for the following two reasons.

A useful baseline estimate of growth rate for Yakutat would be the mean annual increment for Sitka spruce. We have not yet been able to obtain an estimate of annual growth rate in the Yakutat area, however the accepted minimum for commercial forestry in Southeast Alaska is 50 cubic feet per acre per year, which is roughly equivalent to 1.4 tons per acre per year. This figure would not include tops and branches or below ground biomass, so although the growth rate is likely slower in Yakutat, the full utilization of biomass would offset this to some degree. Sampling of roadside Sitka alder conducted in August, 2010 suggested 1.5 tons per acre per year. It is safe to say that we would not invest in an energy crop option unless we can demonstrate a growth rate substantially higher. Two to three times this amount is a reasonable objective.

Based on two energy crop economic models, yields of 4 tons per acre per year were needed to achieve costs approaching $60 per ton. Therefore, we have little choice but to demonstrate that this can be done.

The local Sitka alder may prove to be a viable energy crop option. If the crop can be established by direct seeding, savings of $8 to $10 per ton are possible. Sitka alder is not a commercial species in any system, so there is little information available to substantiate estimates. Seeding success is reliant on mineral soil exposure which could be enhanced by land clearing or other treatments which are part of the overall biomass supply system.

A blended approach using silvicultural techniques is worthy of consideration. This would include enhancement of the in-block areas to increase the area occupied by Sitka alder. Red alder also coppices reasonably well, so this is another option. There is no experience with this approach that we've been able to find, however if these species can be established at high density over a wider area, they are well adapted to the climatic conditions of the Yakutat area and would be likely to thrive and deliver a predictable volume of biomass feedstock.

The yield potential for these systems can only be assessed by growing a variety of potential test crops for an absolute minimum of two growing seasons. Three to five growing seasons could provide a very reliable estimate, along with selection information for best varieties with respect to yield and disease resistance. Further experience with weed management will also prove invaluable.

Equipment access for establishment, tending and harvesting will be a challenge. Estimates are based on tracked equipment, although it is difficult to estimate how much maintenance costs will rise due to tracks rather than wheels. Generally this is a significant difference. If wide flotation tires work out, then at least this challenge could be addressed as a one-time cost.

There are many positive indicators for energy crop success in Yakutat. Topography, ample precipitation and mild winter temperatures lend themselves well to energy crop success. The extensive road system improves harvesting access and contributes favorably to the costs.

The current trial will be expanded to include hybrid willow, Red and Sitka alder seedlings, along with a second site to test a higher piece of ground. The cost of this work is included in the estimates provided later in the report.

Biomass Feedstock Specification and Storage

Equipment selections were based on the following fuel delivery specifications.

- Size of fuel: 3" minus (if conversion equipment requires a tighter limit, costs can be adjusted upward for the additional fuel and grinding time)
- Fines: less than 15% under 1/8"
- Moisture content: 25% to 60% wet basis
- Occasional nails, rocks and other inorganic debris under 3” in longest dimension
- Free of frozen lumps >3"
- Less than 3% inorganic

It should be noted that the Fecon harvester is based on a hybrid grind-chip system and has had problems with stringiness in the past. The manufacturer suggests that they have made excellent progress and by the time a unit is purchased for Yakutat, this problem will be entirely solved.

The secondary biomass sources are based on use of a wood grinder, which will also produce a small quantity of longer pieces that can be troublesome in the biomass feed system. These challenges can be solved by elements in the feed system which could include, e.g., a scalper to remove long pieces and direct this material to re-grind or disposal.

We recommend that the biomass energy conversion system be designed to efficiently use biomass at 40 – 50% MC (w.b.)

Requirements for three forms of feedstock storage are presented below, based on seasonal limitations and reserve requirements to cover maintenance downtime and unexpected stoppages:

- Five days supply in automated wood bin
- Two week’s supply on-site, covered to ensure that fuel delivered to the bunker is free of frozen lumps during winter operation
- Three month’s supply with year-round access. It is not necessary for this to be onsite or fully processed but efficiency is likely to be better if it is
- A separate bunker and metering system for dry MSW could also be considered

Storage Needs	Small	Medium	Large
Used for harvest season compatibility; should not be relied upon for plant design	(green tons)		
Annual consumption	1,221	10,000	20,000
Average weekly consumption	23	192	384
Average daily consumption	3	27	55
Automated wood bin at maximum heating surge level and five day's supply:	26	215	430
On-site storage at maximum heating surge level and two week's supply:	74	602	1,204
Seasonal storage, three month's supply	479	3,925	7,850

Storage needs are calculated based on heating need during the coldest month; heating degree days for the coldest month are 57% higher than the average heating degree days. Electrical consumption varied less than heating.

The harvesting systems selected (grinders) will produce more fines than the ideal level for long term storage. Consistent cool temperatures will reduce decomposition during storage, however the fines in the biomass feedstock will increase the likelihood of losing energy content and could increase ash disposal from a combustor. Therefore utilization will need to be managed to maximize energy recovery by consuming older stock first.

Equipment for Biomass Harvesting, Comminution and Delivery

Based only on the sustainable supply of forest thinnings and native plant re-growth on roadsides and within old cutblocks, an annual supply of 8,300 tons per year can be delivered. This is the simplest and most cost-effective option.

- Chip truck: tractor and 40' live floor trailer
- Fecon Bio-harvester FTX440 & H600
- 8-ton high-dump wagon, with modifications including wide, puncture-resistant flotation tires
- Pickup and ash spreader

Fecon, in partnership with Awhi in Germany, has six to eight machines operating in Europe. None have been sold in the United States as yet, however their latest machine is currently operating in Arizona, so there could be an opportunity to get a look at it. The machine weight is 27 tons (a sturdy machine) so it may not be possible to test it in Yakutat, although the company may be willing if the freight is paid (~$25,000 to $30,000 return). Due to the weight of the machine, we added a mounted winch to the capital cost, for the day that it gets stuck. Fecon advised that they have not found a high-dump wagon that has worked satisfactorily yet. We based our costing on a conventional high dump agricultural forage wagon, modified with wide footprint puncture resistant tires.

In order to go beyond 8,300 tons, we would need to add logging debris, stumps, and combustible municipal waste. This option would allow for an additional 5,200 tons (13,500 in total), assuming that half the stump volume can be economically harvested over a 20-year period.

- Horizontal Wood Grinder, 225-350HP
- Excavator (20-25 ton), add winch, stump shear, log splitter and grapple

Some manufacturers offer grinders that can be converted to chipping. As long as fuel is relatively clean (e.g. forest thinnings) chipping would produce biomass with longer shelf life and lower fuel consumption for comminution.

We could lower the total capital cost by utilizing a tub grinder, however these machines tend to have lower productivity because material is fed by gravity. Grinding of municipal waste would take extra care and probably could not be done at the plant because tub grinders can throw material quite far. The horizontal grinder used for the cost estimates specified is expected to be generally safer to operate and should achieve higher overall productivity. That said, there is a Morbark 950 tub grinder in Sitka, Alaska so there may be an opportunity to give it a try in our conditions. The style of grinder planned for the project is capable of much more grinding than needed, but it is a rugged and reliable choice which should provide years of reliable grinding and tolerate a wide range of biomass.

Purpose-grown energy crops yielding 4 tons per acre per year on 2,500 acres would add an additional 10,000 tons (23,500 in total).

- Main tractor 100 - 200 PTO HP on tracks or very wide flotation tires
- 2nd smaller tractor
- Various agricultural implements (e.g. disc, row-crop cultivator, sprayers, fertilizing equipment)
- Harvesting can be done by the same Fecon unit, or with a separate dedicated harvester depending on volume required
- 2nd high dump wagon
- 2nd chip trailer

Equipment alternatives discarded:

Bundling is an option that can extend shelf life of the biomass. However, the bundling concept is most effective when final comminution is performed at the conversion plant using electric powered equipment. In addition, the equipment is extremely expensive and delicate, requiring year-round and long term use to achieve cost-effectiveness. This equipment is primarily designed for collecting debris after clear cut logging.

The bio-baler equipment would provide better shelf life since material is stored unchipped. The manufacturer is working on a tracked option but this will not be ready for at least a year. This equipment can be operated cost-effectively for the roadside biomass, but has not proved cost-effective for energy crop harvesting as yet.

Feller-chipper-forwarder systems are available for forest thinning (e.g. Bruks, Jenz), but would not be useful for managed in-block or roadside biomass, nor for the energy crop harvesting. I expect to get useful productivity information later this year after a test program currently underway in Oregon is completed. Due to high capital cost and maintenance requirements, this type of equipment can generally be justified only when year-round utilization is possible.

There are many other equipment options, along with smaller scale innovative methods. Most large scale options are geared toward utilizing debris arising from logging. Smaller scale options are in use by fire risk reduction contractors and tend to be locally opportunistic, often sharing equipment with other projects.

Treatment of Carbon Values

There is much debate over utilization of forest thinnings and downed forest debris with respect to carbon mitigation. Energy crops definitely reduce carbon dioxide emissions due to the shorter rotation, and municipal waste utilization also offers more apparent carbon emissions reduction. Carbon values were only considered for energy crops and not for other sources in the estimates. Furthermore, a conservative value per ton of carbon dioxide avoided has been used, i.e. five dollars per tCO_2e. Future values have not been increased in any multi-year model, providing some upside potential.

Further Testing Required

Described here are three key areas that require an adequate testing plan to ensure viability of these options. Following this description are tables including a detailed breakdown of due diligence items and the estimates to complete the work.

Energy crop test plots

- Continue testing alder direct seeding, along with willow and poplar cuttings
- First test plot will require weeding and will test well for frost damage
- Add a second test plot; choose a high site around 40 acres; initially clear just enough space for a trial site - 1 or 2 acres – retain as much soil as possible by removing timber and stumps with excavator (equivalent to overall biomass feedstock plan)
- First test plot cost $30,000; therefore estimating $20,000 after improvement from experience
- Summer student $12,000 for two summers – plant, supervise, collect data, weeding
- Total: $32,000

Test splitting of logyard and in-block forest debris biomass, including stumps

- $20,000 for tree shear for city-owned Cat 320L - test ability to break down logs and stumps to a size that an affordable grinder could handle (i.e. less than ~20")
- Test activities and supervision ($15,000)

Test yarding of forest thinnings to roadside

- This can be done as a time study during upcoming thinning projects ($6,000)

Other work is described in the tables below.

The consultants I would subcontract to are people with decades of experience in various aspects of silviculture and wood recovery. Some examples include:

Neil Hughes, Ecotrust.ca
Bruce Blackwell, Blackwell & Associates
Bruce McCallum, Ensight Consulting
Cees Van Oosten, SilviConsult Woody Crops Technology

These sources have extensive experience in silviculture generally, and also great experience in areas highly relevant for the Yakutat biomass project:

- Alder in Coastal Washington, Oregon, and BC (Hughes)
- Short-rotation intensive culture (Van Oosten)
- Biomass removal, grinding, hauling (Blackwell or McCallum)

We could look more for appropriate local consultants as well. These are listed because they are people we have worked with in the past and they are known as people with broad knowledge and practical solutions.

Testing Estimate Summary

Verify availability of all options under consideration, including refinement of costs and volume to +/- 15% at the 20,000 ton level: $39,000.

Further energy crop trial work required to be sure of establishment costs and growth rate: $32,000

Test splitting of logging debris to <20", acquire data on yarding of thinnings: $41,000

Other due diligence that can be initiated later: $67,000

Total listed: $179,000

Status of Yakutat Biomass Feedstock Issues and Questions with Cost Estimate

Issue/Question	Sep 15/10 Status	Person Responsible	Cost Estimate		Comments
Completed to date			**$44,000**		
Initial energy crop installation	Done		$30,000		Complete
Preliminary evaluation of cost range in order to identify potentially viable biomass supply options	Done		$14,000		Complete
Top priorities which could affect further work			**$39,000**	**$179,000**	
Basal area determination for existing second growth to assess number of years of biomass available before plantation sections are in production. Test harvesting of suitable areas.	Prior Yakutat tests appear to be consistent with other available information		$8,000		planned for fall 2010
Complete biomass feedstock cost and volume estimates to +/- 15%, including the following issues		Kitchen	$8,000		This will require reduction of options in accordance with community needs and available equipment. Calculate volumes from results of fall 2010 tests.
Complete evaluation of biomass feedstock production potential from other, non-organized regeneration areas		Kitchen	$7,000		
Tabulate likely comparisons of growth rates from existing data for all species considered utilizing a ratio of spruce growth to other species, by latitude, since the only local growth information is from spruce. Obtain past timber harvest (USFS, Mental Health Trust, and YTK) and stand density studies from the area. Estimate a correction factor with heating degree-day tables for these growth ratios. Apply expected growth rates to species under consideration.	Recommend that we use energy crop trial results for this task, however a quick external estimate makes good sense	Van Oosten	$6,000		Included in main report estimates, including discussion of utilization of other biomass sources as this option is refined - i.e. don't spend too much up front on this until we see the willows next spring; it's going to take time
Verify suitability of soil	Energy crop trial underway, which will provide the best possible information	Sparrow			Although soil is thin, the underlying gravels are relatively free of large boulders, so mechanized planting is not a concern. In a drier climate, the lack of "topsoil" and underlying gravels would be a concern. In this case, we will get very good initial survival of energy crop plants.
Evaluate necessary buffer widths between the energy crop and wetlands and streams in order to maintain salmon habitat and prevent colonization of non-native species.		Hughes	$10,000		Given that the land requirement for energy crops is estimated at 2,500 acres, vs. 5,700 acres available after allowing 500' riparian buffers, this investigation may not be needed. We will also locate discard logs and grassy swales to mechanically intercept broken branches. Willow is primarily propagated by "cuttings" in nature, with animals, slides and floods doing most of the distribution. Propagation by seed is rare due to remarkably brief viability of male and female flowers and because seed is only viable for a matter of days. Red alder could be considered to be an introduction, but is also adaptive management in light of the long term climate trend.That said, hybridization and colonization are possible, and this requires the expert monitoring of the eventual manager. It is highly unlikely at worst, and probably impossible, for any energy crop variety or its offspring, to out-compete the existing and locally adapted willow without the coddling an energy crop gets.

Status of Yakutat Biomass Feedstock Issues and Questions with Cost Estimate

Issue/Question	Sep 15/10 Status	Person Responsible	Cost Estimate		Comments
Next level priorities			**$140,000**		
Continue energy crop testing		Kitchen	$32,000		as described in main report, includes summer student caretaker
Assess disease potential and predation rates	Energy crop trial				
Estimate costs to provide reduction or elimination of risk due to erosion and runoff (i.e. storm water management)	This is built into energy crop estimates				Wide buffer strips and careful removal of debris have been included in the plan. Gradual implementation of energy crops is possible due to other sources of biomass, so methods can be assessed over time.
Overwinter survival rates and growth rates for initial plantings	Energy crop installed				
Test splitting of logging debris and grinder feed rate		Kitchen	$35,000		includes specialized equipment
Collect data from thinning and yarding operations planned for 2011		Kitchen	$6,000		
Evaluate compliance of options with Coastal Management Plan		Hughes	$1,500		
Obtain list of areas that may require preservation for Alaska Native heritage and other cultural or archealogical values		Kitchen	$800		
Provide a description of integrated weed management required to establish as energy crop		Kitchen	$700		
Consider the advantages/disadvantages of classifying the land as agricultural		Kitchen	$2,000		
Consider permit requirements for the introduction of non-native species/varieties and investigate hybridization potential with native species		Kitchen	$2,000		
Provide evapotranspiration rates for various species in order to assess risk of dewatering existing stream channels	Done				The evapotranspiration rate for the Yakutat area is around 20". Climate records from 1949 to 2006 report 145" mean precipitation and the lowest year (1950) at 86". Further work can be done during scale-up.
Estimate total acreage needed for production	Done				
In-depth estimation of establishment and operating costs for each remaining option, including land clearing, drainage, planting stock and method, production equipment needs, suitability of available Sealaska heavy equipment, personnel needs, and fertilizer requirements for optimum production		Kitchen	$10,000		
Provide energy values of woody biomass by species and moisture content	Done				Species and moisture content is covered in the working papers. I'm using 6.6 million Btu per ton (LHV or NCV), as used at 50% MC (w.b.)
Consider options for local production of planting stock sources, use of greenhouses, seed crops, etc.		Kitchen	$10,000		
Evaluate roadside strip plantations in regards to sunlight and production potential, including design to accommodate potential commercial berry production component		Kitchen	$25,000		Test crops similar to the energy crop option, and should be done with intense management on relatively small areas. A trial design would be developed and a local champion hired to maintain the test plots.
Evaluate road upgrade requirements, particularly on decommissioned roads	Not needed				We can achieve the cost estimates provided that additional roads are not de-activated beyond entrance berms. The excavator can open and close roads relatively quickly and on an as-needed basis.
YSB will contract groundwater /flow analysis to US Geological Survey for existing stream systems in FY 2011		Others			
Review of Yak-Tat Kwaan Forest Stewardship Plan and submission of amendments for inclusion of agroforestry component to the state forester.		Hughes	$2,500		
Author National Environmental Policy Act documents if federal funding subsidizes the project		Unknown	$5,000		Unable to estimate with any degree of accuracy
Estimate acreage of spruce forests left on the landscape necessary to maintain watershed functions		Hughes	$7,500		

Conclusion

Forestry thinning and available roadside and in-block biomass can deliver a sustained yield of 8,300 tons or biomass annually at an expected cost of $52 per ton or less. By adding a horizontal grinder, the volume will increase to 9,400 to 13,500 tons, depending on the range of stumps that can be economically recovered. To go beyond this volume, purpose-grown energy crops will also be required. Further testing is required before we can rely on the required yield of 4 tons per acre per year. With woody energy crops included a yield of 20,000 to 25,000 tons per year can be achieved at an average cost of $56 per ton.

Working papers are included with the report, and remain the property of Bionera per our standard terms. We request that these be shared on a "need to know" basis with people who are working directly on this project and as required by funding agencies. These files have not been formatted for printing. I suggest that we go through the files together, and welcome feedback or suggestions that could improve the value of our work for you.

Thank you for the opportunity to investigate biomass feedstock options on your behalf. It has been a pleasure working with the group in Yakutat and we trust that this information will be useful for your project.

Appendix A – District Heating, 1,000 ton option

Although not originally requested, we also developed a smaller stage entry level project for biomass utilization, described below. Our objective was to estimate whether or not a 1,000 ton heating project could make sense for Yakutat.

The following project would be compatible with the future larger project, including provision of hot water as part of a larger loop or directly to other conversion technology and power generation. This project can be running in 12 months.

8 million Btu Biomass Fired Hot Water Heating System; 1,200 green tons biomass per year

High efficiency low emission gasifier/combustor, hot water boiler and electrostatic precipitator, $1 to $1.5 million to set up, including:

- combustor/boiler $500-$600k
- wood handling components $100k
- electrostatic precipitator $100-$200k
- Building and wood room $200-300k
- connection and fixtures $100-300k

All this equipment is proven and simple to operate. Operators will improve efficiency as they learn the systems. All of this can be purchased under contract, with specifications and performance guarantees.

This system would be used to heat/chill a combination of buildings that directly or indirectly consume $250,000 (62,500 gals) of diesel fuel. For example, this might include YSB/Courthouse, and Mallott's including chillers, and some others. The complex of buildings which include the ranger station might also be suitable.

Biomass collection and handling equipment: capable of handling logging debris and forest thinnings up to 250 feet from roads, and deliver 25 tons with less than 2 worker-days, $300,000 to $600,000.

- 40' walking floor trailer, $65,000 new ($25,000 used)
- Tractor for this trailer, equipped with long reach grapple and winch $100,000 (or $60,000 used)
- Horizontal Wood Grinder, preferably including a grapple, 250HP $225,000, (or $60,000 used, plus $40,000 full re-build = $100,000)
- The city-owned 320L excavator with the addition of a stump shear and/or screw type log splitter for breaking large logging debris down to size for the grinder $20,000 (or $6,000 used with $4,000 rebuild)
- Transport trailer for excavator, if not currently available $20,000 (or $10,000 used)
- $540,000 new + contingency = $600,000; $220,000 used + contingency = $300,000

Total for hot water system and wood handling equipment: $1,300,000 to $2,100,000

Salmon will barely feel a feather drop, and importantly we will buy time to do the environmental and ecological tests needed to be sure that our footprint is modest enough for the larger project.

Absorption chillers would be owned by the user. Hot water purchases at same cost as for heat, i.e. much less than electricity on a per-kWh basis, so that the customer's investment in conversion equipment would meet their capital return expectation.

Operations: collect fuel (1-2 worker-days per week), operate boiler (1-2 hrs / day inspection and cleanup, 1-2 visits per day), routine maintenance (10 days per year), ash disposal (17 days per year), processing municipal waste wood, paper and cardboard (1/2 day per week), and records (1 hr per day).

2 people, 1/2 time $60,000, O&M $23,500, Excavator bare rental $9,600, Capital reserve $10,000; Overhead $10,000; contingency $10,000 = $122,000 (~$100 per ton)

Fuel @ $4 / gallon replaced by 1,200 tons biomass = 62,500 gals diesel = $250,000

The return on this project is too low as is, and will require more effort to refine the heating system estimate. Less expensive grinding options are available, however our intent was to base the system on equipment that is fully compatible with the larger project.

Of equal importance, we will:

- develop the local biomass handling skills needed for the larger project
- get accurate yield and environmental data
- gain local experience with district heating, and provide part of the loop heating for the larger eventual project
- make good use of forest thinnings and logging debris
- get a project on the ground fast

The system will consume a range of 15 tons to as much as 50+ tons of biomass per week, and will deliver 180° to 200° water.

At low use, we'll need one truckload (20-25 tons) every two weeks. During winter, we'll likely need two truckloads per week. At 22 tons average (one load per week) = 1,150 tons per year, each ton delivering ~6.6 million Btu or 1.9 MWh of useable heat, combusted at 50% moisture content.

A ton of biomass costs us a lot at this small scale: $100/ton… but… it replaces 51 gallons of diesel worth $205 (at $4 / gal or $166 at $3.25).

Modern biomass combustors are high tech and clean, but do have a chimney. You will not see or smell smoke when the burner is running at design demand. The chimney will be tall. The key to clean burning is to have a large and variable speed induced draft fan; state-of-the-art and simple to operate process controls; multiple oxygen sensing points and a low-draw electrostatic precipitator.

Smoke may occur for up to 30 minutes after startup or while shutting down as the burner drops down below its idle programming. If fuel moisture exceeds 60%, there will be a risk of smoke and the combustor will be difficult to operate. With wet fuel at 45%, there will be steam at times. However, we will most often be running extremely clean, and burning fuel at 35-45% moisture.

Ash is spread on the growing biomass, returning most of the mineral nutrients taken off the site by the biomass removal. This will be done well away from riparian buffers. For the most part, the nitrogen can be replenished by increasing the amount of alder and taking advantage of its symbiotic relationship with nitrogen converting organisms that attach to their roots – an elegant closed-loop.

Two dedicated local people can be trained in everything needed, and will continuously improve the system. Give them some space for drying and they'll make this system a lot better. The system requires scheduled checks and people to respond to occasional alarms, but runs automatically and unattended, with a shutdown sequence automatically initiated in the event of unattended malfunctions.

We will need access to a heavy duty mechanic with 1-2 day's notice. If we don't have that, then it may be better for a local contractor to own the equipment.

We can pencil it out this fall, build it next summer, and have it running by September.