Practical Solutions for Biomass Heating in the Hazelton Region

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Introduction

Advanced biomass heating systems of all sizes, from 10 kilowatt residential boilers to very large multi-megawatt installations have been common in Europe for several decades. In North America, the first such systems appeared about ten years ago in the greenhouse industry in the lower mainland and they have slowly made inroads replacing conventional systems fuelled by heating oil, natural gas, propane and electricity. The conversion is driven by substantial economic and environmental benefits but it always depends on local conditions in regards to cost differential between biomass and conventional fuels, the size and location of the project and the availability of biomass fuel.

The Hazelton region is of particular interest since it is not connected to the natural gas grid which increases heating costs especially for larger institutional buildings which are forced to use propane or heating oil. Individual residences are commonly heated with electricity – which is currently very competitive with natural gas – and conventional wood stoves.

The following buildings are examined in some detail and their suitability for conversion is evaluated:

1. Hazelton Secondary School
2. New Hazelton Elementary School
3. GWES College
4. North West Community College
5. Upper Skeena Arena (planned)
6. Wrinch Memorial Hospital

These buildings vary greatly in size, location, condition, operation and ease of conversion and are therefore more or less suitable for biomass conversion.

Multiple conversions at the same time would both improve the economic prospects for each individual project since both economies of scale for the boiler equipment, the installations and particularly the procurement of biomass fuel can be expected.

Cost of Heating Fuels

The following conversion factors are used to compare the various heating fuels:

1000 cubic feet of natural gas have a gross energy content of 1 GigaJoule (GJ) which corresponds to 40 litres of propane, 27 litres of heating oil, 222 kilowatt hours of electricity[1] and 60 kg of “bone dry” biomass.

The following delivered costs (including all applicable taxes but excluding GST) are used:

1 278 kwh are the equivalent of 1 GJ of energy but electricity has a 100% conversion rate to usable heating energy while all alternatives have an 80% conversion efficiency. The factor of 222 corrects for this.

Natural gas	$20/GJ
Propane	$0.75 /litre or $30/GJ
Heating oil	$1.15 /litre or $31/GJ
Electricity (regular)	$0.08 /kwh or $18/GJ
Elec. (E-plus)	$0.03 /kwh or $7 /GJ
Wood Chips	$100 /bdt (bone dry tonne) or $6/GJ
Wood Pellets	$200 /bdt or $12/GJ

It is obvious from these figures alone that biomass fuels have a substantial cost advantage over all other conventional fuels (except for subsidized electricity).

Capital cost estimates are based on recently completed actual projects and personal experience. These numbers are realistic and include a safety margin of 15%.

Hazelton Secondary School

This large school of over 7000 m^2 is currently heated with two older Bryan propane water tube boilers with a nominal input of 2,400,000 Btuh and an output of 1,920,000 Btuh (565 kw) each . They are fully functional and although a replacement is planned, there is no urgency. Hot water is produced with a separate propane fired tank style hot water heater.

The existing heating system is configured for a maximum pressure of 30 psi and operates at usual supply temperatures of 80°C to 85°C. There was a proposal to modernize the propane heating system with both new high-efficiency boilers and a new distribution system but the expected cost of close to $1,000,000 was prohibitive and not justified by the expected savings.

Annual propane consumption is estimated at 120,000 litres to 150,000 litres which indicates a winter month (December to February) consumption of 20,000 to 25,000 litres or a peak load demand of 500 kw.

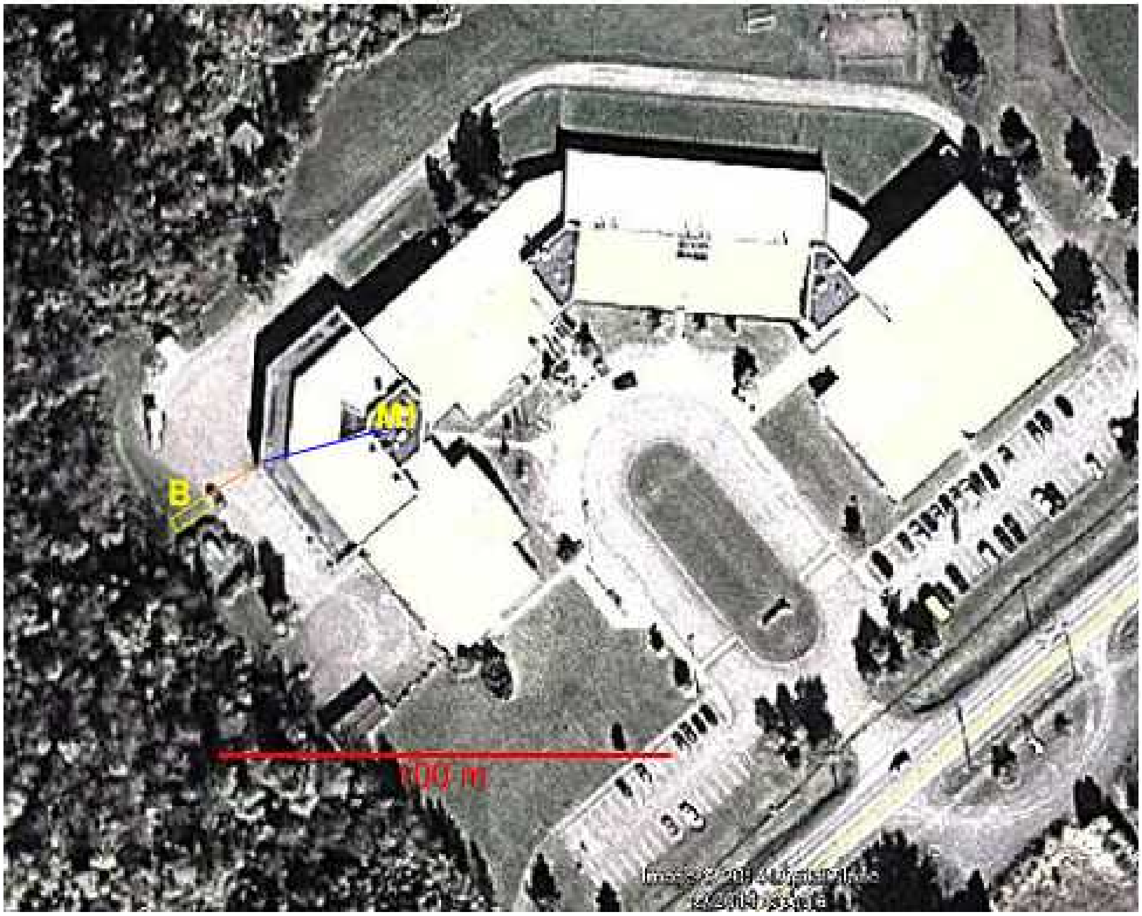
A biomass boiler of 300 kw (output) is the proper size for such a building which would reduce propane consumption by 95%. As usual, the existing boilers would remain in place as back-up and for peak-load operation.

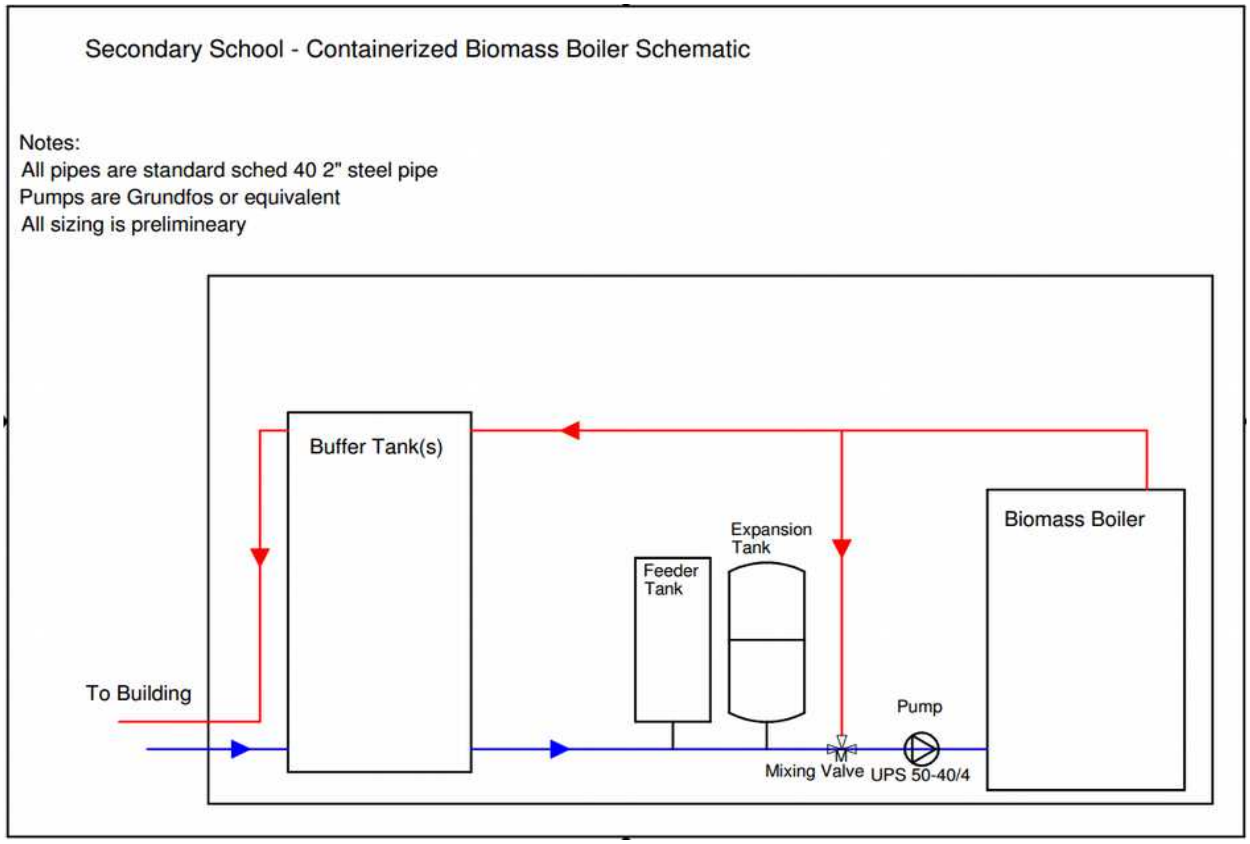
The proposed biomass boiler is housed in a 40 foot hi-cube shipping container, close to the current propane tank and about 20 m from the school building. Besides the boiler, the container would include two 2000 l buffer tanks, an expansion tank, a feeder tank and a pump and all required piping.

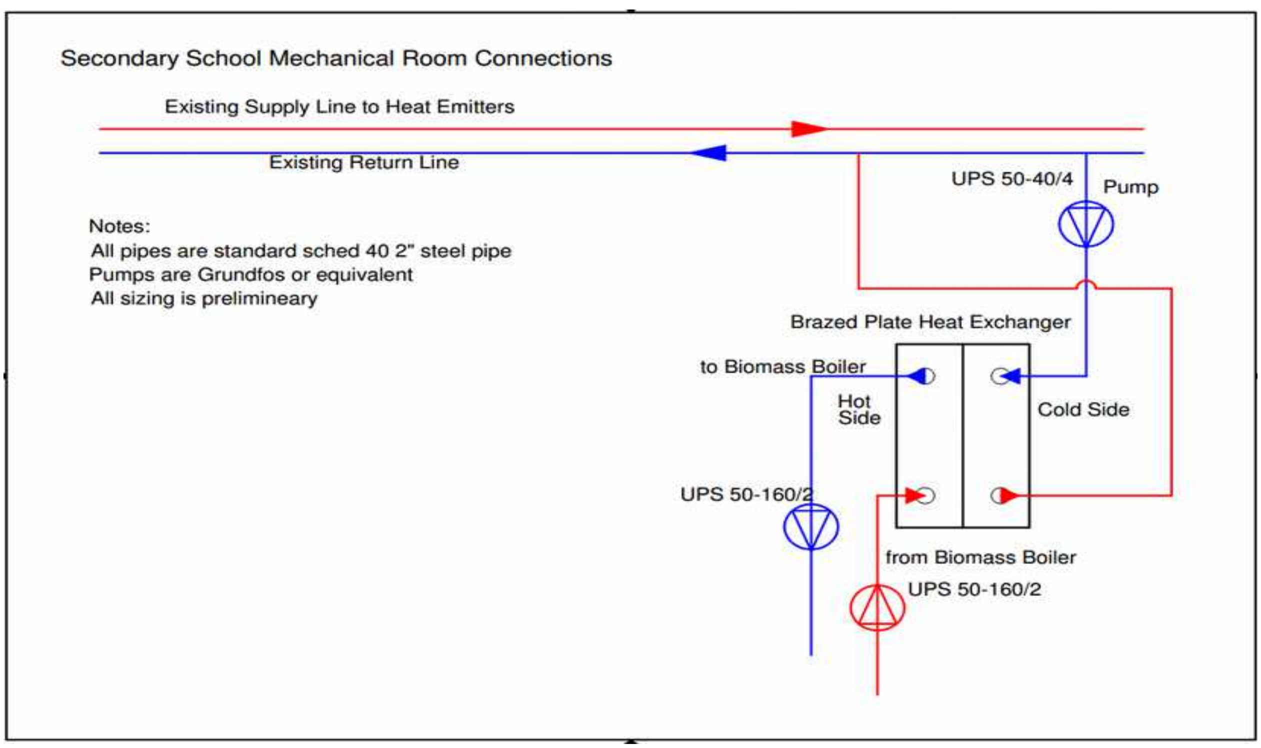
The biomass system is connected to the existing hydronic loop via an underground pre-insulated dual line pex pipe with a carrier I.D. Of 2". Since the school's mechanical room is not located on an outside wall, conventional steel plumbing is required for the final connection.

In the mechanical room, a brazed plate heat exchanger separates the two (biomass, school) hydronic loops. A leak in the biomass boiler or the underground connection will not affect the operation of the conventional system. A (or two) pump(s) on either side of the heat exchanger is responsible for the circulation of the biomass boiler's heating energy. No further modifications are required in the mechanical room (see diagrams below).

The supply temperature for the biomass system is set 5°C higher (f.e., 85°C versus 80°C) than the propane boilers' which assures both maximum use of the biomass boiler and automatic and fail-safe back-up in case the biomass system cannot keep up or is not operating properly. No changes to the digital control system are required. The two systems are entirely separate but work together.


M1
B
100 m


Secondary School - Containerized Biomass Boiler Schematic
Notes:
All pipes are standard sched 40 2" steel pipe
Pumps are Grundfos or equivalent
All sizing is prelimineary
Buffer Tank(s)
Expansion
Tank
Feeder
Tank
Biomass Boiler
To Building
Pump
Mixing Valve
UPS 50-40/4


Secondary School Mechanical Room Connections
Existing Supply Line to Heat Emitters
Existing Return Line
UPS 50-40/4
Pump
Notes:
All pipes are standard sched 40 2" steel pipe
Pumps are Grundfos or equivalent
All sizing is prelimineary
Brazed Plate Heat Exchanger
to Biomass Boiler
Hot
Side
Cold Side
UPS 50-160/2
from Biomass Boiler
UPS 50-160/2

Hazelton Secondary School				
Component	*Description/Size*	*Qty*	*Unit Cost*	*Extension*
Containerized Boiler, equipped	300 kw/ 40' hi-cube	1	$180,000	$180,000
Extraction System	4 m dia. Rotary sweep	1	$12,000	$12,000
Fuel Storage	14' Steel Grain Bin, wood bottom	1	$8,000	$8,000
Loading Equipment	Vertical chip loader	1	$16,000	$16,000
Site Prep	Gravel pad	1	$5,000	$5,000
Underground PEX (installed)	2” I.D. Dual Pex	25	$400	$10,000
Pumps		2	$4,000	$8,000
Heat Exchanger		1	$3,000	$3,000
Water Coil				
Energy Meter		1	$2,000	$2,000
Mechanical Installation		1	$30,000	$30,000
Electrical Installation		1	$15,000	$15,000
Design/Project Management		1	$35,000	$35,000
Contingencies	15%			$49,000
PST (7% on 70% of Cost)	70%			$18,000
Total (ex. GST)				**$391,000**

Operation Cost Comparison			
Fuel	Qty	Unit Cost	Extension
Propane (litres)	150000	$0.75	$112,500
Wood Chips (bdt)	225	$100.00	$22,500
O&M			$5,000
Propane	5.00%		$5,625
Total Cost			$33,125
Annual Savings			**$79,375**
Simple Pay Back Period			**5.0**

CO2 Mitigation: 250 tonnes

Recommendation

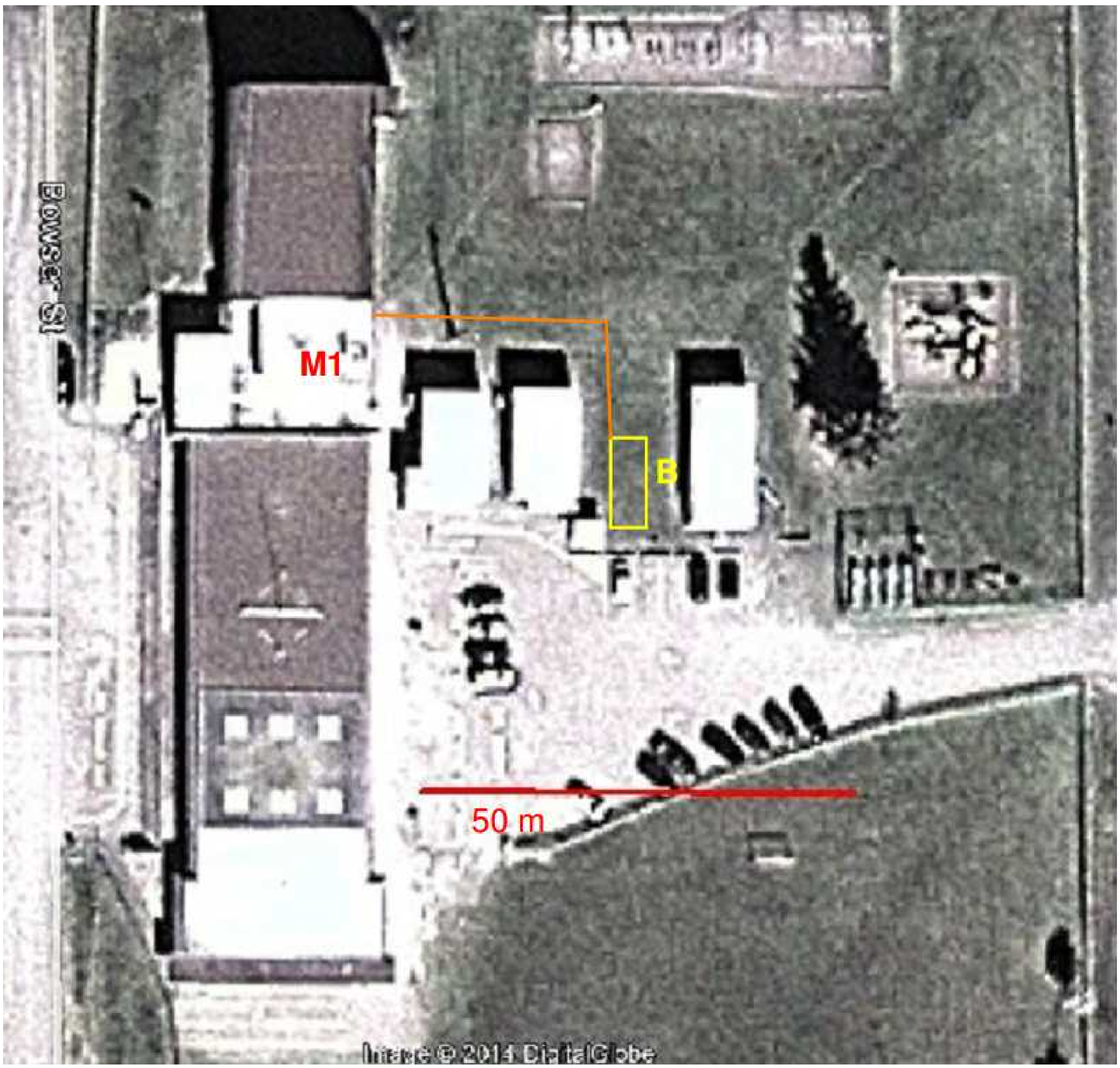
The Secondary School is an excellent candidate for conversion both from a technical and an economic point of view. The size of the project, the location of the building and mechanical room and the fuel cost differential all speak in favour. The expected capital cost of $400,000 are perfectly realistic and the existing personnel should be capable to operate and maintain the new boiler.

New Hazelton Elementary

Located in central New Hazelton, the elementary school covers not quite 2000 m^2 and is currently heated with 5 Raypack propane boilers with 206,000 Btu/h (60 kw) each. As is common in older institutional buildings, this total capacity of 300 kw is well beyond any imaginable peak load.

Annual propane consumption is estimated at 50,000 litres and a 100 kw supplementary biomass boiler is properly sized.

There is an ideal location for the containerized boiler, located between two 'portables' and adjacent to the large parking lot. Only a single parking space would be sacrificed for access to the storage silo.



New Hazelton Elementary				
Component	*Description/Size*	*Qty*	*Unit Cost*	*Extension*
Containerized Boiler, equipped	100 kw/ 20' hi-cube	1	$90,000	$90,000
Extraction System	4 m dia. Rotary sweep	1	$12,000	$12,000
Fuel Storage	14' Steel Grain Bin, wood bottom	1	$8,000	$8,000
Loading Equipment	Vertical chip loader	1	$16,000	$16,000
Site Prep	Gravel pad	1	$3,000	$3,000
Underground PEX (installed)	1.5” I.D. Dual Pex	20	$300	$6,000
Pumps		4	$500	$2,000
Heat Exchanger		1	$2,000	$2,000
Water Coil				
Energy Meter		1	$1,500	$1,500
Mechanical Installation		1	$10,000	$10,000
Electrical Installation		1	$5,000	$5,000
Design/Project Management		1	$15,000	$15,000
Contingencies	15%			$26,000
PST (7% on 70% of Cost)	70%			$10,000
Total (ex. GST)				**$206,500**

Operation Cost Comparison			
Fuel	Qty	Unit Cost	Extension
Propane (litres)	50000	$0.75	$37,500
Wood Chips (bdt)	75	$100.00	$7,500
O&M			$2,000
Propane	5.00%		$1,875
Total Cost			$11,375
Annual Savings			**$26,125**
Simple Pay Back Period			**7.5**

CO_2 Mitigation: 80 tonnes

Recommendation

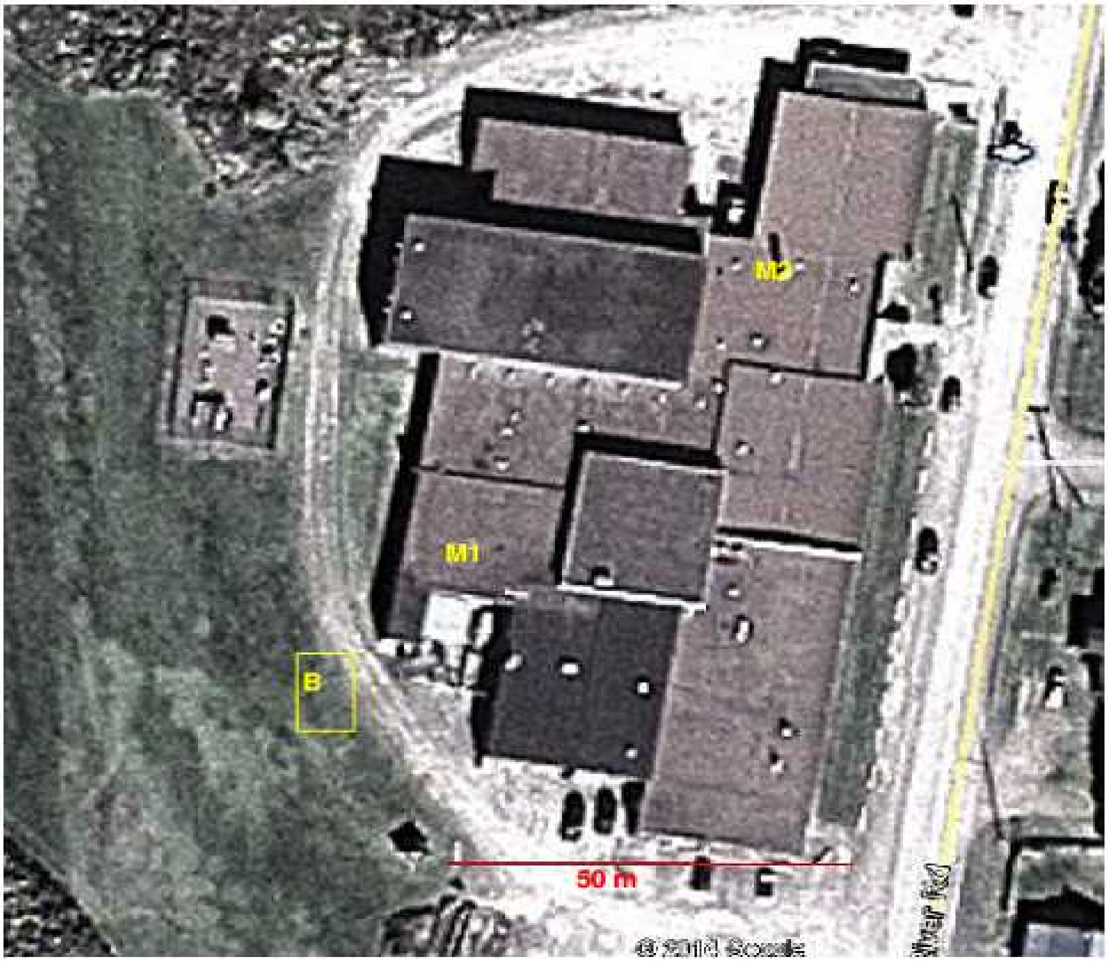
There are no technical issues for the implementation of a biomass heating system but the small size and correspondingly small fuel consumption make this project less attractive economically. Capital cost are estimated at half of the secondary school's but the fuel cost displaced is only one third.

Nevertheless, the project should be seriously considered especially if it were completed in conjunction with the high school since some economies could be expected and even without them, the pay back period for both projects combined is only 6 years.

GWES College

Located in Old Hazelton, it is an old building with a large number of add-ons and modifications. It is estimated that the heating oil consumption is approximately 90,000 litres (~ 3000 GJ) per year which indicates the need for a 300 kw biomass boiler identical to the high school's.

There are two separate mechanical rooms (M1 & M2) at opposite ends of the building that split the heating load. It is assumed that the load is approximately 50/50 although this cannot be confirmed.



There are several potential locations for the containerized biomass boiler and the fuel storage.

The mechanical installer will be challenged to find the easiest path to connect the biomass boiler to the two mechanical rooms, several walls and floors will have to be breached and the pipe length between M1 and M2 will require two lengths of over 100 m of 2” steel pipe.

GWES College				
Component	*Description/Size*	*Qty*	*Unit Cost*	*Extension*
Containerized Boiler, equipped	300 kw/ 40' hi-cube	1	$180,000	$180,000
Extraction System	4 m dia. Rotary sweep	1	$12,000	$12,000
Fuel Storage	14' Steel Grain Bin, wood bottom	1	$8,000	$8,000
Loading Equipment	Vertical chip loader	1	$16,000	$16,000
Site Prep	Gravel pad	1	$5,000	$5,000
Underground PEX (installed)	2" I.D. Dual Pex	20	$400	$8,000
Pumps		4	$1,000	$4,000
Heat Exchanger		1	$3,000	$3,000
Water Coil				
Energy Meter		1	$2,000	$2,000
Mechanical Installation		1	$50,000	$50,000
Electrical Installation		1	$15,000	$15,000
Design/Project Management		1	$35,000	$35,000
Contingencies	15%			$51,000
PST (7% on 70% of Cost)	70%			$19,000
Total (ex. GST)				**$408,000**

Operation Cost Comparison			
Fuel	Qty	Unit Cost	Extension
Heating Oil (litres)	90000	$1.15	$103,500
Wood Chips (bdt)	200	$100.00	$20,000
O&M			$5,000
Heating Oil	5.00%		$5,175
Total Cost			$30,175
Annual Savings			**$73,325**
Simple Pay Back Period			**5.6**

CO_2 Mitigation: 240 tonnes

Recommendation

The economics for the GWES College are very similar to the Secondary School's, i.e., a very short pay back period of about 5 years. The only technical challenge is the age and the generally poor condition of the existing piping infrastructure which, of course, is not improved by the introduction of a biomass boiler and may require a separate investment.

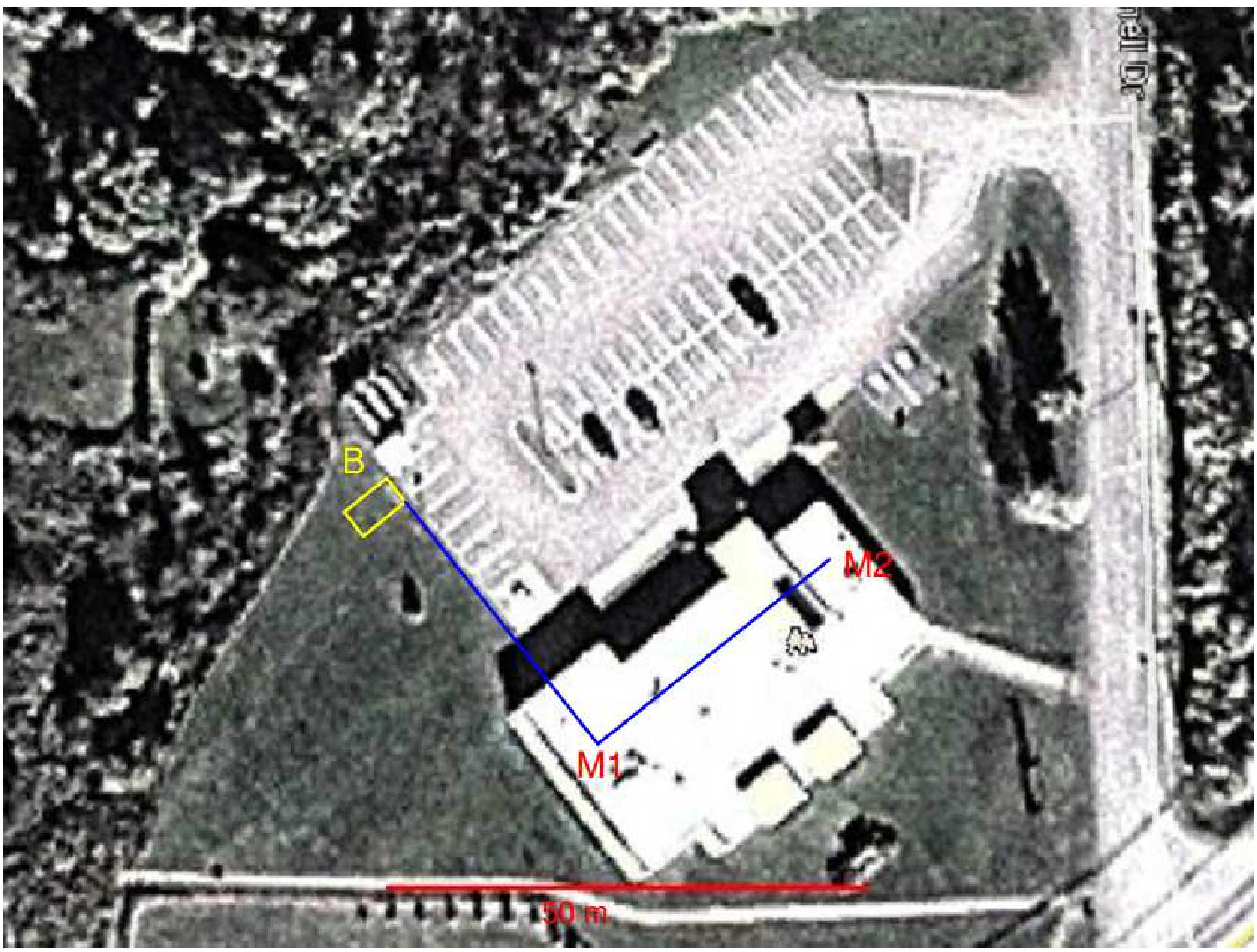
North West Community College

The college is located in a small modern building with an estimated propane consumption of about 30,000 litres per year which requires a supplemental biomass boiler of about 80 kw (270,000 Btu/h).

There are two mechanical rooms at opposite ends of the building, each with four residential “Keeprite DC90” high efficiency forced air furnaces. Each furnace is rate at 75,000 Btu/h (22 kw) or a total of 176 kw.

The building has a fully insulated crawl space with a concrete floor from where every part of the building is accessible. The location of the two mechanical rooms and the complex ducting for 4 individual propane furnaces in each, will increase the mechanical connection cost but this clean and accessible crawl space allows for the use of pex or steel pipes to connect the existing system to the small containerized biomass boiler near the parking lot. It is not necessary to insulated these connection pipes since the moderate heat loss is not actually lost but serves to warm the insulated crawl space and therefore the floor.

The length of the insulated under ground pex pipe is 20 meters while the total length required of the uninsulated pipe in the crawlspace is 50 meters.



North West Community College				
Component	*Description/Size*	*Qty*	*Unit Cost*	*Extension*
Containerized Boiler, equipped	80 kw/ 20' hi-cube	1	$75,000	$75,000
Extraction System	4 m dia. Rotary sweep	1	$12,000	$12,000
Fuel Storage	14' Steel Grain Bin, wood bottom	1	$8,000	$8,000
Loading Equipment	Vertical chip loader	1	$16,000	$16,000
Site Prep	Gravel pad	1	$3,000	$3,000
Underground PEX (installed)	1.5" I.D. Dual Pex	20	$300	$6,000
Pumps		5	$500	$2,500
Heat Exchanger				
Water Coil		4	$750	$3,000
Energy Meter		1	$1,500	$1,500
Mechanical Installation		1	$20,000	$20,000
Electrical Installation		1	$10,000	$10,000
Design/Project Management		1	$15,000	$15,000
Contingencies	15%			$26,000
PST (7% on 70% of Cost)	70%			$10,000
Total (ex. GST)				**$208,000**

Operation Cost Comparison			
Fuel	Qty	Unit Cost	Extension
Propane (litres)	30000	$0.75	$22,500
Wood Chips (bdt)	45	$100.00	$4,500
O&M			$2,000
Propane	5.00%		$1,125
Total Cost			$7,625
Annual Savings			**$14,875**
Simple Pay Back Period			**14.0**

CO2 Mitigation: 50 tonnes

Recommendation

This project is clearly handicapped by its small size and the lack of a hydronic heating system. It is conceivable that total capital cost could be reduced to $150,000 but even then, the pay back period will be ten years. The availability of a 50% subsidy or capital grant would make the project immediately feasible.

Upper Skeena Arena (planned)

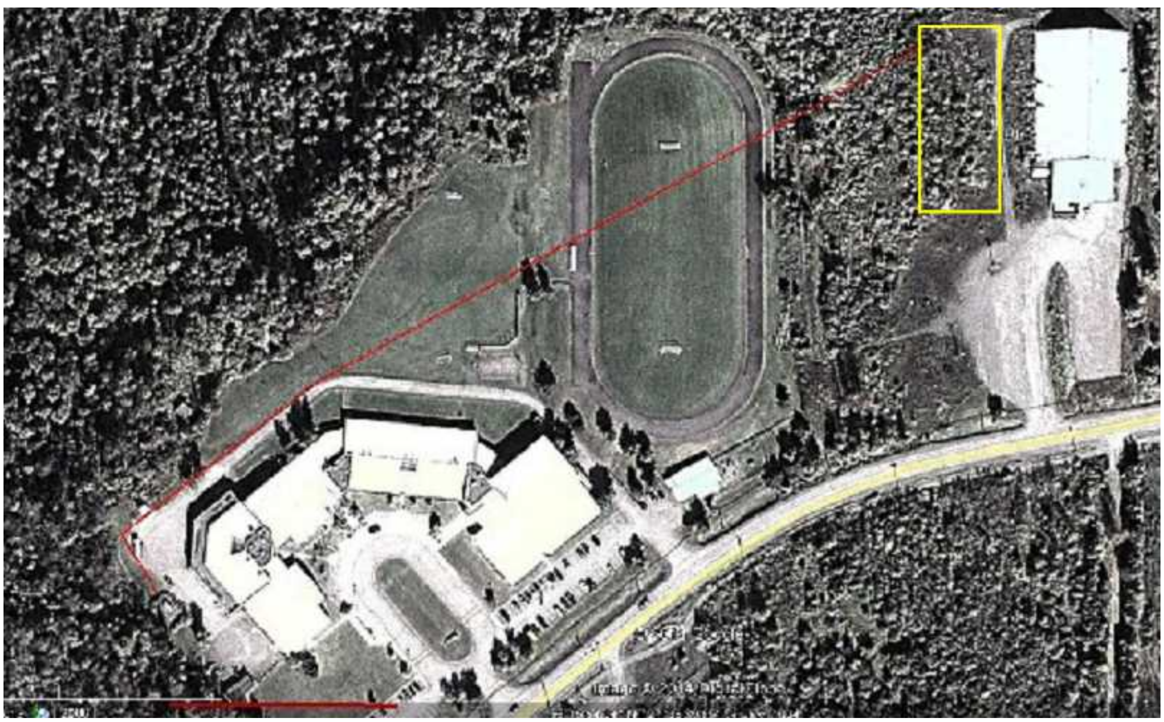
The Upper Skeena arena is a project still in the planning stages. Although the design is largely finished, the financing is still not in place. The most likely opening date is sometime in 2016.

A modern ice rink has low heating requirements since waste heat from the refrigeration compressors can be partially recovered and used in low temperature heating systems.

The current plans show three propane fuelled forced air furnaces of 17.9 kw, 33.8 kw and 81 kw output plus a propane fired hot water heater of 80 kw for supplemental space heat and DHW.

A preliminary estimate indicates that a 100 kw biomass boiler system plus substantial buffer tank capacity between 4000 l and 6000 l would suffice. DHW can easily be stored during the low demand night and requires hardly any biomass base load capacity.

Theoretically, it is possible to connect the new arena to the Secondary School's biomass boiler (if installed) but the required underground pipe of over 400 m is impractical and cost-prohibitive for such a small load. Required pumping capacity of close to 2 kw and a line heat loss of 25% make this option even less attractive.



Upper Skeena Arena (planned)					
Component	*Description/Size*		*Qty*	*Unit Cost*	*Extension*
Containerized Boiler, equipped	100 kw/ 20' hi-cube		1	$90,000	$90,000
Extraction System	4 m dia. Rotary sweep		1	$12,000	$12,000
Fuel Storage	14' Steel Grain Bin, wood bottom		1	$8,000	$8,000
Loading Equipment	Vertical chip loader		1	$16,000	$16,000
Site Prep	Gravel pad		1	$3,000	$3,000
Underground PEX (installed)	1.5" I.D. Dual Pex		0	$300	$000
Pumps			4	$500	$2,000
Heat Exchanger			1	$400	$400
Water Coil			3	$700	$2,100
Energy Meter			1	$1,500	$1,500
Mechanical Installation			1	$10,000	$10,000
Electrical Installation			1	$3,000	$3,000
Design/Project Management			1	$15,000	$15,000
Contingencies		15%			$24,000
PST (7% on 70% of Cost)		70%			$9,000
Total (ex. GST)					**$196,000**

Operation Cost Comparison			
Fuel	Qty	Unit Cost	Extension
Propane (litres)	50000	$0.75	$37,500
Wood Chips (bdt)	75	$100.00	$7,500
O&M			$2,000
Propane	5.00%		$1,875
Total Cost			$11,375
Annual Savings			**$26,125**
Simple Pay Back Period			**7.5**

CO_2 Mitigation: 80 tonnes

Recommendation

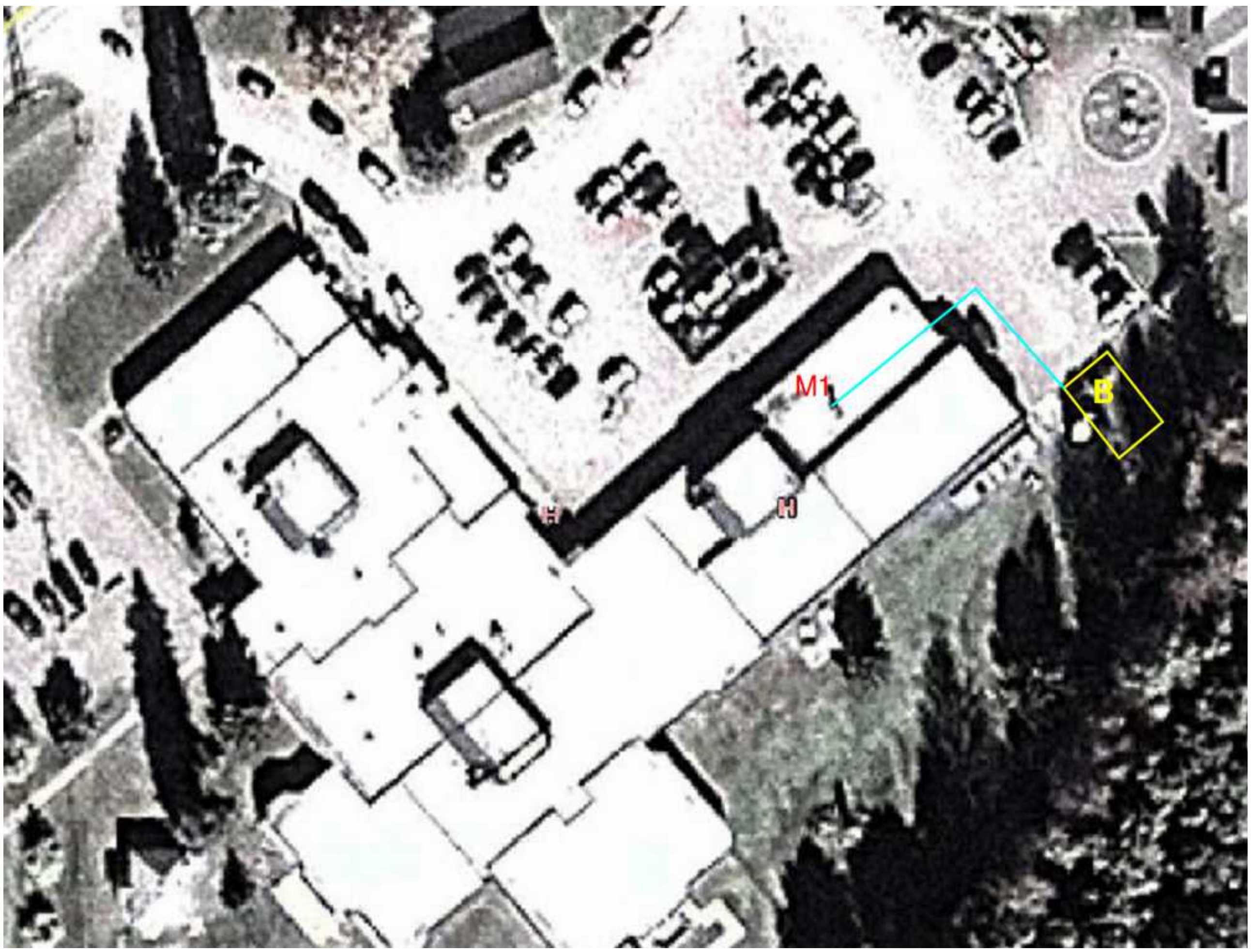
This project is perfectly feasible from a technical point of view although small when considered in isolation. The project should be revisited when realization is closer.

Wrinch Memorial Hospital

Hospitals are usually the largest institutional buildings in any community and the Wrinch Memorial Hospital is no exception as regards to energy use. The hospital has a special arrangement (E-Plus) with BC Hydro which offers very low rates (~3 cents per kwh) for heating purposes. This program has been discontinued but existing customers are grand-fathered.

The hospital uses 1,400 Mwh of electricity for heating purposes each year. Since electricity has a conversion efficiency of 100%, this corresponds to over 6 GJ or 250,000 litres of propane.

A supplementary biomass boiler is sized at 400 kw output and location and ease of connection are convenient.



Wrinch Memorial Hospital					
Component	*Description/Size*		*Qty*	*Unit Cost*	*Extension*
Containerized Boiler, equipped	400 kw/ 40' hi-cube		1	$220,000	$220,000
Extraction System	4 m dia. Rotary sweep		1	$12,000	$12,000
Fuel Storage	14' Steel Grain Bin, wood bottom		1	$8,000	$8,000
Loading Equipment	Vertical chip loader		1	$16,000	$16,000
Site Prep	Gravel pad		1	$5,000	$5,000
Underground PEX (installed)	2” I.D. Dual Pex		20	$400	$8,000
Pumps			4	$1,000	$4,000
Heat Exchanger			1	$3,000	$3,000
Water Coil					
Energy Meter			1	$2,000	$2,000
Mechanical Installation			1	$30,000	$30,000
Electrical Installation			1	$10,000	$10,000
Design/Project Management			1	$35,000	$35,000
Contingencies		15%			$53,000
PST (7% on 70% of Cost)		70%			$20,000
Total (ex. GST) – Subsidy					**$426,000**

Operation Cost Comparison			
Fuel	Qty	Unit Cost	Extension
Kilowatt hours	1400000	$0.03	$42,000
Wood Chips (bdt)	375	$100.00	$37,500
O&M			$5,000
Electricity	5.00%		$2,100
Total Cost			$44,600
Annual Savings			**-$2,600**
Simple Pay Back Period			**-163.8**

Operation Cost Comparison (8 cents/kwh)			
Fuel	Qty	Unit Cost	Extension
Kilowatt hours	1400000	$0.08	$112,000
Wood Chips (bdt)	375	$100.00	$37,500
O&M			$5,000
Electricity	5.00%		$5,600
Total Cost			$48,100
Annual Savings			**$63,900**
Simple Pay Back Period			**6.7**

Operation Cost Comparison (propane)			
Fuel	Qty	Unit Cost	Extension
Propane	250000	$0.75	$187,500
Wood Chips (bdt)	375	$100.00	$37,500
O&M			$5,000
Electricity	5.00%		$9,375
Total Cost			$51,875
Annual Savings			**$135,625**
Simple Pay Back Period			**3.1**

CO_2 Mitigation: only applicable when propane is replaced, over 400 tonnes

Recommendation

Technically and size-wise, the hospital is ideal for conversion. The large consumption of hot water levels the demand curve and increases the overall efficiency of the biomass system, unfortunately, the extremely low and heavily subsidized electricity cost makes the project economically not feasible.

No alternative heating system can meet the expectation to heat a building the size of the hospital for about $40,000 per year. Of course, the situation would change immediately if the hospital were forced to pay market rates for the electricity or switch to propane.

District Heating System (DHS) as an Option

The hospital with an estimated demand of 400 kw and the high school with a demand of 300 kw are the two largest energy consumers in Hazelton. Assuming that the hospital could be converted to biomass, it is conceivable that these two buildings could be connected to a single boiler system of about 700 kw.

When calculating the cost for the DHS, it becomes quickly obvious that it is not a practical solution:

Assuming the location of the boiler is at the hospital, i.e., the best case scenario since the largest demand centre is close by, it will require about 1200 m of 3" I.D. underground pipe at an installed cost of $500 to $600 per meter of distance (600 m) between the two buildings.

In addition, the incremental cost of the larger boiler is estimated at $80,000 while additional pumping cost and a heat loss of 10% through the underground pipe make a DHS even less attractive.

Biomass Fuel Supply

There is no lack of biomass raw material in the Hazelton area. Two small sawmills in the region - West's Sawmill and Lucky 6 Sawmills – can provide enough slabs and standing dead wood unsuitable for lumber production, to fuel several, if not all, of the envisaged projects.

Currently, there is no wood chipping infrastructure of any kind available, neither suitable chippers nor any storage facilities.

A suitable chipper costs between $30,000 and $80,000 and capital cost for permanent storage is between $20 and $30 per square foot. A facility to store 500 tonnes of wood chips would cost between $120,000 and $240,000.

These investments are only justified when the demand for wood chips is both substantial and long-term.

Wood pellets are available although the expected delivered price will be around $200/ tonne and there is currently no delivery infrastructure in place.

It is not recommended that the individual boiler owners are involved with wood fuel production and logistics since this aspect is substantially more complex than the operation of the boiler itself.

It will be necessary to announce the implementation of any of the biomass boiler projects well in advance so that potential wood fuel supplier have enough time to make plans for wood chip production, storage and delivery. Subsidies may be required.

The price of $100/bdt is well above current rates for pulp chips and shavings for pellet production and it is hoped that this will attract local production and supply but it must be admitted that as of today, wood chip supply cannot be guaranteed.

Appendix

Vertical Wood Chip Silo Auger and Grain Bin

Handling of wood chips is substantially more complex and involved than handling of pellets. Pellets flow easily and can be transported and conveyed just like grain while wood chips do not flow and have a tendency to 'bridge' when stored.

A specially designed vertical auger system with an unloading trough allows the use of round flat bottom metal silos for wood chip storage adjacent to the boiler. This is the most compact wood chip storage system available and it can handle unloading from dump trucks, dump trailers or moving floor trailers without any special equipment.