District Energy Feasibility Study for the City of Port Alberni

Prepared for the City of Port Alberni
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Cover photo shows the City of Port Alberni with the Somas River in the foreground, with a view to the East. Used here under the Creative Commons agreement.

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1. Executive Summary

Background

The City of Port Alberni is interested in developing sustainable community projects that will reduce greenhouse gas emissions, support regional sustainability objectives, support local employment, and provide non-tax revenues.

In 2010, the City of Port Alberni's Economic Development Manager commissioned a study of Integrated Resource Recovery options. The study determined that conditions in Port Alberni appeared to be favourable for a district energy system. After considering an industrial partnership to provide energy for the system, the City has focused on developing an Integrated Municipal Energy System it would own and operate.

Innovation

The Integrated Municipal Energy System would incorporate three technical innovations: a three-line district heating distribution system, a direct contact condensing economizer, and an adsorption chiller that will make use of heat from the system to replace the Hospital's existing chiller.

The City could also use an innovative arrangement to help finance the utility: offering shares in the utility to district energy subscribers and the community.

This project represents a reasonable balance among the three issues of risk, benefits, and practicality. To the knowledge of the author and the City of Port Alberni, the technical innovations proposed in this Study have not been integrated into a single system elsewhere. The components however, have been proven individually, which reduces overall risk.

Conclusions

Port Alberni appears to have the necessary conditions for a successful district energy system, including adequate energy demand in public buildings (West Coast General Hospital, North Island College, Alberni District Secondary School, long-term care facilities, Alberni Valley Multiplex, Echo Aquatic & Fitness Centre), a relatively small distribution system, a site for the Energy Centre, and a reliable source of biomass. The City also has the technical, administrative, construction experience, and utility experience capacity to implement this project.

Recommendations

The City should proceed to the conceptual design phase, initiate stakeholder consultations, and accelerate the discussions with district energy clients as the first step toward forming energy supply agreements.

2. Glossary

ACRD	Alberni-Clayoquot Regional District
BAU	Business as Usual
BDT	Bone Dry Tonne of biomass
CO2e	Carbon dioxide equivalent
DES	District Energy System
DHW	Domestic Hot Water
GHG	Greenhouse Gas
GJ	Gigajoule of energy
GWh	Gigawatt hours of electricity
GWP	Global Warming Potential
HHV	Higher Heating Value of biomass
IPCC	Intergovernmental Panel on Climate Change
IRR	Integrated Resource Recovery
LEED	Leadership in Energy and Environmental Design
LHV	Lower Heating Value of biomass
MURBS	Multi-Unit Residential Buildings
MWe	Megawatts of electrical energy
MWth	Megawatts of thermal energy
VIHA	Vancouver Island Health Authority

3. Background

In 2010, the City of Port Alberni's Economic Development Manager commissioned a study of resource recovery options. The study was completed by Farallon Consultants Limited, with 50% funding provided by the BC Ministry of Community, Sport, and Cultural Development.[1]

The study determined that conditions in Port Alberni are favourable for a District Energy System, since several large users of heat such as the West Coast General Hospital, North Island College, Alberni District Secondary School, long-term care facilities, multi-family residential buildings, the Alberni Valley Multiplex recreation facility, and the Echo Aquatic & Fitness Centre are located within modest distances of each other. Further, interest in district energy has been expressed in writing by the Vancouver Island Health Authority, the Alberni-Clayoquot Regional District, and School District 70.

Other conditions that favour a District Energy System in Port Alberni include the Provincial greenhouse gas legislation and associated carbon tax; the availability of urban wood waste and sawmill residues; the availability of land owned by the City for the system; the availability of grants to reduce the capital cost of the system; and the availability of low-cost financing for municipal green energy projects from the Federation of Canadian Municipalities.

In 2011, Farallon worked on the City's behalf to determine the best source of heat for a district energy system. Two main alternatives emerged at that time: form a partnership with the Catalyst Paper operation, or build a facility that would produce heat from waste urban wood and forest residues.

Also in 2011, an application for funding under the EcoEnergy Innovation Initiative was prepared for a system that would be jointly owned with Catalyst Paper. The ranking of the City's application was not high enough to be successful, but did place the application on a stand-by list. In January, 2012 however, Catalyst Paper announced restructuring that resulted in uncertainty concerning the company's ability to become a commercial and operating partner. As a result of this uncertainty, the City has explored the option of developing a biomass boiler as the source of heating for a district energy system.

This report includes an assessment of the feasibility of developing a district energy system in Port Alberni that can incorporate a number of technological innovations that will improve its effectiveness and efficiency, and that will have wide application in other communities. The report also includes estimates of capital costs, operating costs, and revenues for an integrated biomass energy system.

[1] Farallon Consultants Limited. 2010. *Integrated Resource Recovery Options for the City of Port Alberni.* 55pp.

4. Methodology

This feasibility study builds on the work completed in the *Integrated Resource Recovery Options for the City of Port Alberni* (June, 2010). The current study was completed in the following steps:

1. Buildings with the potential to connect to a district energy system were identified as those having a hydronic, natural gas heating system, and those without a hydronic system but that consume significant quantities of domestic hot water heated by electricity.
2. Building owners as well as technical, and management personnel were interviewed concerning their interest in district energy and their current energy expenditures. The energy plants of the largest buildings were also toured to understand system temperatures and configurations.
3. The energy consumption of new buildings (the new high school and Athletic Hall) was estimated based on typical seasonal patterns, NRCAN averages, and floor areas.
4. Based on this information, the current cost of generating heat in these buildings was modelled.
5. Options for providing heat to the district energy system were developed, including a biomass boiler.
6. An evaluate was made of the quantities and quality of biomass available in the region. The Alberni-Clayoquot Regional District was contacted concerning their interests in diverting wood waste to an energy system, and in reducing air pollution from uncontrolled burning of wood waste.
7. Recognizing the need to generate heat efficiently from moist biomass, and to match the energy requirements of existing building energy systems, a conceptual design for a district energy system that could operate efficiently with lower-quality biomass, and that could provide cooling as well as heating was developed. The design incorporates a three-line district energy distribution system, a condensing stack gas economizer, and an adsorption chiller.
8. Vendors of key components of the system were contacted for performance and cost information, which has been included in the engineering and economic models for this study.
9. Various routings for the district energy system were tested, and the capital costs, annual costs, and energy revenues for the system were estimated.
10. Mass and energy balance modelling was completed to evaluate the proposed configuration and to confirm the required equipment capacities.
11. The NRCAN RETScreen International model was used to estimate peak capacities required for the biomass boiler as well as for the natural gas peaking and back-up boilers.
12. Other potential collaborators, including the Vancouver Island Health Authority, North Island College, BC Hydro, and the University of Northern British Columbia were contacted concerning their interest in exchanging expertise and information with the City of Port Alberni, as the district energy system is developed.

5. Potential Clients for District Energy

Of the twenty buildings identified as potential candidates for district energy, eleven larger buildings were chosen for modelling in a first phase of development of the system. These buildings consume an estimated 48,000 GJ/year on an energy basis, which is approximately 60,000 GJ/year on a natural gas basis, and represent approximately 80% of the load of the original twenty buildings. Buildings that could be connected to the district energy system in the first phase could be served by a relatively small 3 km district energy network.

Table 1 Potential Phase I District Energy Clients

Ownership	Building
Public, VIHA	West Coast General Hospital
Public, City	Echo Aquatic Centre & Library
Public, SD70	New High School
Private	Athletic Hall
Public, City	Multiplex
Public	North Island College
Public	Pioneer Towers
Public	Heritage Place
Public	Echo Village
Public	Fir Park Village
Public, City	Public Works Yard

Note that the Echo Aquatic Centre and Library share a single facility, and would form one connection to the district energy system.

Buildings that could be considered for connection to the district energy system in a second phase of development include:

Table 2 Potential Phase II District Energy Clients

Ownership	Building
Public, City	Echo Park Field House
Public, SD70	Wood Elementary School
Public, City	Glenwood Building
Public, SD70	SD70 Bus Depot
Private	Best Western Hotel
Private	Alberni Towers
Public, City	RCMP Building
Private	Cygnet Apartments
Private	Oak Ridge Apartments
Private	Cathedral Place Apartments
Private	BC Hydro Building, Wallace Street

Buildings that could be considered for connection to the district energy system in a third phase of development include:

Table 3 Potential Phase III District Energy Clients

Ownership	Building
Public	Port Alberni Fire Hall
Private	Abbeyfield Supported Living
Private	John Paul II Catholic School

The figure below shows the estimated energy demand of Phase 1 buildings by month. Details of the energy consumption are shown in Appendix 2 - Estimated Building Energy Demand by Month.

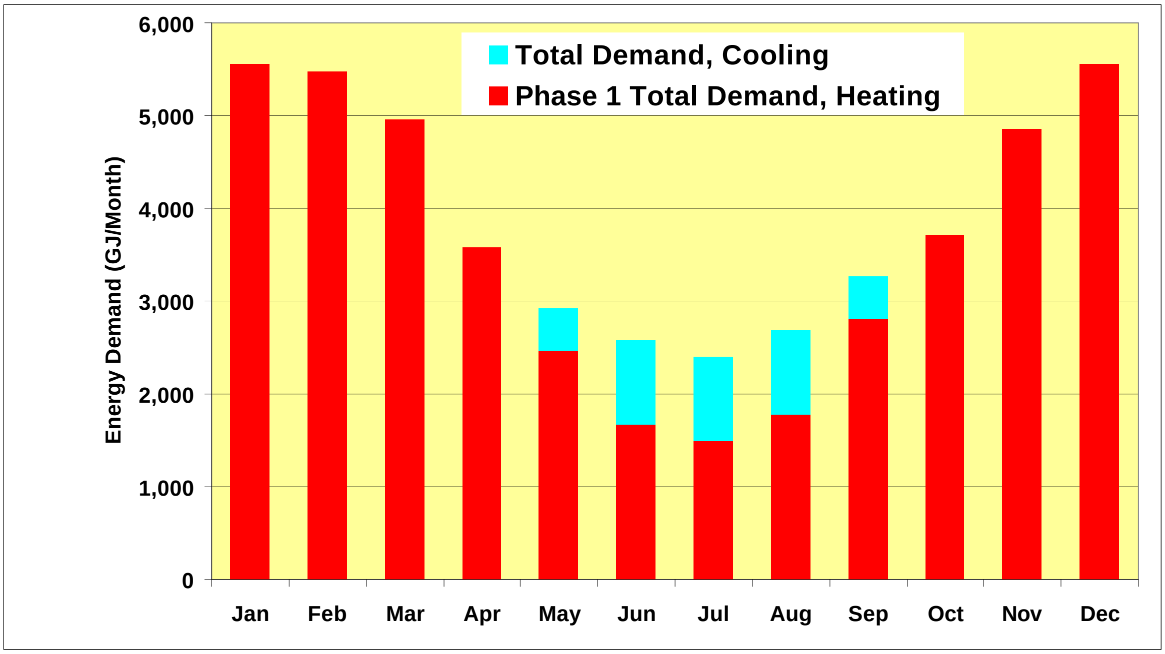

Figure 1 DES Energy Demand by Month, Phase I

The graph shows that demand for energy during the summer months remains relatively high, a pattern that reflects the type of buildings in Phase 1. These buildings include the Hospital, long-term care facilities, and recreation centres that use more hot water than average throughout the year. The blue bars in the graph also show the demand for district energy that could be used to operate an adsorption chiller to provide cooling in the Hospital during the summer. The effect of adding this cooling load to help level the demand for energy during the seasons.

6. Description of the District Energy System

6.1 Potential Energy Sources

The initial Integrated Resource Recovery report completed for the City of Port Alberni identified three potential sources of energy for a district heating system:[2]

- Cogeneration of heat and electricity from wood residues;
- Heat pumps to recover low-temperature (~40°C) industrial waste heat; and
- Steam from the Catalyst Paper industrial wood residue boiler.

Representatives of the City of Port Alberni, Catalyst Paper, and Farallon Consultants Limited met at several points during 2011 to discuss the idea of a district energy system based on steam from the Catalyst Paper mill. From the point of view of Catalyst Paper, the timing for a project that would generate more electricity appeared to be favourable, since BC Hydro has expressed interest in purchasing additional electricity from the company. In addition, the economizer in the Catalyst Paper power boiler was scheduled to be replaced, which would result in a small increase in the efficiency of the boiler, and therefore will slightly reduce the amount of wood residues consumed per unit of steam generated.

Discussions were also held concerning the option of developing a combined gasification system to displace natural gas in the Catalyst Paper operation, and to also provide heat to the district energy system. In January, 2012 however, Catalyst Paper announced restructuring, and as result the City decided to develop its own source of heat for the district energy system.

The proposed district energy system would include three main parts:

1) An Energy Centre to provide heat to the District Energy System (DES) piping network;
2) DES piping to distribute heat from the Energy Centre to client buildings; and
3) Energy Transfer Stations to bring heat from the DES piping into individual client buildings.

6.2 Energy Centre

The Energy Centre will include a biomass burner with capacity to meet approximately 85% of the total *energy demand* of the district energy system, and approximately 50% of the peak *power demand*. Based on the experience of comparable systems elsewhere, this sizing of the biomass system is expected to result in the lowest overall cost. Incremental biomass boiler capacity could be added to meet additional demand in the future.

[2] Farallon Consultants Limited. 2010. *Integrated Resource Recovery Options for the City of Port Alberni.* 55pp.

The Energy Centre will also include infrastructure for receiving and storing five days of fuel, and for automatically conveying fuel from storage to the biomass boiler, natural gas boilers to meet peak demand and for back-up, and with pumps and controls for the district energy system piping network. The boiler capacities are shown in Table 4 below.

Table 4 Energy Centre Boiler Capacities

Boiler Type	Capacity
Base-loaded Biomass Boiler	1.8 MW
Peaking/Back-up Boiler #1 (Natural Gas)	2.0 MW
Peaking/Back-up Boiler #2 (Natural Gas)	2.0 MW
Total Installed Capacity	5.8 MW

The Energy Centre would also include equipment such as natural gas back-up boilers, pumps, water treatment equipment, and controls. The equipment in the Energy Centre can operate with automatic controls, but require part-time monitoring and maintenance.

Pollution control equipment in the form of a cyclone and an electrostatic precipitator will limit particulate emissions from the biomass boiler to less than 20 mg/m^3 of stack gases.

The best location for the Energy Centre appears to be the Public Works Yard, since it is located in an industrial/commercial area, truck access along 6th Avenue to Wallace Street is simple, the land is owned by the City, and City employees will be available to monitor and maintain the Energy Centre equipment. The backgrounds, training, and current duties of employees in the Public Works Department are compatible with the skills required to operate this equipment. Training for Public Works employees in the operation of biomass and natural gas boilers can be provided by the equipment manufacturers. In the figure below, the boundary of the Public Works yard is outlined in yellow, and a potential location of the Energy Centre is shown in blue.

Trees to the east and north of the Energy Centre would provide a natural barrier for sight, noise, and dust between the Energy Centre and commercial buildings to the east. The activities of the Energy Centre would be compatible with the current use of the Public Works yard.

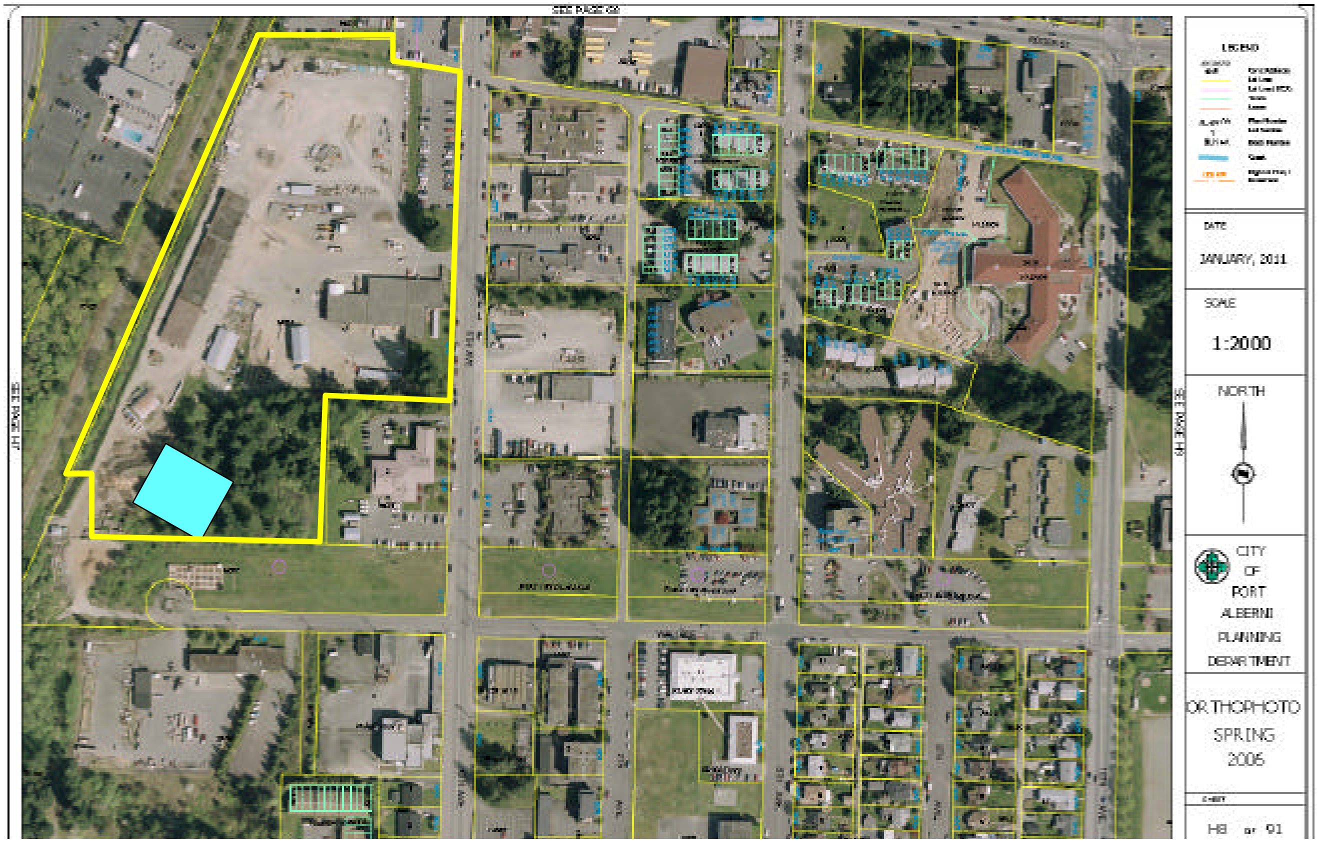

Figure 2 Potential Location for the Energy Centre

6.3 District Energy System Piping

It is helpful that the City of Port Alberni controls the rights of way for much of the proposed district energy system distribution routing. Approximately 70% of the trenching for the district energy system

could be routed through parks, fields, and grass-covered rights-of way along Wallace Street, Roger Street, and the east side of 10th Avenue between Wallace Street and Roger Street. As a result, the excavation costs for the district energy system piping installation in Port Alberni are expected to be lower than average.

Figure 3 District Energy Piping[3]

The City of Port Alberni's Planning Department was engaged in choosing the proposed route for distribution piping in Phase 1, which is shown in Figure 4. The figure shows two areas (outlined in blue) where the City is encouraging higher density and development: one near Redford Street to the south, and the North Island College Future Expansion Site. The presence of a district energy

[3] Courtesy of the Revelstoke Community Energy Corporation

system will be attractive to developers who understand its benefits, including price certainty, and the ability to re-allocate boiler utility space in new buildings for revenue-producing purposes. District energy based on a low-carbon source such as biomass will also help developers to achieve credits under the LEED®[4] criteria.

In addition, an affordable housing development in the vicinity of the West Coast General Hospital is in the early planning stages. If this development proceeds, it could be provided with low-carbon energy at a lower cost than conventional alternatives. When new buildings are designed to work with district energy, the space that would otherwise have been allocated for boilers and related equipment can be reprogrammed for other uses, and the owner also saves the cost of new boilers.

Figure 4 Proposed DES Routing, Phase I

The City could also consider finishing the surface of the district energy system piping route as a bicycle route and walking trail. If the trail were extended to connect the Hospital and North Island College, then a loop would be formed. This *Local Energy Path*[5] could begin at the Energy Centre, and incorporate small information displays to describe the district energy system as well as the buildings that are connected to it along the way. Since the disturbed earth would need to be finished in some manner (e.g. by reseeding), the cost of developing this trail would be relatively low.

The City could also consider opportunities for sharing space in the district energy system piping trench with other municipal utility piping, and also offering space in the trench to communications companies.

[4] Leadership in Energy & Environmental Design

[5] Inspired by the title of the Amory Lovins book, "Soft Energy Paths".

An alternative route would extend in an arc from the Energy Centre, east on Wallace Street, north on 10th Avenue, east on Roger Street, then south via the BC Hydro right of way to the Hospital. Although this route would be slightly shorter that the route proposed above, the route would also make connecting additional buildings south of Wallace Street more difficult in the future.

Figure 5 below shows the Wallace Street right of way: the photo was taken at the Eastern side of the City near the West Coast General Hospital, looking West in the direction of the Public Works yard.

Figure 5 Wallace Street Right of Way

6.4 Building Energy Transfer Stations

Buildings identified as potential candidates to connect with the district energy system already incorporate hydronic heating systems, in which a natural gas boiler delivers hot water to radiators within the building. In these buildings, the connection to a district energy system would be completed through an Energy Transfer Station (ETS) that replaces the building's natural gas boiler as a source of energy. The Energy Transfer Stations are very compact, and building owners can consider removing their existing natural gas boilers after connecting to a district energy system.

Energy Transfer Stations include a heat exchanger such as the one pictured in Figure 6, along with energy metering equipment and controls. The cost of the station would be carried by the district energy utility, and is included in the capital cost estimates in this study.

Figure 6 District Energy Heat Exchanger

6.5 Sources of Biomass

Biomass for the district energy system would come from two sources: waste wood that is currently received by the Alberni-Clayoquot Regional District's landfill, and purchased sawmill residues.

Urban wood waste from construction, demolition, and land clearing would need to be processed by an independent contractor before being delivered to the Energy Centre. As a result, the economic analysis in this study assumes the City's utility would pay $50 per tonne to a local contractor to chip this wood, and to remove contaminants such as plastic and metal.

The price of purchased hog fuel is conservatively assumed to be $50 per green tonne at 50% moisture, to allow biomass to be processed from forest residuals in the vicinity of Port Alberni. This price has been confirmed in work completed by Wood Tech 21 and by a new company, Coastal Char Industries Inc.. CCI is interested in building a pilot plant in Port Alberni that could process biosolids from wastewater treatment facilities into bio-oil and bio-char. Bio-char from this plant could form another source of fuel for the Energy Centre. Because bio-char repels water, it would increase the average energy content of the feed stock to the biomass boiler.

During the study it became clear that significant quantities of wood residues are available in the region, but that the moisture content of this material would reduce the efficiency of a biomass boiler. As a result, the technical innovations described in the following section were developed.

6.6 Innovative Technical Aspects of the System

6.6.1 Three-line Distribution System

In a conventional district energy distribution system, one pipe delivers hot water to Energy Transfer Stations in client buildings, and a second pipe returns relatively cooler water to the Energy Centre. This arrangement is shown in Figure 7 below. In the figure, DHW stands for domestic hot water.

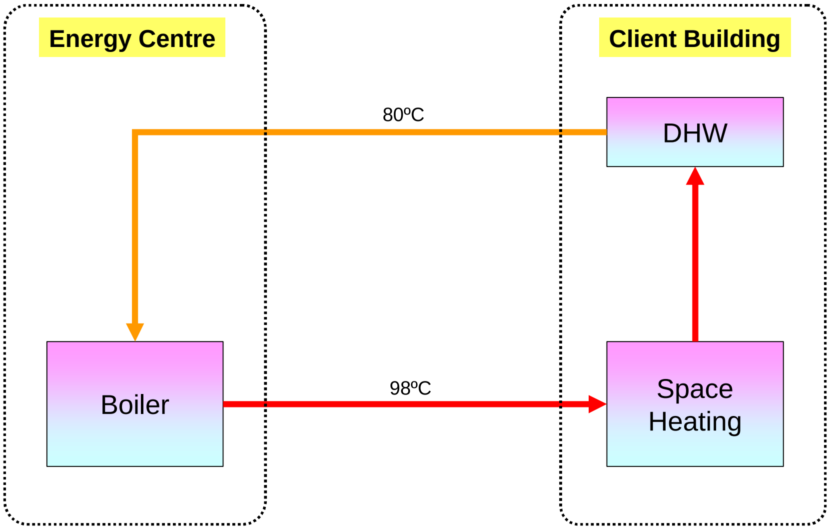

Figure 7 Conventional Two-Line DES

Designers of district energy systems must overcome the challenge of supplying energy to existing hydronic heating system in buildings that were designed to be supplied by relatively high-temperature boilers burning natural gas. Ideally, the return temperature of water in a district energy system would be low, in order to maximize the energy-carrying capacity of the system. In practice, the return temperature is limited by the relatively high design temperature of natural gas-fired hydronic heating systems. Since energy is delivered through a district energy system as sensible heat, supply temperatures in the system must be high. Higher supply temperatures tend to increase heat losses, and higher return temperatures also tend to reduce the efficiency of heat transfer from the district energy system's boilers to water in the district energy system.

One way to reduce return temperatures in a district heating system is to deliver heat to building loads in a cascade or series arrangement. Heat would first be provided to the building's highest-temperature requirement (typically space heating) then to its lower-temperature requirements (typically domestic hot water). While the return temperature can be lowered in this way, the quantity of heat required for domestic hot water is typically lower than the quantity required for space heating, so that the net effect on return temperatures is small.

An innovative solution to this problem is to separate the return flows by:

1. Supplying all heat from the Energy Centre to buildings through a high-temperature supply pipe;
2. Returning DES water from space heating to the Energy Centre through a medium-temperature return pipe; and
3. Returning DES water from domestic hot water heating to the Energy Centre through a low-temperature return pipe.

Within client buildings, heat would first be transferred from the supply pipe to space heating and domestic hot water as shown in Figure 8 below.

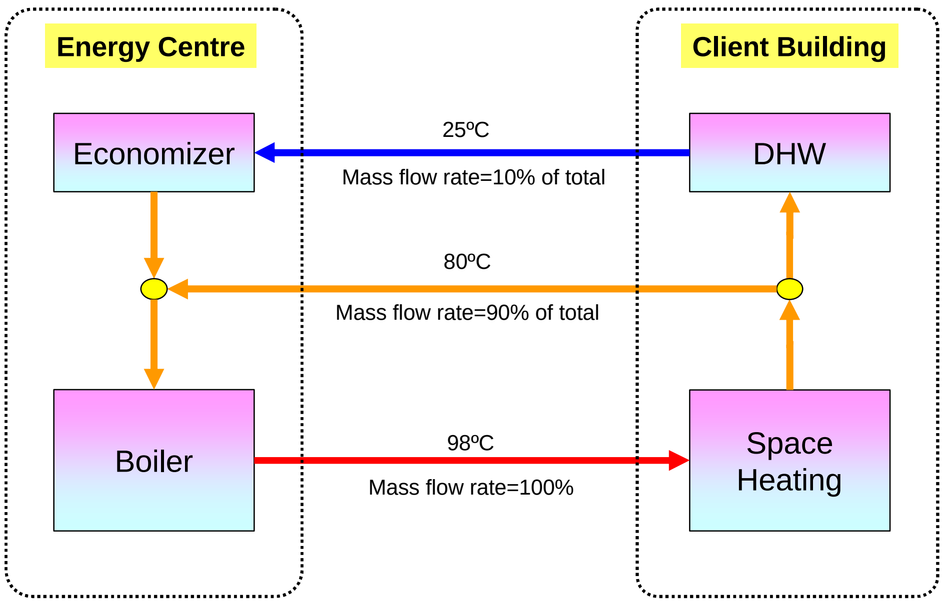

Figure 8 Three-Line District Energy Concept

Achieving a return temperature of 25ºC in the low temperature line is possible since water in this line will exit a counter flow heat exchanger for domestic hot water: potable water will enter the heat exchanger at 10ºC to 15ºC. The figure above shows that only 10% of the total flow returns to the Energy Centre through the low-temperature pipe. Because of the large temperature change (80ºC to 25ºC) however, this line would account for approximately 20% of the energy flows in the system. Within the Energy Centre, the low-temperature flow would first be heated by an economizer to approximately 80ºC, then raised to the supply temperature by the biomass boiler.

The advantages of this approach are:

1. The lower return temperature flow can be used to recover energy more efficiently from the district energy system's boilers by means of an economizer.
2. Some of the Phase I buildings will produce waste heat at temperatures that will be too low for space heating purposes but higher than the temperature of the low-temperature return line. Waste heat from these sources could be transferred through a heat exchanger to water entering the low-temperature return line. An example of waste heat of this type would be heat from the condenser side of the arena's ice-making chiller.
3. If the three pipes are sized appropriately, flows could be reversed so that at times of peak demand two pipes could supply water at the highest temperature, with one pipe returning flows to the Energy Centre.
4. Flows in the three pipes could be arranged to provide both heating and cooling during the summer, although this configuration has not been modelled in the current study. Instead, the costs of installing an adsorption chiller at the Hospital have been included in cost estimates: this chiller would be supplied by heat from the district energy system.

The disadvantages of a three-line district energy system are the higher capital costs of a third pipe and of a wider trench to accommodate it. Modelling in this study showed that in winter, the amount of energy recovered from the economizer would approximately equal the amount of energy required for heating domestic hot water in clients' buildings. An energy and mass balance diagram for the three-line system is shown in Appendix 4 - Energy and Mass Balance Diagram.

Figure 9 below shows the components of the proposed district energy system.

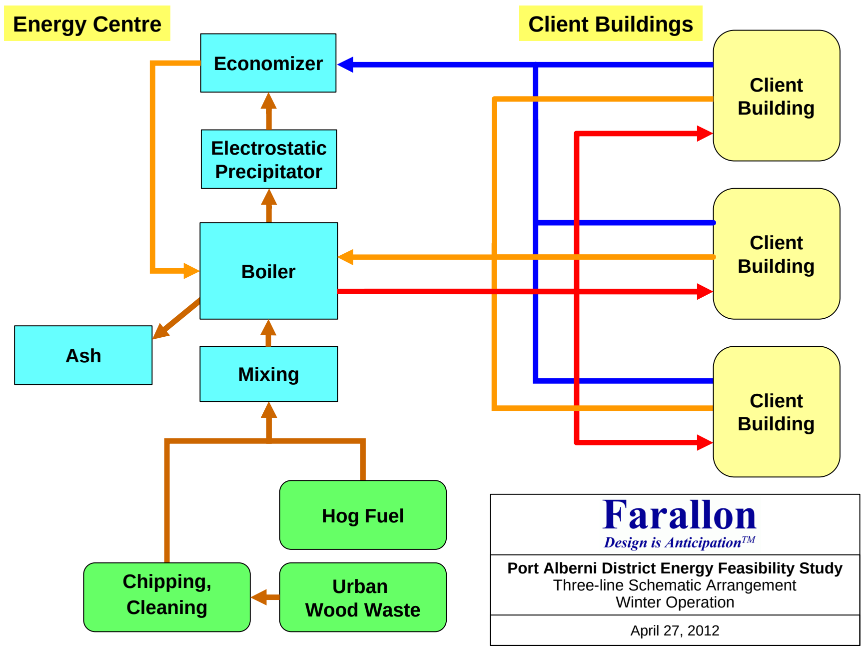

Figure 9 Three-Line District Energy Schematic

The table below summarizes the temperatures and proportions of energy supplied by the economizer and boiler, which match the proportions of energy consumption by buildings for space heating and domestic hot water.

Table 5 Energy Balance for High and Low Temperature Sources

Energy Source	Proportion of Energy	Temperatures	Building Use
Boiler	80%	80ºC in and 98ºC out	Space Heating
Economizer	20%	25ºC in and 80ºC out	Domestic Hot Water

6.6.2 Direct Contact Economizer

An additional challenge facing designers of biomass energy systems that provide heat to district energy systems concerns the moisture content of biomass. All biomass contains moisture, ranging from approximately 5% for pellet fuels, to 25% for urban wood waste (from a mixture of construction, demolition, and land-clearing) to 50% for hogged fuel.

In addition, exhaust gases include water formed during the combustion of wood. Moisture from these two sources in exhaust gases represents a significant loss of energy for biomass systems. When moist wood is burned, part of its available energy is consumed to evaporate water, and this latent heat of vapourization is lost as steam with the stack gases. If however the temperature of stack gases in a biomass boiler can be reduced below the dew point, then both the latent heat and the sensible heat in exhaust gases can be recovered. This form of energy recovery can be accomplished with a condensing stack gas economizer.

Two types of condensing economizers could be used for this purpose: indirect, and direct contact. Indirect economizers circulate an energy transfer fluid such as water or thermal oil through piping in a heat exchanger in the exhaust gas flow. This kind of economizer is suitable for natural gas boilers, but not for biomass boilers since organic compounds tend to foul the economizer surfaces at lower temperatures.

Direct contact condensing economizers work by spraying cool water into the exhaust gases in a counter flow arrangement. Heat is transferred directly to the water and fouling is avoided.

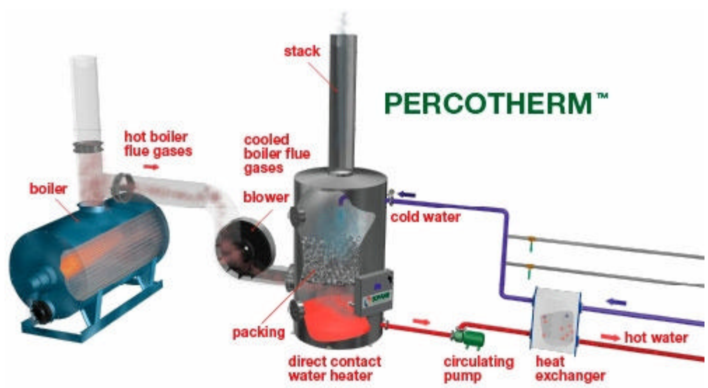

Figure 10 Direct Contact Condensing Economizer[6]

[6] Image courtesy of Sofame Technologies

The disadvantages of this approach are:

1) The economizer increases the capital and operating costs of the system; and
2) A separation process will be required to return insoluble compounds entrained in the economizer water to the biomass feedstock.

The advantages of this approach are that:

1) Less biomass will be required since the overall efficiency of the biomass boiler and economizer combination is higher; and
2) The biomass system will be less sensitive to the amount of moisture in the biomass fuel, so that less expensive fuel with a higher moisture content can be used in the system.

Modelling of the Port Alberni district energy system suggests that the benefits of a direct contact condensing economizer outweigh the additional costs.

6.6.3 Cooling

Because of the high summer temperatures in Port Alberni, buildings such as the West Coast General Hospital operate air conditioning systems which represents an opportunity for the district energy system. In a district energy system, cooling can be provided to clients in two ways.

In the first option, clients could replace their electrically-operated air conditioning systems or chillers with adsorption chillers. Adsorption chillers use heat rather than motor-driven compressors to achieve cooling, and could use heat from the district energy system during the summer for this purpose. Unlike the more common absorption chillers, adsorption chillers have the advantage of not requiring chemicals such as lithium bromide for their operation.

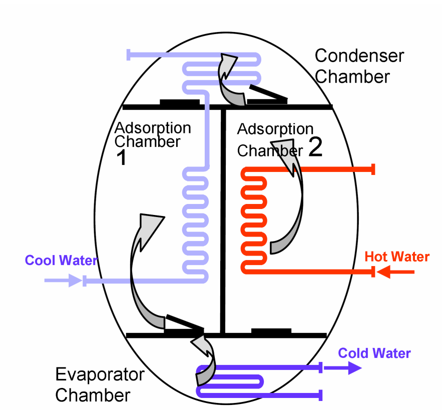

Figure 11 Adsorption Chiller Concept[7]

[7] Image courtesy of Eco-Max Adsorption Chillers.

In the second option, a district energy utility could install a central adsorption chiller, and distribute cold water through a dedicated cold water line. In this option, clients would not need to their operate existing air conditioning equipment, nor would they need to install new adsorption chiller equipment on their premises. In either option, district energy clients would avoid the cost of electricity required to operate their existing air conditioning systems.

The loads on the existing chiller at the West Coast General Hospital are known, and VIHA reports that the maintenance and operating costs of the existing chiller have been somewhat higher than expected. As a result, the costs and benefits of providing cooling through an adsorption chiller have been included in the engineering and economic models for this study.

6.7 Energy Conservation

Table 6 shows the fuel energy inputs before and after the district energy system is implemented. The table is modelled on the Green Municipal Fund application.[8]

Table 6 Fuel Energy Inputs (Fuel Energy Basis)

Project Element	**Energy Source**	**Baseline Consumption** (GJ/year)	**Anticipated Energy Consumption After Project Completion** (GJ/year)	**Anticipated Impact on Energy Consumption (+or -)** (GJ/year)
District energy system	Residual (waste wood)		45,122	(45,122)
	Natural Gas		7,926	(7,926)
Buildings or facilities supplied by the district energy system	Natural Gas	67,936		67,936
Total		**67,936**	**53,048**	**14,888**

The estimate shows that because of higher conversion efficiencies, 22% less energy in the form of fuel would be consumed by the district energy system that burns waste wood for 85% of its energy, and natural gas (for peaking and back-up) for the balance.

[8] Note that the GMF application only includes consumption from fossil fuel and electricity from the grid in its total figures.

6.8 Opportunities for Research

Although the components of the proposed system are well understood, the integrated system will present opportunities for applied research in several areas.

6.8.1 Efficiency

The improvement to efficiency that can be achieved with a biomass boiler and a direct contact condensing economizer supplying energy to a three-line district energy system has been modelled in this study, and the expected costs and benefits will be validated through a more detailed design process. After the system is implemented however, it will be helpful to quantify the actual efficiency gains, and to identify opportunities for further improvement. The results of this applied research will be useful to other communities interested in implementing similar systems.

6.8.2 Pollution Controls

In a direct contact condensing economizer, water is sprayed directly into the exiting flue gases in a counter flow arrangement. Because of its direct contact with stack gases, it would be reasonable to expect that the water could absorb particulates and also soluble contaminants such as SOX and VOCs. The manufacturer of one direct contact condensing economizer has stated that this effect has been observed, but not yet quantified independently, so that the manufacturer does not offer this as a benefit of the system.[9]

Research into the potential for a direct contact economizer to act as a "wet scrubber" could characterize the magnitude of any pollution control effect for each type of contaminant. This research could help biomass system designers to have a clearer picture of its benefits. Further, research could determine if applying an electrostatic charge to water droplets in the direct contact economizer could help improve the efficiency of particulate scrubbing. Wet Electrostatic Precipitator (WESP) technology relies on this effect, and has proven effective in removing fine particulate matter from biomass boiler stack gases. It will be valuable to know if a direct contact economizer and WESP technology could be combined to provide both heat recovery and further particulate reduction.

6.8.3 Control Systems

The integrated energy system described here incorporates components that will require intelligent control. A control system will be provided by the district energy distribution system contractor, but there is an opportunity to research ways to optimize the system. This research could include:

1) Operating strategies to maximize efficiency and minimize air emissions;
2) Feed-forward strategies to increase energy production in advance of demand;
3) Ways of integrating the central control system with existing, older building control systems to maximize efficiency; and
4) Heuristic logic (artificial intelligence) systems that can learn from the pattern of energy use of client buildings to refine the operation of the entire system over time.

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[9] Personal communication between Stephen Salter, PEng and Luc Mandeville, PEng of Sofame Technologies.

7. Economic Aspects

7.1 Pricing of District Energy

When natural gas is burned in a boiler or furnace, not all of the energy in the purchased gas is converted to heat in the building. If a natural gas boiler is 70% efficient for example, then 100 GJ of purchased natural gas will produce 70 GJ of useful heat in a building, and the remainder will be lost. District energy is therefore sold in units of energy delivered to clients, rather than in units of natural gas that would otherwise be burned to produce this energy.

When all costs are accounted for, the total cost of energy to a building owner can be more than twice the cost of fuel, and this total cost of energy is higher in smaller buildings than in larger ones.

A basic evaluation of the building owners' cost of providing heat through natural gas boilers was completed during this study. The cost of natural gas forms only part of the cost of providing heat to a building, which also includes:

- Fuel costs
- Sales taxes
- Carbon tax
- Carbon offsets for publicly-owned buildings
- Operations and maintenance
- Licensing and insurance
- The cost of owning (and replacing) the boiler and related equipment

The capital and operating cost estimates for district energy in the current study include all costs to provide energy to a building, including the biomass boiler, distribution piping, and Energy Transfer Stations. Building owners would not pay to connect to the district energy system. The figure below shows the total cost of providing energy for three Vancouver Island buildings. In the figure, the losses due to boiler efficiency are shown as "conversion loss".

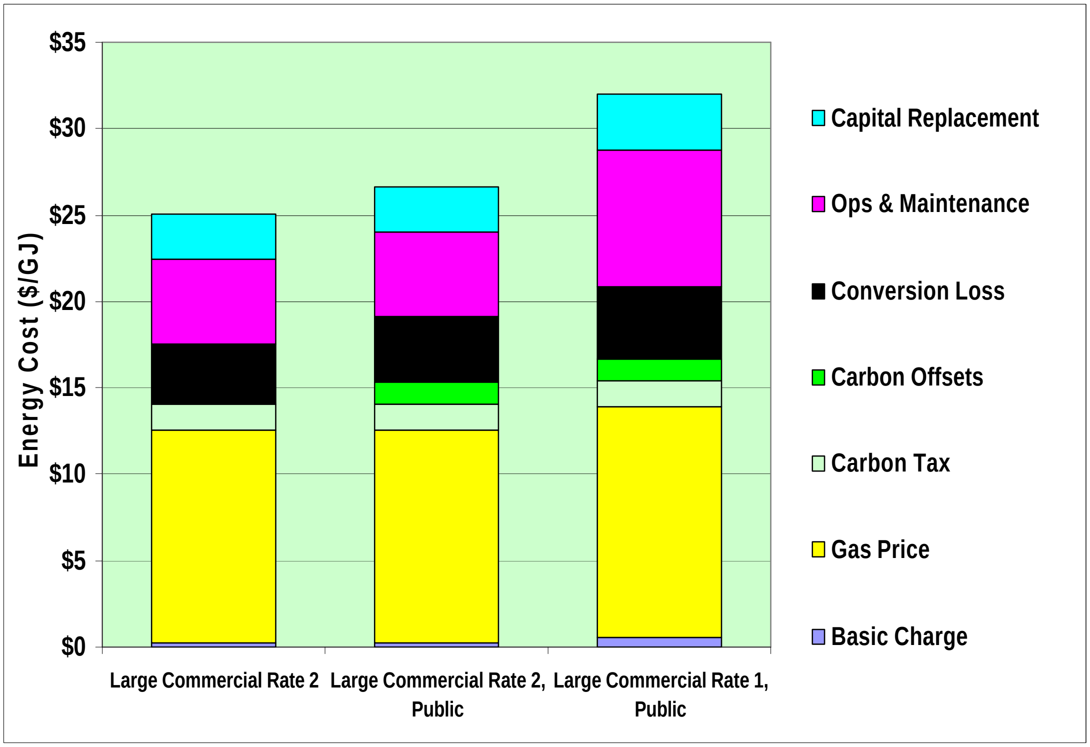

Figure 12 Total Energy Costs for Building Owners

The economics of this district energy system are helped by the fact that most of the buildings in Phase I are owned by public organizations, which pay carbon offset costs. Estimates of the total cost of energy for these buildings were based on actual natural gas expenditures for existing buildings, and on NRCAN energy intensity factors for buildings in the planning stage.

After expenses (including financing costs) the estimated net revenues for the City would be approximately $250,000 per year, assuming no grant funding is available, and assuming that the City carries all of the capital and financing costs. The City would also cover the cost of installing Energy Transfer Stations in client buildings, which is included in current capital cost estimates.

The City will need to obtain expert advice concerning contracting arrangements between its energy utility and energy clients, concerning terms such as price escalation due to inflation.

7.2 Ownership Structures for District Energy Systems

District energy systems can be structured in several ways ranging from full public ownership to full private ownership:

- Direct ownership and operation by the municipality (e.g. the City of Vancouver's Southeast False Creek Neighbourhood Energy Utility)
- Indirect ownership by the municipality via a utility (e.g. Markham District Energy)
- Municipal ownership with private operation (e.g. Lonsdale Energy, Vancouver)

- Municipal/private joint venture (e.g. Enwave, Toronto)
- Private ownership and operation (e.g. Dockside Green)[10]

The City would have a number of significant advantages as the majority shareholder of a utility:

1. Access to Federal and Provincial grants, and to loans at lower effective interest rates than private corporations;
2. Significant borrowing capacity as a result of conservative financial management;
3. Several buildings in Phase 1 are owned by the City;
4. The City owns the rights of way for a significant portion of the proposed district energy system routing, and could facilitate permitting and construction of the piping;
5. The City also has mechanisms for billing district energy system customers, and manages the urban planning strategies that will encourage density increases along the district energy system routing over time;
6. Access to a source of urban wood waste through the Alberni-Clayoquot Regional District;
7. Ownership of land in an area suitable for an Energy Centre;
8. Administrative processes for utility billing that could be expanded to include energy billing;
9. Technical knowledge of utility operations and maintenance; and
10. Credibility as a utility provider that could facilitate contracting arrangements with owners of client buildings.

Expert advice will be needed to structure the City's energy utility, in order to minimize administrative burdens and maximize the economic development opportunities for the community.

7.3 Financing for the District Energy System

The District Energy System could be financed in three ways.

1. The City can apply for Loans and grants from the Green Municipal Fund and Gas Tax Fund.
2. A loan could be obtained from the Municipal Finance Authority. The interest rate on this loan is very favourable, since the MFA invests the City's repayments of principal to provide a credit to the City. As a result, the effective interest rate on such a loan would be approximately 2.5% on an actuarial basis (MFA net).
3. Shares in the energy utility, could be offered to district energy clients, First Nations, and to citizens in the community as a means of raising capital and engaging the community's interest in the system. The City could consider policies to allow for wide participation in share

[10] The author is grateful to FVB Energy Inc. for information concerning ownership options.

ownership, by limiting the number of shares that could be held by any one individual or organization. Adequate rates of compensation for shareholders would need to be determined.

7.4 Basis of Capital Cost Estimates

Appendix 3 - Estimated Revenues, Capital, and Operating Costs contains the details of cost estimates. The estimates were prepared based on inputs from the following sources.

1. Trenching costs are based on experience with comparable projects, and the City of Port Alberni Engineering Department's experience with trenching costs in roads and also in green spaces.
2. Estimates of the cost of DES distribution piping and building connections are based on experience with comparable district energy projects, with confirmation from the RETScreen International program.
3. Estimates of the cost of major equipment in the Energy Centre including the biomass boiler and related fuel handling equipment, electrostatic precipitator, direct contact economizer, and adsorption chiller are based on vendor estimates for comparably-sized equipment.
4. The estimated cost of the enclosure building is based on the RSMeans estimating program.

7.5 Reinvestment of Net Revenues

Based on estimates of revenues and costs associated with the district energy system, the City of Port Alberni would be in a position to invest net proceeds in municipal projects. If the City chooses to invest in energy conservation initiatives in buildings it owns that are connected to the district energy system, then the energy drawn by these buildings from the system will be reduced. This reduction would allow additional capacity from the district energy system to be sold to other buildings as the system expands over time. In this way, the City's investment in energy conservation would be repaid not by lower energy costs in the conventional sense, but through increased revenues from new district energy clients.

8. Environmental Aspects

The district energy system will reduce greenhouse gas emissions by approximately 5,500 tonnes per year, the equivalent output of 1,100 cars. Emission reductions will result from replacing natural gas in client buildings with energy from biomass, and avoiding emissions of methane from decomposing wood waste in the regional landfill.

Approximately 2,800 tonnes per year of urban wood waste could be diverted from the regional landfill to the Energy Centre, which supports the objectives of the Alberni-Clayoquot Regional District Solid Waste Management Plan. The Plan includes a target to increase the diversion of solid waste from the 2005 diversion rate of 15% to 50% by 2015. Diverting an additional 2,800 tonnes per year of wood waste will make a significant contribution toward these targets, by increasing the ACRD's diversion rate from the baseline of 4,321 tonnes/year in 2005 to 7,321 tonnes/year.

The district energy system will conserve approximately 60,000 GJ of natural gas per year, which is equivalent to the annual consumption of approximately 600 homes.[11]

Because the system will be built on an existing brown field site (the Public Works Yard), it will not disturb new land. Unlike district energy systems that are powered by heat pumps, the proposed system will consume only modest amounts of electricity for pumping. Construction of the district energy system piping will result in only minor environmental impacts associated with trenching.

[11] Statistics Canada. 2007. Households and the Environment: Energy Use.

8.1 Air Emissions

The City of Port Alberni and the ACRD are investing significant effort to reduce the impacts of backyard burning and land-clearing burning on local air quality.

The table below shows estimates of the air emissions expected from the existing natural gas boilers in client building and from the new biomass boiler. At a high level, a biomass system would significantly reduce greenhouse gas emissions, but would also result in higher emissions of conventional pollutants such as particulates and NOX.

Table 7 Comparison of Air Emissions

	Units	BAU (Natural Gas)	Energy System (Biomass)	Change	Notes
GHG Emissions	t CO_2e/yr	6,066	489	- 5,577	
Particulates, Heating Systems	mg/m^3	9	<20		1
	tonnes/yr	0.2	0.5	+ 0.3	
Particulates, Brush Burning				- 99%	2
NOX	mg/m^3	49	209		3
	tonnes/yr	2.5	5.7	+ 3.2	
CO	mg/m^3	99	571		3
	tonnes/yr	2.1	15.6	+13.5	
SOX	mg/m^3	1	24		3
	tonnes/yr	0.02	0.6	+ 0.58	
VOCs	mg/m^3	6	18		3
	tonnes/yr	0.4	1.3	+ 0.9	

Notes:

1) The biomass boiler will be equipped with both a cyclone and an electrostatic precipitator to reduce particulate emissions. For scale, a typical pulp and paper mill with a biomass boiler could consume approximately 200,000 BDT of wood residues per year, Ministry of Environment air permits for these boilers typically limit particulate emissions to 230 mg/m^3.

2) The estimate is based on emission factors from the EPA, uncontrolled burning of land-clearing

debris releases particulate emissions of 5 to 35 grams per kg of wood burned.[12] Emissions from a biomass boiler equipped with a cyclone and electrostatic precipitator, so that particulate emissions of 20 mg/m^3 of stack gases, would equate to 0.11 grams of particulate per kg of wood burned, a 99% reduction. To put the increase of particulate emissions from the biomass boiler of 0.3 tonnes per year into perspective, this increase represents the avoided particulate emissions from just 18 tonnes of waste wood in a burn pile. Expressed another way, if more than 18 tonnes per year of wood is diverted from uncontrolled burning to the Energy Centre, then the net particulate emissions in Port Alberni will decline.

3) The estimated emissions from existing natural gas boilers and the biomass boiler for particulates, NOX (oxides of nitrogen), SOX (oxides of sulphur), and VOCs (volatile organic compounds) are based on EPA emission factors.[13]

[12] US EPA. 1996. Evaluation of Emissions from the Open Burning of Land-Clearing Debris. 115pp.

[13] US EPA.1995. Compilation of Air Pollutant Emission Factors. 2038pp.

8.2 Greenhouse Gas Emission Reductions

Table 8 below shows the estimated reductions in greenhouse gas emissions that would result from each option. For scale a reduction of 5,500 tonnes/year of CO_2e is equivalent to permanently removing approximately 1,100 cars from Port Alberni roads.

Table 8 Greenhouse Gas Reductions

	BAU (Natural Gas)	Energy System (Biomass)	Change	Notes
Natural Gas Combustion	3,416	399	-3,017	1
Biomass Combustion	-	90	+90	2
Sub-total: Combustion	**3,416**	**489**	**-2,927**	
Landfill Gas Emissions	2,650	-	-2,650	3
Total	**6,066**	**489**	**-5,577**	
Saleable GHG Credits	0	2,650		4

All figures are in (tonnes of CO_2e/year)[14]

<u>Notes</u>

1. Approximately 85% of the energy in the district energy system will be provided by wood waste, and the balance of energy (required for back-up and meeting peaking loads) will be provided by natural gas. The GHG calculation here takes this fact into account.
2. Calculations for emissions related to combustion of natural gas and biomass were completed per the *BC Reporting Regulation*.[15] Although carbon dioxide from biomass is considered in the *BC Reporting Regulation* to be biogenic and therefore carbon-neutral, biomass combustion does result in minor emissions of oxides of nitrogen and methane, which are included here.
3. The reductions are based on reducing emissions of methane from the regional landfill in Port Alberni. The calculation is based on the assumption that none of the methane emissions from the landfill will be captured in the future, since the magnitude of total emissions is not likely to exceed the trigger thresholds for landfill gas capture in BC's *Landfill Gas Management Regulation (BC Reg. 391/2008)*. Calculations of avoided landfill gas emissions were

[14] CO_2e is "carbon dioxide equivalent". If greenhouse gases that are reduced by a project include methane for example, the amount of methane is converted to its carbon dioxide equivalent value in terms of global warming. One tonne of methane is equivalent to twenty-five tonnes of carbon dioxide in terms of its ability to cause global warming (per the IPCC) or to twenty-five tonnes of carbon dioxide (per the BC Reporting Regulation).

[15] Province of British Columbia. 2009. BC Reporting Regulation Methodology Manual, Version 1.

completed per the IPCC first-order decay algorithm for landfills.[16] Avoided landfill gas emission estimates are based on the following assumptions:

   a. None of the purchased wood residues would be diverted, but all of the wood waste from the ACRD would be diverted from the regional landfill.
   b. A landfill age of 40 years.
   c. A k value of 0.03 and an L_0 value of 100 for wood waste in Port Alberni's climate.
   d. 10% of methane generated in the landfill would be oxidized in soil.
   e. No landfill gas capture system in the Alberni Valley Landfill.
   f. A Global Warming Potential value of 21 for methane, per the *BC Reporting Regulation Methodology Manual* (this value was revised by the IPCC in 2007 to 25, to reflect the current understating of the capacity of the atmosphere and biosphere to degrade methane into carbon dioxide).[17]
   g. Annual emissions are calculated on a steady-state basis.

4. Public organizations would not be able to sell carbon offsets arising from their own fuel switching, since carbon neutrality is a regulatory requirement in BC. The quantity of carbon offsets related to reduced landfill gas emissions and fuel switching in privately owned buildings that could be connected to the district energy system are shown here.

In addition, the City of Port Alberni is a signatory to the Climate Action Charter. When buildings owned by the City are connected to the district energy system, the City's corporate greenhouse gas emissions will be reduced by 38%.

[16] Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5: Waste. Chapter 4: Biological Treatment of Solid Waste.

[17] Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Science Basis. Chapter 2: Changes in Atmospheric Constituents and in Radiative Forcing, Table 2.14. 106pp.

8.3 Other Environmental Considerations

Biomass storage would be covered to limit contact with water and therefore leachate. Any leachate would be collected and discharged to the sanitary sewer, so that the system will not present a risk of contamination to groundwater.

Although 7,900 GJ/year of natural gas will be consumed for back-up and peaking boilers at the biomass energy plant, 67,900 GJ/year of natural gas in client buildings will be replaced with energy from the district energy system. For scale, the amount of natural gas conserved would heat approximately 600 homes.

The biomass boiler will produce an estimated 150 tonnes of clean ash per year. In the worst case, the ash will be used as landfill cover. The City can also pursue other higher-value uses such as:

- Offering the ash to local compost operations for blending with the finished product. The quantity of ash that could be used in this way will be determined by limits for properties such as pH and other parameters in the Organic Matter Recycling Regulation;
- Offering the ash to silviculture operations as a fertilizer; and
- Offering the ash to a producer of road asphalt in the region, to displace a portion of aggregate.

9. Social Aspects

The district energy system will not compete with industry for wood residues, since most of the required fuel will be sourced from urban wood waste. The balance of required hog fuel (approximately 1,000 BDT per year) is small by industrial standards, representing less than 0.5% of the hog fuel that would be consumed by a typical pulp and paper mill.

The district energy system is estimated to create two full-time jobs in operations, maintenance, and administration. In addition, local expenditures for energy of over $1 million per year would "stay home" in the community when these expenditures are received by the City's energy utility. The City can use many of its own assets to develop the Integrated Municipal Energy System, including land available in the Public Works Yard for the Energy Centre, rights of way for district energy piping, economic development experience, utility experience, technical knowledge, planning expertise, and administrative processes for utility invoicing.

Although construction of the district energy piping network will cause modest disruption, more than 70% of the network can be constructed through park lands, which will minimize the disruption to traffic. The district energy system piping will also be invisible after construction.

The public may express concern over air emissions from a biomass burner located at the Public Works Yard. The facility would however incorporate modern air pollution controls, so that emissions from the biomass boiler would be very low.

Delivery of waste wood to the Energy Centre would require one 20-tonne truck per business day, which represents a minor increase in traffic in the area of the Public Works Yard. Deliveries could be made via 6th Avenue and Wallace Street, away from residential areas.

The public can be engaged in the success of the system in several ways. First, a communications and consultation program should be developed to explain the economic, social, and environmental benefits of the district energy system to citizens. Public forums should be held to explain to citizens and other stakeholders how the system will work, and to understand and respond to any concerns. Organizations with expertise in this area, including BC Hydro and North Island College, have offered to provide advice and support to the public consultation process. The City could also consider engaging facilitators with experience in helping stakeholders to identify and express their interests and concerns. The City should also develop a web site to provide information and to receive and respond to questions concerning the district energy system.

In addition to debt financing, Integrated Municipal Energy System could be financed through sales of shares. The rate of return on these shares could be tied to the economic performance of the system. This arrangement could provide citizens with a deeper connection with energy, and also provide an incentive for citizens to separate and divert additional urban wood waste as a fuel source for the system.

The "Local Energy Path" can help citizens and visitors understand how the system works. It is hoped that this understanding will provide an incentive to residents to separate wood waste more effectively, for diversion to the Energy Centre. The route of the proposed trail is shown in Figure 13 below.

If zoning allows the Energy Centre to be built reasonably near to Wallace Street (as opposed to being located in the centre of the Public Works Yard), the Energy Centre could incorporate a large window to allow citizens and tourists to "look into" the operations of the of biomass plant.

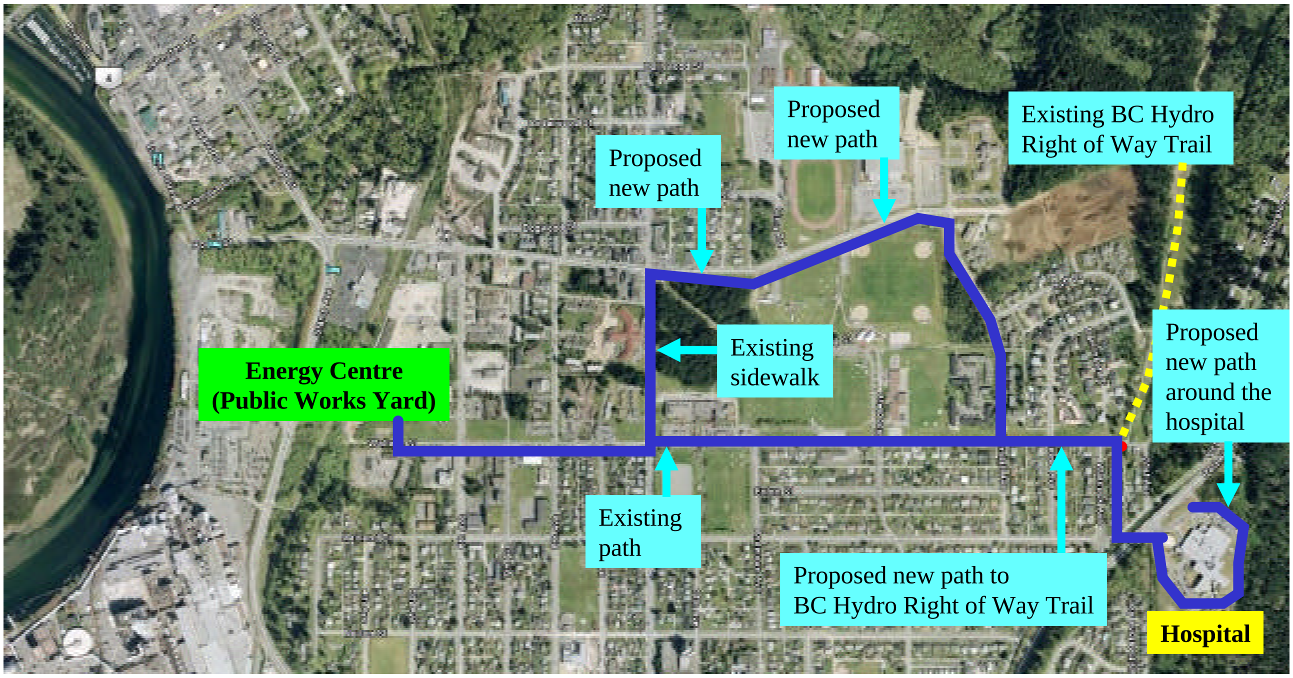

Figure 13 Proposed *Local Energy Path*

Finally, a website can be developed to explain the operation of the biomass plant and district energy system. The website could include webcams showing the current operation of the Energy Centre, along with a "dashboard" of indicators showing the current and running totals for energy produced from biomass, the quantity of fossil fuel conserved, the amounts of wood waste diverted from landfilling, and the quantity of greenhouse gases avoided. This website could be a common portal to information about all energy-related initiatives in Port Alberni, including for example the Upnit Power Corporation's 6.5 MW run of river hydroelectric project. The Upnit project is an initiative of the Hupacasath First Nation, and the website could explain its operation and outcomes.

10. Governance and Public Policy Aspects

An innovative community energy system of the type described in this study supports the following policies at the municipal, Provincial, and Federal levels.

City of Port Alberni

Objectives in the Port Alberni *Official Community Plan*:

OCP Section 1.1 Environmental Protection

- *The use of alternative forms of energy which reduce or eliminate environmental pollution and/ or improve conservation and efficiency of consumption is encouraged.*
- *The City will promote an environmental ethic concerning the value of reducing, reusing and recycling resources*
- *The City will work with government agencies, environmental groups, and citizen groups in an effort to reduce harmful emissions and improve air quality*

OCP Section 9.4 Solid Waste Management

- *In order to reduce the amount of solid waste dumped at the landfill, efforts to compost, recycle and reuse solid waste shall be encouraged*

The City of Port Alberni is also a signatory to the Climate Action Charter.

Province of British Columbia

District energy based on low-carbon sources supports several Provincial objectives:

- Production of energy from renewable, biomass sources *(BC Bioenergy Strategy, BC Energy Plan, BC Climate Action Plan).*
- Reduction of greenhouse gases *Local Government (Green Communities) Statutes Amendment Act (Bill 27),*[18] *Greenhouse Gas Reduction Targets Act (Bill 44),*[19] *notably:*

  "By 2020 and for each subsequent calendar year, BC greenhouse gas emissions will be at least 33% less than the level of those emissions in 2007."

  "By 2050 and for each subsequent calendar year, BC greenhouse gas emissions will be at least 80% less than the level of those emissions in 2007."

  "Each public sector organization (schools, colleges, universities, health authorities and Crown corporations) must be carbon neutral for the 2010 calendar year and for each subsequent calendar year."

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[18] *Local Gov Act*, [RSBC 1979] c. 323, s. 877(3)

[19] [SBC 2007], c. 42

- Renewable energy and climate action *(2008 Speech From the Throne),* including*:*

  "reduce B.C.'s greenhouse gas emissions by at least 33 per cent below current levels by 2020"

  "New measures will also be taken to reduce energy consumption and emissions in the public sector"

  "The Climate Action Team will also be asked to identify practicable options and actions for making the government of British Columbia carbon neutral by 2010"

- Use of renewable energy from agricultural products *(BC Agricultural Plan),*[20] including*:*

  "We will facilitate opportunities to turn agricultural residues like plant material, animal and organic waste into renewable energy. This will have a positive impact on how waste is treated in rural communities and will help reduce overall greenhouse gas emissions. We will continue to assess the suitability of alternative energies for replacing fossil fuels or as an alternative income source. Support for industry in investing in alternative energy systems such as geothermal, wind, solar and biomass can reduce costs for farmers and contribute to producing energy for society."

Canada

District energy based on low-carbon sources also supports Environment *Canada's Sustainable Development Strategy*[21], including;

- *Reduce greenhouse gas emissions.*
- *Clean air for people to breathe and ecosystems to function well.*
- *Canadians and their environment are protected from the effects of pollution and waste in support of a sustainable economy.*
- *Eco-efficient business practices that conserve energy, eliminate use of toxic materials, and reduce or reuse resources can increase productivity while improving environmental performance.*
- *A sustainable community is resilient to change and has a vision for the future.*
- *Communities enjoy a prosperous economy, a vibrant and equitable society, and a healthy environment for current and future generations*
- *The preservation and enhancement of the quality of the natural environment, including water, air and soil quality*
- *Reduce adverse effects on ecosystems and public health from the use of resources*

[20] http://www.al.gov.bc.ca/Agriculture_Plan/index.html

[21] Available at *http://www.ic.gc.ca/eic/site/sd-dd.nsf/eng/sd00474.html*

11. Risks and Risk Mitigation

Project risks for this project fall into four categories: contracting, technical, regulatory, and financial. Table 9 below summarizes the potential risks presented by developing the district energy system, along with risk mitigation measures identified to date.

Table 9 Summary of Risks

Potential Risk	Mitigation
Reduced Supply of Biomass *or* *Increased Cost of Biomass*	The ACRD is expected to provide approximately 70% of the biomass required for the system. The ACRD's sources of urban wood waste are expected to remain steady over time, and even to increase as waste wood is diverted from uncontrolled burning. Sawmill wood residues are available in the region, but the financial estimates assume that the remaining quantity would be sourced from forest residues at a cost of $50 per green tonne, a price equal to the cost of recovering forest residues in the region. This price as been confirmed by work completed by Wood Tech 21 and Coastal Char Industries Inc.. The City of Port Alberni will need to develop long-term biomass supply contracts for the balance of the required biomass, a modest quantity of approximately 1,000 BDT per year.
Increased Capital Cost	RFP processes will solicit proposals for the design and construction of the system: this process will result in refined capital cost estimates. In addition, the net revenue from the system is relatively insensitive to increases in capital cost, because of the low cost of financing available to the City. A 33% increase in capital cost for example, results in a 14% reduction in net revenues. The City of Port Alberni is in a strong position to finance the balance of the cost of the district energy system since the City's liability servicing ratio is very good. Finally, the City has a track record of completing major capital projects on time and on budget, evidence of strong project management abilities.

Potential Risk	Mitigation
Technology Risks	Elements of the design for the district energy system have individually been proven elsewhere, though not in the integrated form proposed here. The direct contact economizer has been used successfully in a number of other Canadian applications; adsorption chillers are a variation on the more common, chemical-based absorption chillers; four-pipe district energy distribution systems have been used elsewhere, though not three-pipe systems. Because the components of the proposed district energy system are commercially available, the project can be designed and implemented in a relatively short time. During the conceptual design stage, the configuration of this system will be modelled by firms with experience designing and building district energy systems, to mitigate the risk of integrating these three technologies into a single system.
Increased Annual Costs	An RFP process will solicit proposals for the design and construction of the system: this process will result in refined operating cost estimates. Financing charges represent approximately 1/3 of the annual costs of the system, and will be fixed.
Reduced Price of Natural Gas	The current bulk cost of natural gas at $3.75 per MMBTU ($3.55/GJ, the "Henry Hub" price) is only 17% of the total estimated cost of providing heat to a building. The remainder includes the cost of gas delivery, tariffs, taxes, boiler efficiency losses, capital equipment replacement costs, and the costs of maintenance, operations and administration. The price of district energy is therefore only affected in a relatively minor way by fluctuations in the price of natural gas. In addition, the National Energy Board predicts that the bulk price of natural gas will rise from $3.75/MMBTU in 2012, to $4.25 in 2012, and to $4.50 in 2014 (Source: NEB. Short-term Canadian Natural Gas Deliverability 2012-2014 - Energy Market Assessment. April 2012.)[22]

[22] NEB. Short-term Canadian Natural Gas Deliverability 2012-2014 - Energy Market Assessment. April 2012.

Potential Risk	Mitigation
Acceptance of the District Energy by Building Owners	Experience with district energy systems is growing in BC, so that building owners in Port Alberni will be able to communicate with their counterparts whose buildings are already served by district energy in Revelstoke, Whistler, downtown Vancouver, Southeast False Creek, the City of North Vancouver, and elsewhere. Buildings included in Phase I of the system are publicly owned, and the building operators' knowledge of the real costs of producing heat through natural gas boilers is well developed. In addition, owners of these buildings pay for carbon offsets in addition to the carbon tax. As a result, it is expected that building owners identified in Phase I will agree to become clients of the system. Several of the largest building owners (including the largest potential customer VIHA, who manage the West Coast General Hospital) have already expressed their written interest in connecting to the district energy system. Groundwork completed to date indicates that the conditions are favourable for these contracts to be completed, and expert advice will be obtained from collaboration partners (e.g. UNBC, BC Hydro) and others to develop equitable district energy contract terms. The City can engage a negotiator to facilitate agreements that address the interests of both parties.
Reduced DES Price	Net revenues are relatively sensitive to changes in the price of district energy. A 10% reduction in the price of district energy for example would result in a 20% reduction in net revenues. Larger clients may expect deeper discounts for district energy, since the total cost of generating heat through conventional natural gas boilers decreases with size. Careful negotiations between the city and its largest potential client (VIHA) will be required to ensure that the interests of the City and of VIHA are met in a way that provides adequate savings to VIHA, and adequate revenues to the City. These negotiations should take place before the City commits to developing the Integrated Municipal Energy System.

Potential Risk	Mitigation
A change in Provincial government may result in the elimination of the carbon tax, and of the requirement for publicly-owned organizations to offset their carbon emissions.	Although the price of district energy would take into account the carbon tax and the value of the avoided carbon offsets for publicly-owned organizations, contracts with district energy clients can index the price of energy to the rate of general inflation rather than to the actual price of fossil fuels. If the price of fossil fuels continues to rise over time, then the price advantage of district energy to building owners will also increase over time. This increasing difference between the price of greenhouse gas-neutral district energy and conventional fossil fuels will make the benefit of the carbon tax less critical to the economic viability of all options, over time.
Regulatory Approval	The risk of failing to obtain regulator approval is low, given that planned pollution controls will limit emissions.

12. Potential for Collaboration

During this study, a number of organizations have been contacted for advice and to explore the potential of collaboration during the development of the system. The table below lists the organizations that have agreed to collaborate, along with their area of expertise.

Table 10 Collaborating Organizations

Organization	Area of Collaboration
Alberni-Clayoquot Regional District	The Alberni-Clayoquot Regional District will provide urban wood waste that will be diverted from the regional landfill. This will contribute to the Regional District's Solid Waste Management Plan goal to increase its diversion of solid waste away from landfilling from 15% in 2005 to 50% by 2015.
North Island College	North Island College has agreed to provide advice concerning public consultation, and will be provided with performance information for case studies, research opportunities, access to the system for faculty and students, and opportunities for trades training related to the district energy system and the biomass boiler. NIC will also play a role in the communication of the performance and outcomes of the project, including lessons learned. The district energy system will also provide students and apprentices in the NIC trades programs with an opportunity to gain hands-on experience with biomass boilers, related control systems, district energy systems. In addition, the NIC's Port Alberni campus would be a district energy system client.
BC Hydro	BC Hydro will provide advice concerning public consultation, and technical assistance concerning displacement of electrical loads such as domestic hot water in the near term, and for adsorption chillers in the long term. BC Hydro will also play a role in communicating lessons learned with the Integrated Energy System in Port Alberni, especially in the area of displacing electrical demand for heating domestic hot water and for operating chillers with heat from a district energy system.

Organization	**Area of Collaboration**
University of Northern British Columbia	The University of Northern British Columbia has seventeen years of experience with district energy, the source of heat for which is now a biomass gasifier. UNBC has expressed interest in sharing their expertise in the areas of best practices for public consultation and their future research work in the area of sustainable biomass harvesting. The City will provide access to the energy system to UNBC faculty and students for research and for educational purposes. UNBC will also be welcome to communicate the performance and outcomes of the project, including lessons learned. Finally, the City will ask for UNBC's advice concerning operating strategies for biomass-based district energy systems.
Alberni Valley Community Forest Corporation	The City of Port Alberni owns the Alberni Valley Community Forest Corporation, and can collaborate in the area of sustainable harvesting options for community forests. While biomass for the district energy system will come from urban wood waste and purchased industrial wood residues, the collaboration could investigate ways to make better use of roadside residuals from forestry harvesting operations.
Vancouver Island Health Authority	VIHA has fully supported the development of the district energy system, by providing detailed information concerning their energy requirements and energy infrastructure in the West Coast General Hospital. The project will reduce VIHA's energy costs at the Hospital, at a minimum by reducing the cost of carbon offsets currently purchased to bring the Hospital's carbon emissions to zero. VIHA has also expressed interest in replacing its existing chiller with an adsorption chiller.

13. Implementation Phases

The district energy system could be implemented in the phases outlined below.

Timeframe	Phase
3Q 2012	Form a Project Team within the City, name a Project Manager, and name a member of Council to the Team. Develop an RFQ for the district energy system. Evaluate responses to the RFQ and engage a prime consultant with the necessary experience designing and building district energy systems to complete a conceptual design for the energy system to confirm cost estimates. Initiate community and stakeholder consultations. Develop a long-term supply agreement for urban wood waste that involves the ACRD. Begin discussions concerning expectations for district energy pricing with the largest clients in Phase 1. Choose an ownership model.
4Q 2012	Discuss the required air permitting processes with the Ministry of Environment. Contact utility and telecommunication firms to discuss opportunities to share district energy system trenching with other utilities. Engage a legal specialist to form the Integrated Municipal Energy System as a municipal utility in which the City would have majority ownership. Engage a negotiator to form energy supply agreements with district energy clients. Choose a tentative site for the Energy Centre in the Public Works yard.
1Q 2013	Complete conceptual design, including validation of the proposed technical innovations (three-line distribution piping, direct contact condensing economizer, and adsorption chiller). Confirm required capacities, update the cost estimates, and develop the expected distribution piping routing.
3Q 2013	Complete detailed design and procurement.

Timeframe	Phase
3Q 2014	Complete construction for the Energy Centre, distribution piping, and Energy Transfer Stations.
4Q 2014	Complete commissioning, as-built drawings, and lessons-learned.

14. Conclusions

Port Alberni is fortunate to have many of the conditions necessary for a successful district energy system based on biomass. Such a project has the potential to provide modest non-tax revenues to the City, reduce greenhouse gas emissions, and to support the City's economic development goals by keeping energy expenditures in the community.

The City has a significant number of physical, economic, organizational, and governance advantages that will help it to develop a district energy system successfully, including experience as a utility and experience managing projects of comparable scale.

This proposed system represents a reasonable balance among the issues of risk, benefits, and practicality. Funding will be helpful to overcome first-of-a-kind issues that the proposed innovations will bring, and the return on this funding investment will be an opportunity to test new options for efficiently converting existing buildings to district energy. This strategy has the potential to make energy sources more compatible with the heating systems of existing buildings, which will reduce one barrier to district energy implementation. The strategy described here could be used in a large number of other installations.

A district energy system could bring the following benefits to the City of Port Alberni:

1. Local energy expenditures of over $1 million per year will remain in the community when these expenditures are received as revenues by the City's energy utility;
2. Greenhouse gas offsets of $65,000 per year that are currently paid by public organizations to the Pacific Carbon Trust will also remain in the community;
3. The city would realize an estimated $250,000 per year in net revenues as non-tax revenues;
4. Employment will be created for City personnel involved in operations, maintenance, and administration of the district energy system;
5. Greenhouse gas emissions will be reduced by approximately 5,500 tonnes per year, the equivalent output of 1,100 cars;
6. Dependence on fossil fuels will be reduced and energy security will be improved in key Port Alberni buildings, including the regional hospital and a significant number of City-owned buildings;
7. The City's reputation as a progressive and innovative community will be enhanced;
8. If paper manufacturing operations in the City cease operations, then two local sawmills that depend on steam purchased from the local paper mill would be affected. In such an event, the City would consider expanding the Energy Centre to provide steam for these sawmills and also electricity for the community.
9. The system can be expanded to serve new developments that may be built along Port Alberni's inner harbour.

15. Recommendations

The City should apply for grant funding from the Green Municipal Fund and from the Gas Tax Fund to help offset some of the additional time and expense of implementing the innovative aspects of the proposed system.

The City should engage a prime consultant with the necessary experience in designing and building district energy systems to complete a conceptual design for the energy system to confirm cost estimates.

Once the status of the grant applications is known, it is recommended that the City:

1. Arrange for financing for the balance of capital costs not covered by grants;
2. Form a Project Team to include a member of the Port Alberni Council, and provide regular briefings on the project to the Mayor and Council;
3. Engage a legal specialist to form the Integrated Municipal Energy System as a municipal utility in which the City would have majority ownership;
4. Offer shares in the Integrated Municipal Energy System to district energy clients, First Nations, and individuals;
5. Engage a negotiator to draft the terms of energy supply agreements between the City and its district energy clients;
6. Issue an RFP to solicit proposals for construction of the district energy system; and
7. Encourage the development of all sources of biomass that could serve as a fuel for the system, including locally-produced bio-char.

16. Acknowledgements

The author would like to express his thanks to Pat Deakin, Economic Development Manager for the City of Port Alberni, Guy Cicon, PEng, City Engineer, and the city staff for their tireless help in providing access to individuals and information during this study, and for their thoughtful suggestions and feedback.

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Andy Daniel, Manager of Environmental Services, Alberni-Clayoquot Regional District

Anna Berry, Manager, Wood Tech 21

Bob Ericksen, Manager, Utilities Pulp Operations, Catalyst Paper

Brad Madelung, Port Manager/CEO , Port Alberni Port Authority

Brian Hooper, Technical Manager, Catalyst Paper

Brian Mousley, Utilities Superintendent, City of Port Alberni

Bruce Fitzgerald, Utilities Manager, Catalyst Paper

Cathy Rothwell, Controller, City of Port Alberni

Cheryl McLay, Regional Manager, Ministry of Community and Rural Development

Cindy Stern, Chief Operating Officer, Tseshaht First Nation

Darcy Berry, Manager, JW Trucking

David Claus, Energy Manager, University of Northern British Columbia

Deanna Fourt, Director of Energy Efficiency and Conservation Facility Maintenance, VIHA

Denis Tardif, Specialist, Utilities, Catalyst Paper

Diane Matchett, Controller, School District 70

Don Anderson, Manager of Environmental Services, Alberni-Clayoquot Regional District

Doug Murray, Site Manager, Port Alberni Assisted Living Society

Ellen Brown, RN BScN, Site Director, West Coast General Hospital

Garry McLeod, Manager, North Island College

Greg Smyth, Assistant Superintendent, School District 70

Harry Eberts, Operations Manager, School District 70

Janine Langford, Senior Maintenance Worker, City of Port Alberni

Jerry Linning, CGA , Secretary-Treasurer, School District 70

Joe Holmes, Division Manager, Western Forest Products

Joyce Coates, Manager, North Island College

Ken Watson, PEng, City Manager, City of Port Alberni

Larry Cross, PEng, Supervisor, Environment and Lab Services, Catalyst Paper

Larry Spencer, Director, Alberni Athletic Association

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Scott Smith, MCIP, City Planner, City of Port Alberni

Steve Hodge, PEng, Project Assessment Manager, Terasen Gas

Theresa Brossard, Manager, North Island College

Tom Paisley, Mill Manager, Catalyst Paper

Veronica Irg, Receptionist, City of Port Alberni

Stephen Salter PEng, LEED® AP

Farallon Consultants Limited

17. Closure

We trust that this report fulfills the current requirements of the Vancouver Island Health Authority. If questions arise, please contact the undersigned at any time.

Original signed and sealed, on file

Stephen Salter, P.Eng., LEED AP

President, Farallon Consultants Limited

Appendix 1 - Assumptions and Inputs

Input		Units	Notes
Energy Prices			
$12.81	Price of natural gas to commercial clients	$/GJ	
$14.31	Price of natural gas to commercial clients	$/GJ	Including carbon tax
$1.50	Carbon Tax	$/GJ	
$1.25	Value of Carbon Offsets to Public Buildings	$/GJ	
$25.00	Price of GHG offsets bought by public organizations	$/tonne	
$10.00	Price of GHG offsets bought by Industry	$/tonne	
$15.00	Value of GHG credits sold, for example to PCT	$/tonne	
$23.34	Price of DES heating to commercial clients	$/GJ, Energy	On the basis of delivered energy. Includes conversion losses based on a natural gas boiler efficiency of 70%, and avoided carbon tax, carbon offsets, capitalization and O&M costs.
$20.92	Price of DES cooling to commercial clients	$/GJ, Energy	
$65.00	Price of purchased electricity	$/MWh	
$50.00	Price of purchased hog fuel	$/BDT	
$20.00	Tipping fees for wood residues	$/wet tonne	
Technical			
95%	System Availability		
0.050287	Emission factor, natural gas	t CO_2e/GJ	
0.007250	Emission factor, biomass combustion, 12% moisture	t CO_2e/BDT	BC Reporting Regulation Methodology Manual
0.031790	Emission factor, biomass combustion, 50% moisture	t CO_2e/BDT	BC Reporting Regulation Methodology Manual
70%	Boiler efficiency, existing natural gas boilers		
75%	Boiler efficiency, biomass boiler		Not including the contribution of the economizer.
16.0	Energy content of biomass	GJ/BDT	At 35% moisture, before conversion losses

Input		Units	Notes
Construction & Operations			
0.8%	Population growth rate,		Guy Cicon, PEng, City of Port Alberni
20%	Contingency for capital cost estimates		
15%	Engineering as a percentage of capital cost		
10%	Construction and project management as a percentage of capital cost		
2.5%	Financing rate (MFA net, based on the actuarial value of 5%)		Cathy Rothwell, City of Port Alberni
1.5%	O&M rate: District Energy System		
3.5%	O&M rate: Adsorption Chillers, Heat Pumps		
$90,000	O&M cost per job		
$1,000	Cost per m^2 of basic steel on concrete enclosure		

Appendix 2 - Estimated Building Energy Demand by Month

Phase I Buildings	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hospital	1,622	1,772	1,834	1,258	922	628	649	641	850	1,030	1,475	1,698	**14,379**
Echo Aquatic/Fitness Centre	693	733	662	674	536	397	342	342	397	524	532	637	**6,468**
Library[23]	24	20	16	8	3	2	2	2	2	3	5	25	**112**
North Island College	461	425	328	200	83	14	14	83	200	328	425	461	**3,022**
Athletic Hall	201	189	157	115	76	53	53	76	115	157	189	201	**1,583**
Multiplex	592	512	461	334	307	324	206	193	393	307	408	527	**4,564**
New High School	938	864	667	408	170	28	28	170	408	667	864	938	**6,148**
Public Works Yard	175	135	139	99	68	35	0	5	6	95	125	201	**1,082**
Echo Village	161	180	171	135	109	83	88	79	98	95	187	173	**1,556**
Heritage Place	124	114	89	55	23	5	5	23	55	89	114	124	**821**
Fir Park Village	150	148	140	113	92	80	86	87	108	124	152	157	**1,437**
Pioneer Towers	414	382	295	182	78	16	16	78	182	295	382	414	**2,735**
Total Demand (GJ)	5,557	5,473	4,957	3,580	2,467	1,666	1,490	1,781	2,813	3,711	4,858	5,556	**43,910**
Total Average Demand (MW)	2.14	2.11	1.91	1.38	0.95	0.64	0.57	0.69	1.09	1.43	1.87	2.14	
Estimated Peak Demand (MW)	5.15	5.07	4.59	3.32	2.28	1.54	1.38	1.65	2.60	3.44	4.50	5.14	

Note that the values shown are in GJ of energy, not G of natural gas.

[23] The Library and Aquatic Centre would form a single Energy Transfer Station connection.

Appendix 3 - Estimated Revenues, Capital, and Operating Costs

Parameter	Value	Units	Notes
Options			
Cogeneration Included (Yes/No)	No		
Stack Economizer Included (Yes/No)	Yes		
District Cooling Included (Yes/No)	Yes		
Biomass Sources	Wet T/year	BDT/year	
Total Biomass Required	4,312	2,853	
Wood Residues, Urban Wood Waste	2,789	2,091	Assuming 25% moisture content for urban wood waste.
Wood Residues, Purchased	1,524	762	Assuming 50% moisture content.
Blended Moisture Content	34%		
Trucks per Day	1.0		20 tonnes per delivery, 5 days/week, 48 weeks/year.
Calculated Energy Yield	14.3	GJ/BD Tonne	Without the economizer, this value is 12.0 GJ/BDT.
Energy Required for Heating, Total, Natural Gas Basis	62,729	GJ/yr, Gas Basis	
Energy Required for Heating	**43,910**	GJ/yr, Energy	
Energy Input to the Adsorption Chiller	3,645	GJ/yr, Energy	
Energy Required for Heating and Cooling, Total	**47,555**	GJ/yr, Energy	
Cooling Energy Supplied	2,187	GJ/yr, Energy	Assuming a COP of 0.6 for the adsorption chiller.
Proportion of Energy From Biomass	85%		
Energy Provided by Biomass, Energy Basis	40,422	GJ/yr, Energy	85% of energy for heat, all energy for cooling from biomass.
Energy Provided by Biomass, Fuel Basis	45,122	GJ/yr, Gas Basis	
Energy Required from Natural Gas, Energy Basis	7,133	GJ/yr, Energy	

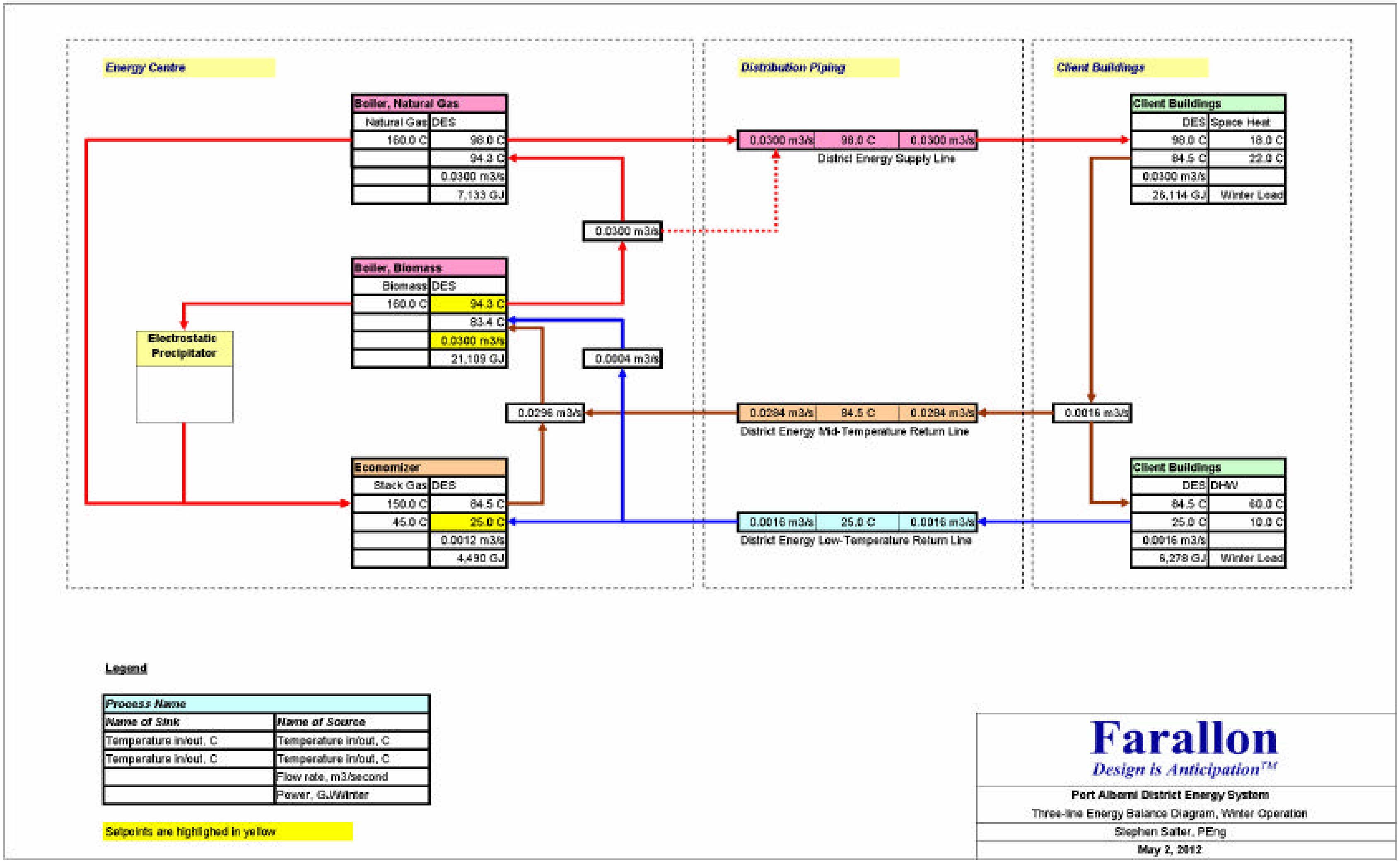
Parameter	Value	Units	Notes
Energy Required from Natural Gas, Fuel Basis	7,926	GJ/yr, Gas Basis	
Biomass Energy from the Boiler	33,675	GJ/yr, Energy	
Biomass Energy from the Economizer	6,907	GJ/yr, Energy	Direct contact, condensing economizer.
Capacities for Phase One			
Average Demand, Total	1.60	MW	
Average Demand, Biomass	1.36	MW	
Peak Capacity Needed	5.20	MW	
Base-loaded Biomass Boiler Capacity	1.80	MW	
Peaking/Back-up Boiler Capacity (Natural Gas)	2.00	MW	
Peaking/Back-up Boiler Capacity (Natural Gas)	2.00	MW	
Total Installed Heating Capacity	**5.80**	MW	
Total Installed Cooling Capacity	**150**	tons	
Capital Costs			
Capital Cost, DES Trenching and Distribution Piping			
Number of Building Connections	11		Phase I buildings.
Trench Length, via Roads	880	m	
Rate per Metre, via Roads	$300	$/m	
Trench Length, Off-road	2,120	m	
Rate per Metre, Off-road	$250	$/m	Lower rate for off-road trenching.
Total DES Piping Length	**3,000**	m	
Trenching Costs	$794,000		
Piping & Mechanical, DES	$1,443,000		
Building Connections and Energy Transfer Stations	$1,285,000		

Parameter	Value	Units	Notes
Sub-total, DES Trenching and Distribution Piping	**$3,522,000**		
Capital Costs, Energy Centre			
Boilers: Biomass	$765,000		
Boilers: Biomass, Installation	$136,000		
Fuel Handling System	$69,000		
Electrostatic Precipitator	$140,000		
Boilers: Peaking and Back-up	$520,000		
Balance of Plant, Installation	$300,000		
Economizer, Including Installation	$189,000		Direct Contact Condensing Stack Economizer.
Adsorption Chiller, Equipment and Installation	$240,000		
Enclosure Building	$727,000		The plant will be located at the Public Works yard.
Sub-total, Energy Centre	**$3,086,000**		
Sub-total, DES System Construction and Equipment	**$6,608,000**		
Public Consultation	$15,000		
Conceptual Design	$59,000		
Detailed Engineering	$882,000		
Project Management and Construction Supervision	$646,000		
Commissioning and Training	$200,000		
Information Sharing	$30,000		
Contingency	$1,322,000		
City of Port Alberni Staff	$215,000		In-kind contributions.
Total Capital Costs	**$9,977,000**		Assuming no grants.

Annual Costs			
Hog Fuel	$50,600	$/yr	
Cost of Processing Urban Wood Waste	$112,000	$/yr	To remove contaminants and to chip wood.
Ash Removal	$1,600	$/yr	Replaces soil for landfill cover, or higher use.
Natural Gas	$92,300	$/yr	For back-up and peaking.
Carbon Tax	$10,800	$/yr	
Carbon Offsets	$9,000	$/yr	
Electricity	$14,000	$/yr	
Operations and Administration	$90,000	$/yr	
Insurance	$40,000	$/yr	
Maintenance, Energy Centre	$95,400	$/yr	
Maintenance, DES and ETS	$35,200	$/yr	
Maintenance, Adsorption Chiller	$10,800	$/yr	
Financing	$244,100	$/yr	
Total Annual Cost	**$805,800**	$/yr	Assuming no grants.

Annual Revenues			
DE Revenues from Heat	$1,025,000	$/yr	Based on a 20% discount below the total current cost of heating existing buildings.
DE Revenues from Cooling	$45,800	$/yr	Based on the avoided electricity, capitalization, and O&M costs of the existing West Coast General Hospital chiller.
Total Annual Revenues	**$1,070,800**	$/yr	
Total Net Annual Revenues	**$265,000**	$/yr	Assuming no grants.

Appendix 4 - Energy and Mass Balance Diagram



Notes

1) The energy and mass balance diagram is included here to illustrate how the three-line distribution system operates.
2) Energy values are shown in GJ of thermal energy, not fuel energy.
3) The following simplifying assumptions are made in the energy and mass balance diagram:
    a. The energy and flow values in the diagram are based on average winter rates.
    b. The diagram ignores the effects of branching lines, and models a single diameter line. In practice, the main sections of the distribution lines would be built with larger diameters closer to the Energy Centre and smaller diameters distant.
    c. The peaking boiler is shown working in a cascade arrangement with the biomass boiler, to simplify the model. In practice, this boiler could be arranged in parallel with the biomass boilers. In addition, the peaking boiler would only operate as a back-up or to serve peak loads.

Appendix 5 - Photos of Potential District Energy Client Buildings

Four of the buildings included in Phase I of the district energy system are show below.

West Coast General Hospital

North Island College

Echo Aquatic & Fitness Centre and Library

Echo Village Retirement Home

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Appendix 7 - About Farallon

Farallon Consultants Limited (*www.farallon.ca*) is a Victoria, BC consulting firm that works with communities and industry to find practical ways of reducing their environmental impacts. Farallon works with multidisciplinary teams to find innovative ways to conserve resources, use alternative energy, and to recover value from waste streams. The work is based on the idea that an integrated approach can uncover solutions that are environmentally and socially sustainable, and that are also economically viable. Stephen J, Salter PEng is the President of Farallon.

Closure

We trust that this report fulfills the current requirements of the City of Port Alberni. If questions arise, please contact the undersigned at any time.

Original signed and sealed, on file
Stephen Salter, P.Eng., LEED AP President, Farallon Consultants Limited