Feasibility Study for a District Energy System

City of Courtenay

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Final Report
February 21, 2013

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The information in this study has been compiled to offer a preliminary assessment of the potential for a District Energy System for the City of Courtenay. The authors have prepared this document at the request of the City of Courtenay, solely for this purpose.

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The construction cost estimates in this report provide an opinion of probable cost based on normal competitive conditions from multiple contractors. The costing information and data contained herein represent FVB Energy's best professional judgment in light of the knowledge and information available to FVB Energy at the time of preparation.

This report replaces the draft report of January 21, 2013.

Executive Summary

Background

The potential for a District Energy System in the vicinity of the planned Comox Valley Hospital was identified in a 2012 CVRD study of resource recovery opportunities in the region. This report provides the results of a more detailed study of the technical and economic feasibility of the District Energy System.

Methodology

Modelling of the system was based on the actual energy consumption of existing buildings, and the expected energy consumption of planned buildings. Estimates of capital and operating costs of the District Energy System were developed to estimate the price the City would need to receive for energy sold to clients from the system.

Conclusions

A District Energy System in Courtenay would be economically viable if potential clients pay $140/MWh of delivered heat. In order to make a correct comparison between the cost of purchasing heat from a District Energy System and the cost of their Business-as-Usual option, potential clients will need to carefully analyze their costs of providing heat to their buildings, including fuel costs, sales taxes, carbon tax, carbon offsets (for publicly-owned buildings), operations and maintenance, licensing and insurance, and the cost of owning boilers and related equipment over time. Potential clients will also need to assess the value of the price stability over time that district energy can provide.

The system would create three direct full-time jobs, in addition to the economic value related to the local supply of biomass.

The system would reduce greenhouse gas emissions by approximately 1,600 tonnes of CO2e per year, equivalent to 400 cars.

Deliveries of biomass to the system would result in a very modest truck traffic increase of 0.02% above the current levels.

Recommendations

The City of Courtenay should communicate the price for district energy indicated by this study to potential energy clients, including the Vancouver Island Health Authority, North Island College, the CVRD on behalf of the Aquatic Centre, and School District 71 on behalf of Queneesh Elementary School, and any other potential district energy clients in order to gauge their interest. If the response is positive, then the City should consider proceeding with the next steps in the development of the District Energy System, including entering Memoranda of Understanding with energy clients, securing long-term sources of biomass, seeking funding from senior levels of government, and engaging in stakeholder consultation.

Glossary

BAU	Business-as-Usual
BDT	Bone Dry Tonne of biomass
CVRD	Comox Valley Regional District
CO_2e	Carbon dioxide equivalent
District Energy System	District Energy System
DHW	Domestic Hot Water
EFLH	Equivalent Full Load Hours
FSR	Floor Space Ratio
GHG	Greenhouse Gas
GJ	Gigajoule of energy
GWh	Gigawatt hours of electricity
GWP	Global Warming Potential
HHV	Higher Heating Value of biomass
IRR	Integrated Resource Recovery
IRR	Internal Rate of Return
LEED	Leadership in Energy and Environmental Design
LHV	Lower Heating Value of biomass
MWe	Megawatts of electrical energy
MWt	Megawatts of thermal energy
MURBS	Multi-Unit Residential Buildings
VIHA	Vancouver Island Health Authority

Introduction

In January, 2012 Farallon Consultants Limited was engaged by the CVRD to find resource recovery options with the potential to reduce greenhouse gas emissions, support the local economy, and recover the cost of their initial investment.

The resulting report described two promising options: an anaerobic digestion facility that could produce biomethane from organic solid waste, and provide an estimated $3 million per year of greater value to taxpayers than the Business-as-Usual alternative, and a District Energy System in the area of the Comox Valley North Island College Campus.[1]

In May, 2012, the Vancouver Island Health Authority announced plans to construct two new hospitals on Vancouver Island: the Campbell River Hospital and the Comox Valley Hospital. The Comox Valley Hospital Master Program indicates a main building size of 29,500 m^2, and capacity for 180 beds. This announcement improved the potential for the District Energy System for two reasons. First, the Hospital's energy consumption would represent a significant part of the overall capacity of the District Energy System. Second, the Hospital could potentially benefit by saving the cost of a new boiler system, and by allocating space that would otherwise be required for boilers to health care services.

In October, 2012 the City of Courtenay engaged Farallon Consultants Limited to further investigate the feasibility, costs, and benefits of a District Energy System in the vicinity of the planned the Comox Valley Hospital. Farallon engaged FVB Energy Inc., a firm that specializes in district energy design, to model the energy loading and economics of the District Energy System. This report provides the results of the feasibility study.

[1] Farallon Consultants Limited. 2012. Integrated Resource Recovery Options for the Comox Valley Regional District. 127pp.

Description of the District Energy System

A District Energy System includes three main components: an Energy Centre, distribution piping, and Energy Transfer Stations within client buildings. The Energy Centre would include biomass boilers, pollution control equipment, natural gas boilers to meet peak demand and to provide back-up capacity, pumps, and controls. Hot water from the boilers is circulated to client buildings in a closed loop of insulated steel pipes, buried below the frost line. The Energy Transfer Stations within client buildings include heat exchangers with hot water from the distribution piping on one side of the exchanger, and water from the building's hydronic heating system on the other. The Energy Transfer Stations also include valves and controls that interface with the building's energy control systems, along with meters to measure the amount of energy delivered to each building.

During the CVRD's 2012 Integrated Resource Recovery study, the concentration of energy demand in the group of buildings near the North Island College was noted. This demand included buildings on the NIC campus, the Comox Valley Aquatic Centre, Queneesh Elementary School, the planned Comox Valley Hospital, and the planned Mission Professional Buildings. This cluster of buildings was of interest since the economics of district energy are favoured by concentrations of energy demand that exist within short distances.

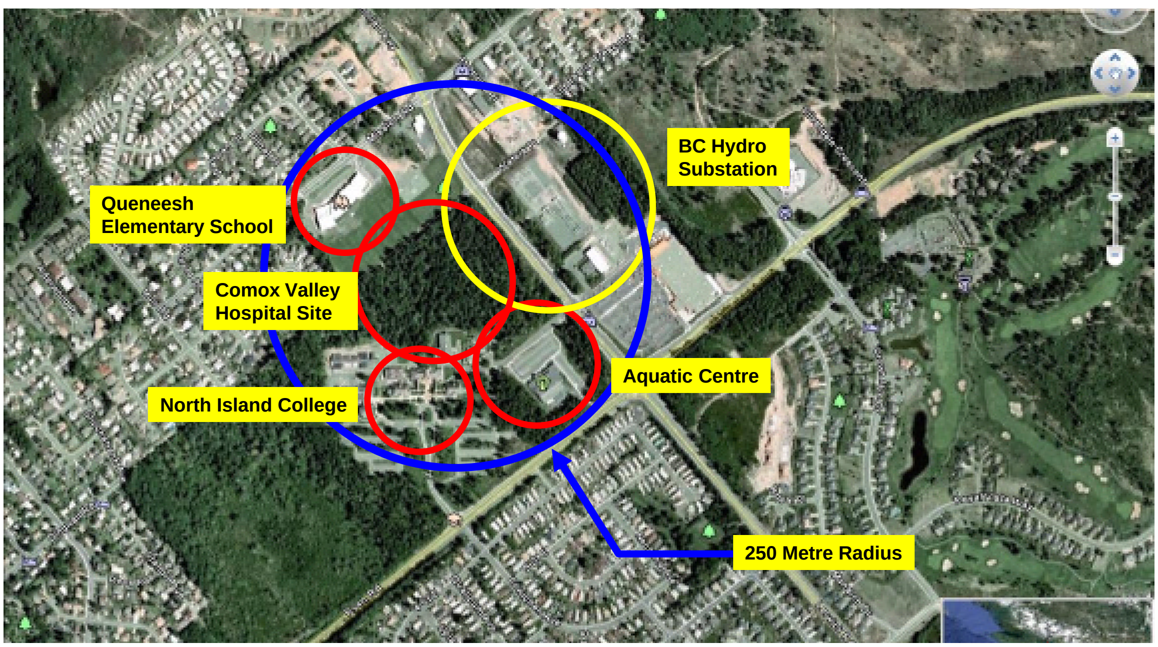

Figure 1. Courtenay District Energy System Building Clusters

On May 18, 2012 Stephen Salter, P.Eng. met with David Graham, Director of Facilities Management and Andrew Thomas, Manager of Facilities Management, North Island College to explore their interest in a District Energy System. This very positive meeting confirmed that the College is interested in low-carbon sources of energy, and in expanding its offering of hands-on trades training in sustainable energy.

Also on May 18, 2012 Stephen Salter, P.Eng. gave a presentation on district energy to the Vancouver Island Health Authority's Vancouver Island Facilities Maintenance and Operations Team. The potential for a District Energy System on or near the site of the planned Comox Valley Hospital was discussed, as well as the fortunate timing that could allow the energy systems of the new hospital to be designed to take the greatest advantage of sustainable energy sources. VIHA has expressed a strong interest in heating its buildings with low-carbon energy.

On May 23, 2012 Stephen Salter, P.Eng. was asked by Deanna Fourt, Director of Energy Efficiency and Conservation Facility Maintenance, VIHA to join a meeting among VIHA, Partnerships BC, and the technical consultants responsible for drafting the terms of reference and performance criteria for the planned Comox Valley Hospital. The option of drafting the performance criteria in such a way that the new Hospital could take advantage of low-temperature heat (for example from waste heat recovery) was discussed. The possibility of receiving energy from a District Energy System in which the energy source is outside the Hospital is of interest to VIHA, since this would allow space normally allocated to energy utilities to be reprogrammed for other uses.

A District Energy System based on low-carbon energy supplying energy to the CVRD's Comox Valley Aquatic Centre would support a number of objectives in the *Comox Valley Sustainability Strategy*.

District Energy Modelling

In order to assess the feasibility of developing a District Energy System in this area, information concerning energy consumption in the existing buildings was collected. Building owners were also asked for their views concerning the option of connecting their buildings to a District Energy System supplied from a low-carbon source. The existing buildings were also toured, to interview operators and to uncover any practical or technical challenges to connecting these buildings to a District Energy System. For planned buildings, the energy consumption of comparable structures was used, with allowances for the greater energy efficiency of new buildings.

Cooling demand in the existing buildings included in this Study is not significant. The planned Comox Valley Hospital however is very likely require cooling, which could be provided through absorption or adsorption chillers with heat energy provided by the District Energy System.

Table 1 below lists the information collected for existing buildings.

Table 1: District Energy System Building Data

Building Information	Heating System	Domestic HW System
Building Name Building Type Year Built Ownership (Public/Private) Building Size Address Name of the Owner Name of the Manager Contact Information	Boiler Make, Type, and Fuel Boiler Capacity Boiler Efficiency Boiler Installed Date Supply Temperature Return Temperature	Boiler Make, Type, and Fuel Boiler Capacity Boiler Efficiency DHW Storage Capacity Supply Temperature

Building energy information was then analyzed, and potential District Energy System routes were tested. Estimates of capital costs and ongoing maintenance, administration, and administration costs were developed. This information was then processed in a model to estimate the price at which energy would need to be sold in order for the district energy utility to cover its costs. In addition, the environmental and social aspects of the District Energy System were evaluated.

Over 90% of the energy would be consumed by publicly-owned buildings. The cost of energy for these buildings includes not only the carbon tax at $1.50 per GJ of natural gas, but also the cost of carbon offsets to achieve carbon neutrality at $1.25 per GJ of natural gas.

Table 2 below summarizes the estimated energy demand in buildings that have been included in the feasibility study. The Aquatic Centre figures only include energy consumption for heating water.

Table 2: Estimated Building Energy Consumption

Building Name	Ownership	Building Area (m^2)	Peak Heating Load (Output) (kW)	Displaced Heating Energy (MWh/yr)	Displaced Full Load Hours (Hrs/yr)	Estimated Seasonal Boiler Efficiency (%)	Total Gas Use (GJ/yr)	Total Gas Use per m^2 ($MJ/yr/m^2$)
Existing								
Queneesh Elementary School	Public	5,745	340	370	1,088	70%	1,879	327
NIC: Discovery Hall	Public	1,923	120	260	2,167	60%	1,585	824
NIC: Raven Hall	Public	1,284	80	180	2,250	60%	1,058	824
NIC: Puntledge Hall	Public	1,442	90	200	2,222	60%	1,188	824
NIC: Komoux Hall	Public	2,417	150	330	2,200	60%	1,992	824
Aquatic Centre	Public	N/A	300	790	2,633	60%	4,766	N/A
Planned								
Comox Valley Hospital	Public	29,000	2,030	4,930	2,429	70%	25,354	874
Mission Professional North	Private	2,649	160	280	1,750	70%	1,457	550
Mission Professional South	Private	2,769	170	300	1,765	70%	1,523	550
Totals:			**3,440**	**7,640**			**40,802**	
Distribution Losses:				3%				
Diversification:			90%					
Total After Diversification & Losses:			**3,100**	**7,900**				

Sustainable Energy Sources

In the course of the CVRD Integrated Resource Recovery Study, the option of recovering waste heat from transformers in BC Hydro's Courtenay Substation (which is located within a few hundred metres of the Courtenay District Energy System) was analyzed. Heat pumps would be required to recover waste heat from utility transformers, an approach that has been used elsewhere. [2] A recent example of this form of heat recovery was completed in London's Bankside Substation, which began to provide 600 kW of heat to the adjacent Tate Modern art gallery in 2011. Representatives of BC Hydro were contacted regarding their interest in this arrangement, and responded that the utility will not pursue heat recovery from substations at this time.

Biomass boilers were chosen for modelling in this Study. The advantages of biomass as a source of energy for the Courtenay District Energy System are:

- Biomass can provide energy at high-temperatures, which will be compatible with existing building energy systems as well as new buildings, and makes the further option of adsorption chilling possible;
- Biomass combustion would reduce greenhouse gas emissions by displacing natural gas in buildings served by district energy;
- Biomass in the form of urban wood waste and industrial wood residues is available in the Comox Valley; and
- Unlike natural gas, biomass fuel can be stored on the Energy Centre site, and also on the site of the local provider. This ability to store fuel contributes to the energy security of the District Energy System.

Biomass boilers can also be equipped with pollution controls to limit particulate emissions to levels that are comparable to emissions from natural gas boilers (air emissions are addressed in section the Environmental Aspects section of this report).

[2] Zhao, Y. et al. 1995. A heat-pump system for heat recovery at a substation. Energy, Volume 20, Issue 3, March 1995, Pages 243–245.

The table below shows the quantities of biomass that would be required for the District Energy System.

Table 3: Biomass Fuel Requirements

		Units	**Notes**
Quantity Required, Green	4,600	Green Tonnes/Year	1.
Quantity Required, BD	2,800	BDT/Year	
Traffic	4.5	Trucks/Week	2.
Ash	80	BDT/Year	3.
Storage Required, Days	2	Days	
Storage Required	45	m^2	

Notes

1. Based on an average moisture content of 40% for urban wood waste.
2. Based on 20-tonne tractor-trailers.
3. Based on an ash content of 3%. This quantity of ash would require one 20-tonne truck every 3 months.

In the course of this Study, several firms involved in sourcing and processing waste wood in the Comox Valley were contacted in order to develop an opinion of the availability and likely price of biomass. This background work showed that biomass is available in the quantities that would be required by the District Energy System, at an estimated average price of $45/BDT.

Further, the City of Courtenay may have access to a second, independent source of biomass. Approximately 5,000 tonnes/year of wood that is currently used for composting biosolids would become surplus if the CVRD chooses to develop an Integrated Anaerobic Digestion Facility. This facility is estimated to provide approximately $3 million/year of greater value to Comox Valley taxpayers than the Business-as-Usual alternatives for organic solid waste.[3]

[3] Farallon Consultants Limited. 2012. Integrated Resource Recovery Options for the Comox Valley Regional District. 127pp.

District Energy Routing

The optimum routing for a district energy network is shown in the figure below. During the detailed design stage of a District Energy System, it may be possible to further optimize the route, taking into account the potential locations of additional future demand.

Figure 2: District Energy Routing Modelled in the Study

Potential Energy Centre Locations

Figure 2 shows a conceptual routing for the district energy piping, and for the Energy Centre. The Energy Centre is shown roughly in the centre of the cluster of potential district energy client buildings in order to minimize the length and cost of distribution piping.

Ideally, a location for the Energy Centre would be chosen that would provide North Island College personnel with access to support their sustainable trades training curricula, and that would address VIHA's need to comply with the CSA standard Z317.2-10.[4] Our understanding of this standard is that if the source of district energy is located on VIHA property, then the Hospital would not need to incorporate a back-up source of heat. One option that could meet the interests of both VIHA and the North Island College could be to locate the Energy Centre on the boundary of the two organizations' properties.

The table below shows the capacities of equipment that would be required for the Courtenay District Energy System.

Table 4: Energy Centre and District Energy System Capacities

	District Energy System	Units	Notes
Peak System Demand	3.1	MW	1.
Displaced Heating Energy	7,900	MWh/yr	1.
Biomass Boiler Capacity	1.0	MW	2.
Peaking and Back-up Boiler	2.0	MW	3.
Peaking and Back-up Boiler	2.0	MW	3.
Total Capacity	**5.0**	MW	
N-1 Capacity	3.0	MW	4.
Length of Distribution Piping	1,220	m	
Number of Energy Transfer Stations	9		

Notes

1. Based on modelling of the actual energy consumption of existing buildings, and the estimated energy consumption of planned buildings.
2. The biomass boiler would be base-loaded, and although its capacity would only be

[4] Canadian Standards Association. 2010. CSA Z317.2-10 Special requirements for heating, ventilation, and air-conditioning systems in health care facilities. 90pp.

approximately 30% of the peak capacity, it would provide approximately 85% of the total energy required.

3. Two natural gas boilers would provide redundancy.
4. 15% of total energy provided by back-up boilers and peaking boilers
5. This would be the capacity available in the event that either of the largest boilers was unavailable.

Future Developments

At the time of this Study, the CVRD was considering potential locations for a new office facility, with the design and location to be chosen within the next few years.

The City of Courtenay has also been considering the option of building a new fire hall in the vicinity of the North Island College. If the fire hall and CVRD office are both located near the Courtenay District Energy System, then these buildings could also be served by a District Energy System. Further, the *Comox Valley Sustainability Strategy* calls for new CVRD buildings to achieve LEED Gold accreditation.[5] Connection to a low-carbon source of heat would make it simpler to achieve this accreditation.

As the Courtenay District Energy System undergoes further development, the costs and benefits of providing additional capacity in the system for future growth can be modelled.

Shared Interests in the District Energy System

British Columbia is experiencing a shortage of Power Engineers, and the North Island College has expressed its interest in expanding its sustainable energy offerings.[6] If an arrangement can be made for the NIC to have access to the Energy Centre, then opportunities for hands-on trades training and research could result.

If the Courtenay District Energy System is developed, the new Comox Valley Hospital could potentially be designed without a conventional energy plant. Space and capital that would otherwise be consumed by this plant would be available for other healthcare purposes. The Hospital could also be designed to take advantage of cooling from district energy by means of adsorption chillers.

The Courtenay District Energy System would also support a number of objectives in the *Regional Growth Strategy* and the *Comox Valley Sustainability Strategy*.

Finally, any new buildings served by the Courtenay District Energy System would qualify for LEED credits in the area of sustainable energy.

[5] Leadership in Energy & Environmental Design

[6] Personal communication between Stephen Salter, P.Eng. and David Graham, Director of Facilities Management, North Island College.

Capital Cost Estimates

Energy Centre

The Energy Centre capital cost estimate is based on a delivered total heating capacity of 3.1 MWt from a combination of natural gas and biomass boilers. Major equipment in the Energy Centre would include:

- One of 1 MWt biomass boiler equipped with an economizer;
- An electrostatic precipitator for the biomass boiler;
- Two of 2 MWt natural gas boilers without economizers;
- Primary variable speed distribution pumps with pump controllers;
- Boiler circulation pumps;
- An emergency generator with capacity for one natural gas boiler and circulation pump, and one primary distribution pump;
- One 12 m tall biomass boiler stack, and one 12 m tall stack for the natural gas boilers.

Table 5: Capital Cost Summary, Energy Centre

Energy Centre Cost Estimate	Installed Capacity	($)
Natural Gas		
Architectural/Civil/Structural	104 m2	$307,000
Electrical Installation	500 kVA	$240,000
Mechanical Installation	4 MWt	$489,000
Process Equipment	4 MWt	$377,000
GC Admin OH & P, Const Mgmt, and HST		$250,000
Subtotal Construction		**$1,663,000**
Soft Costs		
Engineering		$191,000
Design Contingency		$166,000
Construction Contingency		
Natural Gas SubTotal		**$2,020,000**
Biomass Module		
Architectural/Civil/Structural	110 m2	$321,000
Electrical Installation	500 kVA	$110,000
Mechanical Installation	1 MWt	$193,000
Process Equipment	1 MWt	$883,000
GC Admin OH & P, Const Mgmt, and HST		$265,000
Subtotal Construction		**$1,772,000**
Soft Costs		
Engineering		$168,000
Design Contingency		$177,000
Construction Contingency		
Biomass Module SubTotal		**$2,117,000**
Grand Total (incl. Tax)		**$4,137,000**

Detailed Costing Assumptions

Cost estimates assume purpose-built structures as follows:

- A building housing the boilers, pumps, heating system auxiliaries, electrical room, and staff areas of 104 m^2, with an assumed building height of 6 m at a cost of $250 per square foot;
- A building housing the biomass combustion unit of 65 m^2, with an assumed building height of 13 m at a cost of $250 per square foot;
- A fuel storage area of 45 m^2, sized for 50 hours of storage at 1 MWt output, at a cost of $175 per square foot;
- Required utility services are assumed to be available at the lot line;
- Generally all process areas assumed to be 8 inch thick reinforced concrete slab on grade;
- Exterior primary transformers, ESP, and heat dump radiators on concrete pads;
- Allocation for electric utility primary service and plant substation; and
- Installation assumed to be via single lump sum contract with general contractor.

Source of Cost Data

Generally the Energy Centre capital has been estimated using the following:

- FVB in house data base from previous community energy projects; and
- Unit costing from Means 2nd Quarter 2012 Costing for the City of Victoria.

Construction Soft Costs

Construction soft costs include for the following:

- 7.5% for General Contractor OH&P;
- 2.5% for permitting, bonding, & insurance;
- 2.5% for construction management & supervision; and
- 12% for Harmonized Sales Tax.

Owner's Soft Costs

Owner's soft costs include engineering costs, design and construction support, and design & construction contingency.

Exclusions

The budgets exclude:

- LEED Accreditation;
- Land costs;
- Legal fees and expenses;
- Loose furnishings and equipment;
- Erratic market conditions, such as lack of bidders;
- Accelerated schedule;
- Site environmental evaluation and remediation if needed; and
- Blasting or significant bedrock removal.

Accuracy of Costing Assumptions

The cost estimates provided are based on concept sketches and are preliminary with an accuracy of -20% to +45%.

Distribution Piping

The distribution piping capital cost has been estimated based on the following:

- Medium Temperature Hot Water (MTHW) System, European st37.0, DIN 2458 (EN253 Standard) thin walled steel pipe, insulated with polyurethane foam insulation, High Density Polyethylene outer jacket and a built-in leak detection system;
- Design Conditions:
    - Supply Temperature: 115 °C
    - Return Temperature: 75 °C
    - Design Pressure: 1,600 kPa (232 psig)

- Piping costs include mechanical (material & installation) and civil costs;
- Communication conduits and wiring are included along the distribution routing;
- An allocation is made for manholes, mobilization and demobilization, road crossing planning and barricading, and x-ray testing.

Table 6: Capital Cost Summary, Distribution Piping

		Heating ($)
Distribution Piping		
Mechanical - Material & Installation	1,220 m	$360,000
Civil - Excavation, Backfill & Reinstatement	1,220 m	$466,000
DPS Subtotal		**$826,000**
Construction Soft Costs		
Contractor Admin., Bonding, Insurance & OH&P	20.0%	$165,000
Construction Management & Supervision	4.0%	$33,000
Construction Change Allowance	3.0%	$25,000
Harmonized Sales Tax	12.0%	$99,000
Construction Soft Costs Subtotal		**$322,000**
Owner's Soft Costs		
Engineering (Design & Construction Support)	10.0%	$115,000
Contingency (Design & Pricing)	10.0%	$115,000
Owner's Soft Costs Subtotal		**$230,000**
DPS Total		**$1,378,000**

Detailed Costing Assumptions

- All distances are based on Google Maps;

- Trench depth allows for 900 mm cover to top of pipe;
- Price includes supply and return lines;
- Pricing assumes LOGSTOR Series 1 insulation;
- Installation assumed to be via single lump sum contract with the general contractor;
- Mechanical and civil costs include allowance for mobilization and demobilization, subcontractors, bonding and insurance;
- Off-site hauling has not been included;
- U-loops are assumed for expansion purposes;
- Assumes 10% of welds will be x-ray tested; and
- Welded isolation ball valves are included in the cost for each branch connection (inside building penetration).

Source of Cost Data

Generally the distribution piping capital has been estimated using the following:

- FVB in house data base from previous community energy projects; and
- Unit costing from Means 3rd Quarter 2012 Costing for the City of Victoria.

Construction Soft Costs

Construction soft costs include for the following:

- 4% for construction management and supervision;
- 20% for General Contractor OH&P, administration, bonding & insurance; and
- 12% for Harmonized Sales Tax.

Owner's soft costs include engineering costs, design and construction support, and design & construction contingency.

Exclusions

- Blasting or significant bedrock excavation;
- Easement procurement;
- Premium time (for off-hours work or an accelerated schedule);
- Permitting;
- Owner's project development, marketing of service, and accounting costs;
- Owner's project management or onsite inspector/supervisor;
- Third party QA/QC inspection;
- Inflation;
- Erratic market conditions, such as lack of bidders; and
- Escalation for deferred, phased or future works.

Accuracy of Costing Assumptions

The cost estimates provided are based on concept sketches and are preliminary with an accuracy of -20% to +35%.

Energy Transfer Stations

In general the energy transfer station costs are based on the following:

- The costs are representative for the design and construction of multiple Energy Transfer Stations (i.e. a minimum of four) in the same phase of work;
- ETS costs reflects an indirect connection (via heat exchangers) based on a district heating supply temperature of 115 °C; and
- ETS costs include primary side piping, equipment and instrumentation with additional costs added as necessary for internal piping to reach mechanical rooms and to include building secondary system modifications.

Table 7: Capital Cost Summary, Energy Transfer Stations

Energy Transfer Station		Heating ($)
4500 kW of Heating (9 Heating ETS's)		
Owner Supplied		
Heat Exchangers		$60,000
Isolation Valves		$15,600
Controls & Metering		$141,600
Owner Supplied Subtotal		**$217,200**
Contractor Supplied		
Mechanical & Electrical Material and Installation		$663,700
Additional Primary & Secondary Modifications		$170,000
Contractor Supplied Subtotal		**$833,700**
Construction Soft Costs		
General Contractor Overhead and Profit		Included
Construction Management and Supervision	4%	$42,000
Harmonized Sales Tax	12%	$126,100
Subtotal Construction		**$168,100**
Owner's Soft Costs		
Engineering (Design, Construction and Commissioning Support)	15%	$182,900
Contingency	10%	$121,900
Subtotal Owner's Soft Costs		**$304,800**
Total ETS Cost (w/ Taxes)		**$1,523,800**

Detailed Costing Assumptions

- Pricing reflects a combined commercial grade control system and thermal metering;
- Pricing reflects all primary side and a set of main secondary isolation valves; and
- Typically pricing assumes sufficient floor space for the ETS in a ground or basement level mechanical room within 10 metres of the DPS penetration, unless otherwise noted.

- **Comox Valley Hospital:**
  - Space heating: Two heat exchangers at 65% of peak load capacity each for 2,650 kW of total installed capacity.
  - Domestic hot water: Two heat exchangers at 50% load each for 1,160 kW of installed capacity.

- **Queeneesh Elementary School:**
  - Space heating: One heat exchanger at 120% capacity, 400 kW installed capacity.
  - Domestic hot water: One heat exchanger at 100% capacity, 115 kW installed capacity.
  - ETS room located on the second floor near the back of the building.

- **North Island College Discovery Hall:**
  - Space heating: One heat exchanger at 120% of peak load, installed capacity 150 kW.
  - No domestic hot water heat exchanger.
  - ETS room located in the centre of the building and would require removal of one of the boilers.

- **North Island College Raven Hall:**
  - Space heating: One heat exchanger at 120% capacity, installed capacity 100 kW.
  - No domestic hot water heat exchanger.
  - Allowance for ETS room not located within 10m of basement exterior wall.

- **North Island College Puntledge Hall:**
  - Space heating: One heat exchanger at 120% capacity, installed capacity 100 kW.
  - No domestic hot water heat exchanger.
  - Allowance for ETS room not located within 10m of basement exterior wall.

- **North Island College Komoux Hall:**
  - Space heating: One heat exchanger at 120% capacity, installed capacity 150 kW.
  - No domestic hot water heat exchanger.
  - ETS room located in the second floor / penthouse of building.

- **Aquatic Centre:**
  - Space heating: Three heat exchangers at 160% capacity each, total installed capacity 500 kW.
  - No domestic hot water heat exchanger.
  - ETS room located in the centre of the building and would require removal of one of the boilers.

- **Mission Professional North and South:**
  - Separate ETS for the North and the South buildings.
  - Space heating: One heat exchanger at 120% capacity, installed capacity 200 kW, for each building.
  - Domestic hot water: One heat exchanger at 100% capacity.
  - ETS room located in the centre of the building and would require removal of one of the boilers.

Source of Cost Data

Generally the energy transfer station capital has been estimated using FVB in house data base from previous community energy projects.

Construction Soft Costs

Construction soft costs include the following:

- 4% for Construction Management and Supervision;
- General Contractor OH&P is included; and
- 12% for Harmonized Sales Tax.

Owner's Soft Costs

Owner's soft costs include engineering costs, design and construction support, and design & construction contingency.

Exclusions

- Premium time (for off-hours work or an accelerated schedule);
- Asbestos or other hazardous material abatement;
- Removal of existing equipment;
- Cost of permitting;
- Owner's project development, marketing of service, and accounting costs;
- Owner's project management or onsite inspector/supervisor;
- Commissioning of system;
- Third party QA/QC inspection;
- LEED Accreditation/certifications;
- Erratic market conditions, such as lack of bidders;

- Inflation; and
- Escalation for deferred, phased or future works.

Accuracy of Costing Assumptions

The cost estimates provided are based on concept sketches and are preliminary with an accuracy of -20% to +35%.

Economic Aspects

Pricing of District Energy

District energy is 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 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. The price of district energy accounts for this fact, since district energy is priced on the basis of heat actually provided to the building. This total cost of energy is higher in smaller buildings than in larger ones.

In addition, the cost of natural gas is only one part of the cost of delivering heat to a building, which 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 over time

The capital and operating cost estimates for district energy in the current study include all costs to provide energy to a building, including the Energy Centre, distribution piping, and energy transfer stations (consisting of heat exchangers and controls). Building owners would not pay to connect to the District Energy System.

Estimated District Energy Rates

To test the economic viability of the Courtenay District Energy System, the capital costs, annual costs, and potential annual revenues from sales of energy to clients were modelled. The analysis is included here to give a preliminary indication of whether or not the net value of the system would be positive. The analysis is somewhat conservative since it does not take into account the value to VIHA of the avoided capital cost of an in-house energy plant in the planned Comox Valley Hospital.

The analysis is based on a nominal interest rate of 4.65% from the Municipal Finance Authority (MFA). Because the MFA accrues interest on the principal repaid by a municipality, the actuarial or effective interest rate for a 25-year amortization is approximately 2.54%. Other financial and technical assumptions are shown in Appendix I - Assumptions and Inputs.

Revenues received by the District Energy System utility were modelled to consist of two parts: a capacity charge of $19.65/month per kW of required capacity, and a consumption charge of $0.03/kWh. This combination would result in an average, blended energy price to clients of $140/MWh. These rates were chosen to cover the estimated annual costs of operations, maintenance, depreciation, financing charges, biomass fuel, and natural gas for back-up and peak demand.

Individual clients would need to accurately assess their Business-as-Usual costs to determine if it is advantageous for them to subscribe to the Courtenay District Energy System. To make a correct comparison between of the cost of purchasing heat from a District Energy System and the cost of the Business-as-Usual option, potential clients will need to carefully analyze all costs of providing heat to their buildings, including fuel costs, sales taxes, carbon tax, carbon offsets for publicly-owned buildings, operations and maintenance, licensing and insurance, and the cost of owning and replacing boilers and related equipment over time. Potential clients will also need to assess the value of the price stability over time that district energy can provide.

Previous feasibility studies by the Study Team found that the overall cost of the natural gas Business-as-Usual option was relatively insensitive to a reduction in the price of natural gas. In one study, a natural gas price reduction of 25% for example, would only reduce the total cost of producing heat from natural gas by approximately 11%. This is a result of the fact that the cost of fuel is only one component of the overall cost of supplying energy to a building.

Environmental Aspects

Greenhouse Gas Emissions

It is conservatively assumed that none of biomass for the Courtenay District Energy System would be diverted from landfills. If biomass is in fact diverted from landfills to the Courtenay District Energy System, the resulting greenhouse gas reductions would be significantly greater as a result of avoided methane emissions from decomposing wood in the landfill.

The District Energy System would result in a net reduction in greenhouse gas emissions in the City of Courtenay of 1,628 tonnes/year of CO_2e, as shown in the table below.

Table 8: Greenhouse Gas Emission Reductions

Source	**BAU (Natural Gas)**	**Energy System (Biomass)**	**Notes**
Natural Gas Boilers	1,976	260	1.
Biomass Combustion	-	88	2.
Total	**1,976**	**348**	3.

<u>Notes</u>

1. Units are in tonnes/year of CO_2e.
2. Although carbon dioxide from biomass is considered in the *BC Reporting Regulation Methodology Manual* 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. Calculations for emissions related to combustion of natural gas and biomass were completed per the *BC Reporting Regulation Methodology Manual*.

Air Emissions

Particulates are the most notable emission from biomass boilers. The biomass boiler modelled in this study would incorporate air pollution controls in the form of an electrostatic precipitator to limit particulate emissions

For perspective, BC Ministry of Environment permit limits on average particulate emissions from pulp and paper mill biomass boilers (approximately fifty times larger than the system described for the North Island College District Energy System) are typically between 135 mg/m^3 and 320 mg/m^3 of stack gases. On the other hand, particulate emissions from the Courtenay District Energy System are expected to be less than 10 mg/m^3, which is only slightly higher than the particulate emissions from natural gas boilers.

The criteria air emissions for a biomass energy system were compared with the emissions from natural gas boilers that would otherwise be used to supply heat to the four buildings, are summarized in the table below. The table compares the estimated air emissions from existing natural gas boilers with expected emissions from a biomass boiler. The table shows that a District Energy System based on biomass would reduce greenhouse gas emissions, but would also result in slightly higher emissions of conventional pollutants such NOX.

Table 9: Comparison of Air Emissions

	Units	BAU (Natural Gas)	Energy System (Biomass)	Change	Notes
GHG Emissions	tonnes CO_2e/yr	1,976	348	-1,628	
Particulates	mg/m^3	9	<10		1.
	tonnes/yr	0.13	0.18	0.05	
NOX	mg/m^3	49	194		2., 3.
	tonnes/yr	1.5	3.4	1.9	
CO	mg/m^3	91	529		3.
	tonnes/yr	1.3	9.4	8.1	
SOX	mg/m^3	1	21		3.
	tonnes/yr	0.01	0.39	0.38	
VOCs	mg/m^3	6	15		3.
	tonnes/yr	0.08	0.26	0.18	

Notes:

1. The biomass boiler would be equipped with pollution control equipment to limit particulate emissions. As a result, the additional particulate emissions, over and above the emissions from existing natural gas boilers, would be equivalent to the annual output of a single EPA-approved wood stove.[7] For a second comparison, the additional particulate emissions from the biomass boiler would be equivalent to the emissions from a single public transit bus.[8]

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[7] US EPA.2013. List of EPA Certified Wood Stoves January 15, 2013, 23pp.

[8] Transport Canada. Urban Transportation Emission Calculator, CAC Emission Factors. (http://wwwapps.tc.gc.ca accessed in December, 2012).

2. At the time of this study, the CVRD had not established an air quality bylaw with limits for criteria pollutants. The Metro Vancouver Bylaw No. 1087-2008 however includes the following limits:
    a. For new natural gas boilers, a NOX limit of 60 mg/m^3
    b. For biomass boilers, a particulate limit of 18 mg/m^3
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.[9]

Other Environmental Aspects

The Courtenay District Energy System will also produce approximately 80 tonnes of ash per year. Research is underway in other jurisdictions to find high-value uses for this ash, including blending with compost. In the worst case, the CVRD could be approached concerning the option of using the ash for landfill cover.

The Courtenay District Energy System will not consume significant quantities of water, which will circulate in a closed loop within the system.

Biomass storage would be covered to limit contact with rainwater. Any water from biomass would be collected and discharged to the sanitary sewer. As a result, it is not expected that contained biomass storage would present a risk of contamination to groundwater.

The Courtenay District Energy System would conserve approximately 33,000 GJ/year of natural gas. This estimate includes natural gas required for the District Energy System's back-up and peaking boilers.

The City of Courtenay could consider incorporating other services within the District Energy System trenching, such as a dedicated pipe to provide buildings with reclaimed water at a later date.

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

Regulatory Aspects

Implementing a District Energy System in the City of Courtenay will not require regulatory changes. The City will however need to discuss the requirements for an air permit with the Ministry of Environment.

Concerning connections to a District Energy System, some local governments have mandated that new buildings connect to existing District Energy Systems. In the authors' discussions with building owners however, many have expressed their preference to retain the right to choose to connect, based on their estimation of savings. When building owners have been mandated to connect to District Energy Systems, they may believe that if connection is mandatory, it must not be beneficial to their interests. An alternative could be to require new buildings to be designed to take the greatest advantage of district energy, should their owners choose to connect.

Social Aspects

The following social aspects of district energy are discussed in this section:

1. Stakeholder Consultation
2. Local Jobs and Business
3. District Energy System/Community Integration Impacts
4. Public Education and Amenities
5. Impacts on Private Property
6. Quality of Service

Stakeholder Consultation

In the process of developing a District Energy System, the City of Courtenay will need to identify and engage with the stakeholders such as:

- The Vancouver Island Health Authority
- Faculty and Staff of North Island College
- Comox Valley School District 71
- Comox Valley Regional District (operator of the Aquatic Centre)
- City of Comox
- Neighbourhood Associations
- Ministry of Environment

Issues which may be of interest to stakeholders are likely to include the economics of district energy, changes in air emissions versus Business-as-Usual, changes to greenhouse gas emissions, and any noise and traffic associated with biomass deliveries.

The City of Courtenay could engage a specialist to ensure that the community consultation process is fully transparent and provides value to the City and stakeholders. It will also be helpful to provide scale to the questions of truck traffic and air emissions, using information about current conditions and the natural gas BAU option.

In the consultation process, the City of Courtenay could point out that developing a District Energy System involves incorporating an element of our energy supply infrastructure into the City that is normally invisible in Canada. The environmental, health, and safety impacts of the Business-as-Usual (fossil fuel exploration, extraction, refining, and delivery) are invisible to urban citizens, and hence normally out of mind.

Regarding greenhouse gas emissions, the District Energy System would result in reductions comparable to removing approximately 400 cars from the City of Courtenay, and this fact could be a good starting point for discussions with stakeholders.

Traffic

Deliveries of biomass to the District Energy System are expected to result in an increase in traffic of 4.5 trucks per week, which represents a modest increase in local traffic. To put this in perspective, a 2012 study into the anticipated effects on traffic of the Comox Valley Hospital:

1. Measured the 2011 afternoon peak (3-4PM) traffic Eastbound on Ryan Road at approximately 720 vehicles per hour, and Northbound on Lerwick Road at approximately 760 vehicles per hour.
2. Estimated that the Hospital would generate approximately 456 trips in the morning peak (8 to 9AM) and 483 trips in the afternoon peak (3-4PM).[10]

As such, the addition of 4.5 trucks per week to deliver biomass to the District Energy System would represent an increase of 0.02% above the volumes of traffic in the two daily rush-hour periods.

The fuel delivery system can be designed to allow trucks to travel in one direction only while unloading wood chips, to avoid noise from back-up alarms. The City would also be able to choose the best time of day for deliveries in order to coincide with the least busy traffic periods.

Local Jobs and Business

The financial modelling in this study resulted in an estimate of the ongoing costs of direct labour of $180,000 per year, the equivalent of three full-time jobs.

In general, the development of a District Energy System involves a substitution of infrastructure for fossil fuel. The Business-as-Usual (BAU) fossil fuel is consumed but not produced in the City, whereas the work to construct, operate and maintain the District Energy System would be done to a large extent within the City. More importantly, some sustainable energy technologies use fuel produced in the City. For example, local businesses would be involved in sourcing, preparing, and delivering biomass fuel to the District Energy System. Therefore, establishment of the District Energy System is expected to create incremental jobs and opportunities for businesses to supply goods and services during both the construction and operating stages. In turn, these businesses purchase parts and other goods and services from other businesses thereby creating indirect jobs. These indirect jobs are referred to as Tier 2 and Tier 3 effects in the reference discussed below used as a guide in this analysis.

Further, some of the additional income of workers and businesses will be re-spent thereby inducing further employment. The indirect and induced employment could, in theory, be estimated roughly using economic multipliers against the direct jobs, if suitable economic multipliers were available. In reality, validated economic multipliers for these specific types of jobs applied specifically to the City of Victoria are not available to the best of FVB's knowledge. However, the analysis may still be worthwhile as a comparative, and an illustrative, exercise using factors

[10] Opus International Consultants. 2012. Vancouver Island Health Authority North Island Hospitals Project Comox Valley Hospital Transportation Impact Assessment. 94pp.

that have been used in other studies. Clearly, the local employment factors for biomass are higher than for natural gas or electricity. It is useful, in the context of this study, to suggest some quantitative estimates.

In the case of the Courtenay District Energy System, the fuel that would be displaced is natural gas. The reduction in cost to customers for energy commodities achieved by the District Energy System, possibly supplemented with funding assistance from senior levels of government, would notionally pay for *most of* the wages of the jobs created and other inputs to construct operate and maintain the District Energy System. The qualifier "most of" is used because the District Energy System creates other savings to customers in the capital, replacement capital and operation and maintenance cost of in-building heat systems. Reduction of BAU capital and operating cost for in-building heating systems eliminates jobs to an extent, but the BAU work is not so much eliminated as diverted to more valuable activities.

For example, building operators can devote more attention to running a better building to the benefit of the owners and occupants after being liberated from the chore of looking after the heating system, because it no longer needs so much care when it consists of a simple heat exchanger that is any case the responsibility of the District Energy System. Similarly, the manufacturers and engineers who would have otherwise have been employed to supply and install inefficient building heating systems can instead devote their efforts to developing more efficient and sustainable systems not only for building heating but in other fields that contribute to enhanced sustainability of the community.

Therefore, no attempt will be made in this analysis to offset the jobs created by the District Energy System with any "lost" in the BAU scenario. Even with this simplification, precise quantitative estimation of the economic development impact is still complex, being very place, time and technology dependent, with little simple guidance or relevant data readily available.

One simple guide recommended by Natural Resources Canada that appears to be applicable and reasonable is a paper that was published in 2006 by a university professor in Denmark entitled Socio-economic and Regional Benefits Employment Assessment. The recommended method is a production chain analysis. For simplification, only Tier 1, i.e. direct jobs, are estimated in this analysis, which, by itself would provide too conservative results. As a result, these are then grossed up using economic multipliers. The best approach readily available that has some validity, especially in a comparative exercise, is to use multipliers that FVB has used for a similar purpose drawn from a recent economic study in another community in western Canada[11].

The average number of jobs per year created locally are calculated from dollars spent, the local share, the share of wages and the average wages in dollars per year. This is done for capital investment, non-fuel operation and maintenance (O&M) and fuel and summed, after dividing the number of jobs from capital investment by the years in the study period to get the average per year during the study period. This methodology seems quite logical and clearly points to the importance of fuel type as the most significant factor in social impact.

The methodology and results are summarized in the table below using most of the same factors as estimated in the referenced paper for the local share (30% for capital, 80% for O&M, 100% for

[11] Edwards School of Business. 2010. Saskatoon Airport Authority – Economic Impact Study 2010. 38pp.

biomass fuel and 0% for fossil fuel or electricity) and the share of wages at 50% for O&M. Whereas the referenced paper uses 8% as the share of wages for the capital investment, 50% (similar to O&M) is considered more reasonable in the B.C. context, after also factoring for local share.

Table 10: District Energy System Jobs and Business Generation

Capital	
Local Share	30%
Share of Wages	50%
Average Wage - k$	60
O&M	
Local Share	80%
Share of Wages	50%
Average Wage - k$	60
Fuel	
Local Share	100%
Share of Wages	50%
Average Wage - k$	60
Years of Analysis Period	*25*
Capital Investment - k$	27,800
Local Share - k$	8,340
Share of Wages (50%) - k$	4,170
Jobs - person years	70
Jobs - average (over 25 years)	3
O&M (2012$) (25 years) - k$	29,000
Local Share - k$	23,200
Share of Wages (50%) - k$	11,600
Jobs - person years	193
Jobs - average over 25 years	8
Fuel (2012$) (17 years) - k$	34,858
Local Share - k$	34,858
Share of Wages (50%) - k$	17,429
Jobs - person years	290
Jobs - average over 17 years	12
Local Jobs	22
Total local business - k$/year	2,656

On the whole, the method and the factors seem reasonable as applied to heat energy projects, which was the subject of the referenced paper.

The average wage used in this analysis is $60,000 per year, which is the median for an Operations Manager in British Columbia, according to www.payscale.com.

To be clear, the O&M shown in the table above includes all O&M costs except fuel. The results shown are, for simple presentation purposes, the average each year for 25 years starting in year 1 - although in reality there may be a build-up corresponding to the phased build-out of the District Energy System.

The total economic development impact including indirect and induced local jobs and total income to local business would be represented by the amounts shown multiplied by appropriate economic multipliers. These are difficult to derive with a high level of confidence for a specific project. It is proposed to use the multipliers inferred recently in relation to airport jobs (Saskatoon Airport Authority, 2010); specifically, 1.9 for jobs (Table 2, page 9 of this reference) and 3.02 for the total expenditures (Table 4, page 10). The total economic development impact estimated by using these multipliers is shown in the table below. This might be a bit high because there may be a greater portion of money spent outside the City than was the case for the reference economic study. Therefore, the Table 10: District Energy System Jobs and Business Generation results represent a high estimate.

There is a greater level of confidence in the calculated impact in terms of local share of business expenditures than as further derived in terms of jobs, because the latter involves two additional uncertain variables, i.e. the share of wages and the average wages of those specific jobs that are created. These results are shown in Table 11 below.

Table 11: Economic Impacts of District Energy

Economic Multipliers	
Jobs	1.9
Total Business Expenditures	3.02
Jobs	42
Total Business Expenditures (000$)	8,021

District Energy System development should not be viewed as a major job creation exercise, since it is more capital intensive than labour intensive. But by helping a community become more efficient and energy self-sufficient a District Energy System takes away risk and this reduced risk environment itself strengthens the local economy and is known to have been a factor in facility location decisions by major employers, e.g. IBM in Markham. Similarly, in a high fossil-fuel priced future, including carbon taxes or caps on GHG emissions, developers would prefer to build in locations which have access to a District Energy System with fuel flexibility.

Risk reduction also has economic value. The potential economic risk to the City from long-term dependence on heating with natural gas at lower then optimal efficiency is significant in terms of potential increased leakage of dollars from the community.

District Energy System/Community Integration Impacts

Integration issues that have been considered include traffic, noise, odours, public safety and general disruption. Some of the impacts occur for only the construction phase, but these are no different from the familiar impacts of other types of construction (noise, dust, road restrictions etc) for which mitigation measures are conventionally employed.

On-going noise and emissions from the Energy Centre will be subject to regulation. Sometimes members of the public raise the issue that the emissions from individual building stacks are each relatively small as compared with the point source created by a central energy plant. It may be necessary to provide information to the public concerning relative levels of emissions from Energy Centres that are well operated, maintained and subject to regulatory monitoring versus the individual building stacks that are essentially uncontrolled. It may be advisable to take architectural measures to make the Energy Centre more esthetically acceptable to neighbours.

Some prior District Energy System projects that attempted to incorporate biomass in an urban environment have met with community opposition. However, it is possible that there is a growing appreciation of the fact that biomass is widely used for district heating in Europe and has been established in North America for many years in both the largest hot water district heating system in the U.S. in Saint Paul and the largest hot water district heating system in Canada in Charlottetown. More recently there have been start-ups, retro-fits and plans for biomass based District Energy System in Revelstoke, Seattle, Victoria, Prince George and Vancouver. Therefore, with appropriate pollution controls and material handling and storage systems, biomass systems may become easier to integrate into urban locations.

Fuel delivery and storage are another frequently mentioned community impact of biomass. In this case, the biomass fuel requirement has been estimated to be approximately 4,600 tonnes/year which amounts to approximately 4.5 truck loads per week. Storage should be in a closed silo and material handling equipment designed to mitigate spills, dust and odours. For example, in the Seattle Steam System biomass is conveyed from silo to burner pneumatically, which creates a slight negative pressure in the receiving and handling facility thereby reducing duct and odour emissions.

Public Education and Amenities

BAU building boilers are usually hidden away in small, often cluttered and dangerous, dark spaces inaccessible to the public, promoting “out of sight – out of mind” attitudes to energy consumption. In contrast, some District Energy System, e.g. in Markham, Hamilton and Regent Park in Toronto, have welcomed visitors, including large tour groups. These Energy Centres are well lit, clean and tidy and spacious to allow room for maintenance and equipment replacement.

The Energy Centre can be made into a public amenity suitable for hosting tour groups for public education about the fundamentals of energy conversion and its environmental impact.

Impact on Private Property

A District Energy System is installed mainly in the public realm. The portion which is installed on private property are the Energy Transfer Stations (ETS), which are relatively quiet, low maintenance and small, consisting basically of stationary insulated equipment with water flowing through but no moving parts other than small control valves and little impact on their host building.

ETS will occupy less space than the boilers they replace, and in addition, domestic hot water (DHW) storage tanks are not necessary with district heating. The exact amount of space saved will vary with the overall size and type of building and alternate system design. As an illustration, a typical multi-residential building with 200 units might save in the order of 30 m^2 indoors.

The replacement of building equipment such as boilers, furnaces, hot water heaters and stacks by simple heat exchangers saves money, space and complexity in building design.

Greater architectural freedom is achieved, e.g. in the use of roofs for gardens, decks or terraces, resulting in more and superior quality public and/or private outdoor space. Determining where to place air intakes in relation to stacks is no longer an issue.

Natural gas can also be eliminated from buildings, which represents enhanced public safety.

Quality of Service

District energy provides a more reliable and effective service as compared with the BAU approach. Reliable service is assured by having redundant equipment, employing qualified operators and by continuous monitoring.

Heating coils in air handling units provides a means of controlling indoor air temperature while allowing good ventilation. Building residents must no longer suffer the noise, emissions, vibration, safety, space and repair and maintenance issues created by operating mechanical equipment distributed throughout the living space. Although fan-coils may still be used, they are much quieter than the compressors used in heat pumps.

Out-sourcing the energy conversion duty of HVAC systems (i.e. those functional parts subject to high temperatures with pumps and fans) greatly reduces the cost and risks associated with installation, commissioning, on-going maintenance and breakdowns.

Replication Potential

High quality energy consumed for building heating and domestic hot water represents a large quantity of “low hanging fruit” in Canada in terms of its potential to be substituted with energy from sources other than fossil fuels or electricity.

The quantity of energy used for building heating and domestic hot water in Canada is very large. According to the Office of Energy Efficiency, Natural Resources Canada:

1. Building operation accounts for approximately one-third of Canada's secondary energy use is due to the operation of buildings. (Secondary energy use means by end users, as opposed to, for example, energy used to generate electricity).

2. 71% of energy used in residential buildings is for space heating and DHW.
3. 58% of energy used in commercial buildings is for space heating and DHW.
4. Residential buildings consumed annually 1,422 PJ, resulting in 67.9 million tonnes of GHG emissions in 2009.
5. Commercial buildings consumed annually 1,186 PJ, resulting in 60.9 million tonnes of GHG emissions in 2009.

Clearly a very large amount of energy is used in Canada simply for space heating and domestic hot water (1 PJ = 1 million GJ). On the other hand, district heating currently serves only 1% of the market in Canada versus approximately 50% or more served by district heating in other cold, northern countries. Hence district heating has a large potential for growth. The vision statement of the Canadian District Energy Association is that 30% of the market will be served by district energy by 2030.

Establishment of a District Energy System in Victoria would, by way of example, encourage other systems to become established in similar smaller centres. It would make the concept more acceptable through familiarity to developers and engineers.

For example, a District Energy System was established in Markham Centre in the year 2000 serving only 3 buildings. Today this District Energy System has approximately 25 customer buildings connected or committed and Markham District Energy is currently engaged in starting another District Energy System at the east side of Markham.

Ownership Models

Overview

District energy is not new in Canada, since the first system was installed in 1880. Interest in reducing greenhouse gas emissions, making the best use of local resources, and creating opportunities for energy expenditures to "stay home" in the community have accelerated the development of district energy in recent decades.

Table 12: District Energy System in Canada Serving Municipal Markets

Location - Owner	Started	MWt
London - Veresen	1880	100
Ajax – Index Energy	1941	~25
Montreal – CCUM (Gaz Metro/ Dalkia)	1947	120
Toronto - Enwave (BPC/City)	1961	600
Vancouver – Central Heat	1968	180
Charlottetown - Veresen	1986	40
Cornwall - Fortis	1994	14
Windsor – Split City/BPC	1997	10
Sudbury – Joint Venture City/Toromont	1999	10
Markham – Town	2000	25
Hamilton – City	2003	10
Lonsdale, North Vancouver – City	2004	5
Revelstoke – City	2005	2
Sherwood Park – Strathcona County	2006	2
Dockside Green–Vancity/Corix/Terasen	2008	2
Regent Park – Joint Venture City/Corix	2009	25
SEFC, Vancouver – City	2009	16
Calgary – City	2010	30

The following sections discuss the governance aspects of various district energy ownership options. In the sections below, the term "City" refers to the City of Courtenay.

Determination of the preferred, viable owner/operator model and governance (e.g. relationship with the City) is a prerequisite to developing a District Energy System. There must be an entity with a clearly defined structure that will be responsible for the project, raise financing and enter service agreements with customers, whether it is the City itself, an agency or corporation of the City, a Joint Venture or a totally private company.

An identified and credible District Energy System owner is also essential for effective marketing. This is because customers expected to sign long-term service agreements naturally need to understand exactly who would be their counter-party and who they can rely on to deliver this essential service. Prospective customers will want to know the City's precise plan for ownership and operating structure, or at least the most likely option, if it is not firmly established at the time marketing activity commences.

A summary of different ownership and operating models that have been used in Canada, together with examples of each are listed in the table below. For the purpose of this discussion, the terms "municipal", 'the City", "Town" or "City" includes wholly owned municipal corporations, agencies or commissions, e.g. Toronto Community Housing Corporation, Markham Enterprises or the Windsor Utilities Commission. More often than not the municipal component of ownership or operation is exercised through a wholly owned corporation, which may itself be part of a holding company, e.g. Markham District Energy is one of several corporations owned by Markham Enterprises and Hamilton Community Energy is one of several corporations owned by Hamilton Utilities. Both Markham Enterprises and Hamilton Utilities are wholly owned by their respective municipalities.

Table 13: District Energy System Ownership Models in Canada

Model	Description	Examples
1	100% municipal ownership and operation directly (through the engineering services department)	Southeast False Creek (SEFC) Neighbourhood Energy Utility; Strathcona County
2	100% municipal ownership and operation, through a subsidiary corporation	Markham District Energy; Hamilton Community Energy; Calgary
3	100% municipal ownership with private sector operation	Revelstoke Community Energy; Lonsdale Energy
4	Joint Venture between a municipality and a private sector company (the private sector company may provide operating expertise)	Enwave; Regent Park Energy; Sudbury District Energy
5	Split ownership and operation, the municipality owning and operating the distribution systems with private sector owning and operating Energy Centre	Windsor Utilities Commission/Ontario Municipal Employees Retirement System
6	100% private ownership and operation	Dockside Green Energy; Central Heat Distribution, Veresen (London and Charlottetown); Cornwall; Ajax

Attributes of these six models are discussed below.

Control

The Triple Bottom Line values to the City include social and environmental benefits that do not strictly benefit outside investors. The City is sensitive to community concerns and environmental benefits, which may not be entirely consistent with maximization of profit.

In order to protect its interests, the City may desire a certain level of continued oversight. Some influence or control can be exercised, regardless of ownership, through Bylaws and agreements.

FVB's experience of participating in a team of advisors tasked with drafting agreement provisions to retain desired oversight after transfer of ownership, including reversion of ownership triggered by unacceptable performance, was that the legal issues became very difficult and, in fact, the attempt was abandoned after considerable expenditure on professional services. This experience supports the approach of achieving control simply through level of ownership.

It is generally recommended that, if possible, municipalities take majority control of district energy start-up Joint Ventures. That allows some risk reduction, in the limit up to almost half, while still maintaining control, not compromising access to funds only available to municipalities nor the moral high-ground in terms of relations with customers and the public. Accordingly, the discussion and scoring in this Section assumes municipal majority control of Joint Ventures.

Efficient Governance

The governance of the District Energy System must, at a minimum, allow for the conduct of the required business activities, such as execution of long-term service contracts, procurement of goods and services needed for construction and operation, collection of bills and operation and maintenance of the system. The ability to take on debt is also usually required.

There should be a dedicated District Energy System manager with necessary approval for day to day management and the responsibility for business planning and recommending larger investments to a higher approval authority.

The District Energy System could be managed through an existing City organization. Alternately, the City could establish a partly or wholly owned corporation, under the B.C. Community Charter and Local Government Act. This may more efficiently provide for the establishment of reasonably required approval authorities; e.g. it may be easier to contract out the operation of the system, which would be desirable in order to secure the desired level of expertise. Otherwise, management of the District Energy System inside the City organization may be subject to rules and restrictions that are intended to apply to the City's other operations, which would be different in nature, e.g. they may be non-profit oriented or suited to monopoly services with obligations to serve.

The corporate form could provide the flexibility to raise capital if needed through selling shares, i.e. bringing in a private partner.

It is desirable to have no cross-subsidization between the District Energy System and other City operations. The governance structure however must enable the District Energy System manager to somehow access funds to meet obligations during the early years of operation when the net operating revenue of the District Energy System will be weak.

Experience has shown that Model 5, split ownership, does not promote efficient system planning and expansion and is therefore not recommended despite its apparent attraction. The apparent attraction is that the municipality limits its financial responsibility to the district energy component that is familiar, namely underground piping. But this model has not proven successful in supporting system expansion and deployment of efficient technologies such as Combined Heat and Power (CHP) to the extent that might have been expected in the one location where it has been tried. The experience of Windsor has been that incentive for growth or enhancement is removed because such investments would require negotiations between the two parties, for which neither has the appetite.

With respect to the relationship between District Energy System owners and management, Sudbury, North Vancouver, Revelstoke, Dockside Green and Regent Park are examples where the District Energy System owners employ private operators under contract. Windsor also does this after a fashion by contracting for energy wholesale from an Energy Centre owned and operated by a private company. In the case of Sudbury, Dockside Green and Regent Park these operators are also part owners (Sudbury 50%, the other two < 50%).

On the other hand, Cornwall, Markham, Hamilton, Vancouver, Strathcona County and Calgary proceeded to build and operate their District Energy System without private partners or operators. In the case of Cornwall, Markham and Hamilton, local electric distribution utilities were originally involved and it still is in the case of Calgary. This provides the benefit of a utility management structure during development and construction. Being a relatively minor and therefore low priority department of a non-district energy utility is generally not a preferred governance model for a District Energy System long-term. Markham and Hamilton subsequently split off the District Energy System as separate wholly owned corporations, with dedicated staff having district energy experience. Vancouver and Strathcona County established the District Energy System as public utilities managed through their engineering services departments.

Cost of Capital

The experience of those involved in structuring Public-Private-Partnership (P3) deals is that the involvement of private capital is more costly. The value it imparts to the public partner is transfer of risk, i.e. private capital at risk instead of public capital. A similar approach for district energy runs into the dual challenge of 1) district energy start-ups in Canada tend to much smaller than typical P3 deals, e.g. in the order of $10 million investment versus over $50 million and 2) the IRR achievable for a district energy is constrained, as it must be competitive with BAU alternatives that are less capital intensive.

FVB has completed many district energy feasibility studies generally finding IRR in the range of 8-12%. If this project proceeds it is likely that the rates (customer prices) will be consistent with an IRR in this range. Whether this IRR would be sufficient to attract private interest can only be discovered through engaging prospective investors. The following factors might then influence the amount and cost of capital that could be raised from the private sector.

It will help if all possible steps are taken to reduced risk, e.g. confirm willingness of customers to sign long-term, and develop firm service agreements at specified rates.

The deal may be sweetened for private interests if they are also given an operations contract and this approach was used in Sudbury and Regent Park. This would provide additional revenue to the private partner and allow them to mitigate their risk by active management.

There is always a limit to the amount of capital a private partner would be willing to commit to a given project. Assembly of government support might then be needed in order to fully fund the project.

Revenue from projected connection of customers, whether existing or new development, is not assured until they have made commitments to enter service agreements. Since projected revenue from uncommitted customers is higher risk it may be discounted in the view of the prospective private partners' assessment of how much capital they would be willing to commit to the project.

Risk

The nature and management of risks associated with district energy development are discussed more fully in a later section of this report. Reduction of financial risk to the municipality represents value that private partners can bring. Financial risk is the possibility that for whatever reasons the actual net revenue may turn out to be different than the amount the City was counting on. The impact would be softened to the extent the City had less investment committed because part of the required investment was contributed by a partner. A private partner may also contribute management skills that can help avoid negative variances.

The 100% private owner model will take away a large part of the risk from the City. Not all the risk will be taken away because if the District Energy System turns out to be problematic for the community, the City may be pressured by its citizens to take it over. That happened in Ajax, although subsequently the Town managed to transfer the District Energy System to another private company.

The extent to which private ownership would reduce the risk to the City is proportional to the % of private ownership and whether they are also involved in the operation, which may be one of their conditions. However, the optimal level of private ownership and risk reduction must take into account the cost and other City goals, such as Control. There is always a cost to risk reduction that must be weighed in this evaluation. The cost will be lower to the extent that the private partners have ways to manage the risk.

In this case, the marketing risk may be difficult for private partners to mitigate. The City is likely to have more influence on customer connection than the private partners could have.

The private sector is adept at managing construction risk in general, but again, at a cost. If the City wishes to retain some level of ownership, especially majority ownership, then it should retain its own independent engineers even if it relies on the private partner to manage the design and construction and this alone will add to the capital cost.

The primary role of the partner may be to determine optimal timing. For example, as the engine supplier to the Sudbury District Energy System, Toromont had a high level of expertise in the design and construction of CHP facilities, therefore it made sense to participate early and take some of the construction risk. On the other hand, Corix was recruited as a partner in the Regent

Park Community Energy System by Toronto Community Housing Corporation not so much for their design and construction management skills as for their district energy management skills and therefore it made sense to form the Joint Venture later in the development cycle, in fact after design had been completed, but before system commissioning.

Regulation

Privately owned District Energy System in B.C. are subject to rate regulation by the B.C. Utilities Commission, but municipally owned systems are not. In general, it is less costly to be unregulated, so this would be another factor giving a relatively minor advantage to 100% or majority municipal ownership. There should be a relatively small difference in revenue, whether regulated or not, since it is essentially constrained by the need to offer a competitive service.

Potential Sources of Incentive Funding

At the time of this study, the Province had not allocated new funding for the *Public Sector Energy Conservation Agreement*. Local governments, however, have access to sources of capital specifically designed to assist with sustainable energy and waste diversion initiatives, including the FCM's Green Municipal Fund, and the UBCM Gas Tax Fund.

Federation of Canadian Municipalities –The Green Municipal Fund

The FCM's GMF program offers loans in combination with grants for capital projects in the energy, transportation, waste and water sectors. The maximum loan amount is $10 million, with the grant portion being up to 20% of the loan to a maximum of $1 million.

Organizations eligible for funding through this source include:

- Municipal governments
- Agencies owned entirely by municipal governments
- Public non-governmental or private groups applying with a municipality

Guidelines and application forms, as well as more detailed information, can be accessed on the Federation of Canadian Municipalities website under the heading "The Green Municipal Fund" (http://fcm.ca/home/programs/green-municipal-fund.htm).

UBCM Gas Tax Fund

The Gas Tax Fund provides funding for local governments for capital projects in the following categories:

- Public Transit
- Community Energy
- Solid Waste
- Water and Wastewater
- Capacity Building / Integrated Community Sustainability Planning

Evaluation criteria for the Gas Tax Fund include the following:

- How much the project is expected to contribute to reduced greenhouse gas emissions, cleaner air or cleaner water;
- How well the project is linked to broader planning initiatives in the community;
- The degree to which the project develops or supports strategic infrastructure investment decisions or links to sustainability and capital investment plans;
- The degree to which the project uses sustainability principles or leads to sustainable

community outcomes;

- The capacity of the project to provide new innovative research, testing, technology, methodology or approaches that may be used by other jurisdictions in planning or implementing sustainable infrastructure;
- The capacity of the project to improve public and/or environmental health or to move the community towards evolving environmental or health protection standards; and
- The degree to which the project supports inter-jurisdictional cooperation in planning and implementing infrastructure priorities.

A District Energy System based on biomass from a central facility that also reduces the cost of energy to a local hospital could score well against these criteria. Further information can be found on the UBCM website (http://www.ubcm.ca/EN/main/funding/gas-tax-fund.html).

Challenges and Benefits

The table below summarizes the potential barriers and benefits of a District Energy System in the City of Courtenay.

Table 14: Potential Challenges and Benefits

Aspect	Challenge	Benefit
Economics	Developing the District Energy System will require approximately $7 million in capital.	Provided that the Business-as-Usual costs of fossil fuel energy for clients is accurately assessed and greater than $140/MWh, revenues from sales of energy can cover the costs of the system over time. Economic turnover related to the District Energy System will remain in the Comox Valley.
Environment	A District Energy System will increase emissions of air conventional pollutants such as particulates.	Because the biomass boiler would be equipped with pollution controls the additional particulate emissions, over and above the emissions from existing natural gas boilers, would be equivalent to the annual output of a single EPA-approved wood stove or a single transit bus. The District Energy System would reduce greenhouse gas emissions by a total of 1,628 tonnes/year.
Governance	No governance-related challenges are anticipated.	A District Energy System supports a number of Provincial initiatives for greenhouse gas reductions, green energy, and diversion of waste from landfills. Diversion of additional wood waste from the regional landfills also supports diversion targets set by the CVRD.

Aspect	Challenge	Benefit
Social	The public may have concerns with respect to new sources of air emissions, and the small increase in truck traffic.	The public supports initiatives to reduce greenhouse gas emissions. The addition of 4.5 trucks per week to deliver biomass to the District Energy System would represent an increase of 0.02% above traffic the two daily rush volumes. A District Energy System based on local biomass will result in local jobs and will support the local economy.
Energy	No energy-related challenges are anticipated.	Unlike natural gas, biomass fuel can be stored on the Energy Centre site, and also on the site of the local provider. This ability to store fuel contributes to the energy security of the District Energy System. Energy from biomass can meet the existing and future needs of buildings for both high-temperature and lower-temperature energy.

Risks and Risk Mitigation

Basic risks and suggested mitigation measures are listed below, and a more detailed assessment of risks will need to be carried out at a detailed feasibility stage. The scales for severity and probability are 1 to 5.

Table 15: Risks and Mitigation Measures

Risk	**Severity**	**Probability** (over 25 yrs)	**Suggested Mitigation Measures**
The cost of wood residues may rise over time.	3	3	The City of Courtenay will also need to implement long-term biomass supply contracts with alternative, private sector sources of biomass. The administrations of the CVRD and the City of Courtenay should also cooperate on initiatives divert additional wood waste from the region's landfills.
Actual capital costs may differ from the estimates in this study.	3	2	Feasibility studies of other District Energy Systems have found that the overall price of energy is relatively insensitive to changes in capital cost, since this cost is financed over time. Capital cost estimates would be refined however during the detailed design and development of the Courtenay District Energy System.
The technologies required for the District Energy System may not perform as well as expected.	4	1	The technologies involved in the District Energy System have been demonstrated extensively elsewhere, and in over one hundred systems in Canada. Contracts with equipment suppliers (e.g. suppliers of biomass boilers) should include performance clauses.

Risk	**Severity**	**Probability** (over 25 yrs)	**Suggested Mitigation Measures**
District energy clients may not choose to subscribe to the District Energy System.	5	1	The City of Courtenay can enter into agreements to develop the Courtenay District Energy System further, concurrently with the conceptual design of the planned Comox Valley Hospital (taking place during 2013). In addition, 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.
The permitting process for a biomass system may be more difficult than expected.	4	1	The City of Courtenay will need to invest effort in community and stakeholder consultation before applying for a permit, in order to ensure that the costs and benefits of a biomass system are well understood by stakeholders. The biomass system modelled in this study includes air pollution controls to reduce particulate emissions.
A change in Provincial government could result in the elimination of the carbon tax, and of the requirement for publicly-owned organizations to reduce or offset their carbon emissions.	2	2	The price of district energy in this study takes into account the carbon tax and the value of avoided carbon offsets for publicly-owned organizations, but the overall contribution of carbon taxes on the price of energy from the natural gas Business-as-Usual alternative is modest.

Conclusions

1. A District Energy System in Courtenay would be economically viable if potential clients pay $140/MWh of delivered heat. In order to make a correct comparison between the cost of purchasing heat from a District Energy System and the cost of the Business-as-Usual option, potential clients will need to carefully analyze their costs of providing heat to their buildings, including fuel costs, sales taxes, carbon tax, carbon offsets (for publicly-owned buildings), operations and maintenance, licensing and insurance, and the cost of owning boilers and related equipment over time. Potential clients will also need to assess the value of the price stability over time that district energy can provide.
2. The economics of district energy for new buildings such as the planned Comox Valley Hospital and the planned Mission Professional Buildings will be more evident than for existing buildings, since the cost of boilers and dedicated utility spaces can be avoided for new buildings served by district energy. The space that would otherwise be occupied by utilities could also be re-programmed to generate revenue (in the case of privately-owned buildings) or for health care purposes (in the case of the planned Comox Valley Hospital).
3. A District Energy System in Courtenay would greenhouse gas emissions by a total of 1,628 tonnes/year, equivalent to removing approximately 400 cars from the City's roads.
4. A District Energy System based on biomass would result in modest increases in conventional air pollutants such as particulates. Because the biomass boiler would be equipped with pollution controls however, the additional particulate emissions, over and above the emissions from existing natural gas boilers, would be equivalent to the annual output of a single EPA-approved wood stove or a single transit bus.
5. A District Energy System in Courtenay would directly result in local employment in the operation and maintenance of the system, and also in the area of recovering, processing, and delivering urban wood waste.
6. Biomass in the quantities required for a District Energy System is available in the Comox Valley.
7. A District Energy System in Courtenay would support a number of Provincial objectives, including reducing greenhouse gas emissions, a carbon-neutral public sector, production of green energy, and diversion of solid waste from landfills.

Recommendations

1. The City of Courtenay should communicate the price indicated by this study for district energy to the Vancouver Island Health Authority, North Island College, the CVRD on behalf of the Aquatic Centre, and SD71 Comox Valley on behalf of Queneesh Elementary School, and any other potential district energy clients in order to gauge their interest.
2. The City of Courtenay should consider applying for capital funding to help offset some of the capital costs of the District Energy System.
3. The City of Courtenay could approach the CVRD concerning their interest in diverting additional quantities of urban wood waste away from regional landfills, either directly or through a third party processor, to a District Energy System.
4. In developing a District Energy System in Courtenay, the City should work with local biomass suppliers to form long-term supply agreements.
5. In developing a District Energy System in Courtenay, the City should develop a thorough and well-planned public consultation process.
6. The City of Courtenay should consider its potential advantages as a district energy utility owner:
    a. Exemption from the BC Utilities Commission Act, which can simplify the process of implementing district energy;
    b. Access to capital at low interest rates through the Municipal Finance Authority;
    c. Access to senior government funding in the form of Federal and Provincial grants, and loans at lower interest rates than are available to private corporations;
    d. Management of the urban planning strategies that can encourage future development in the vicinity of the District Energy System;
    e. The ability to facilitate rights-of-way for district energy piping, as well as the permitting process that would be required for district energy infrastructure;
    f. The potential to co-locate municipal infrastructure in district energy trenches (e.g. replacement water piping or piping dedicated to reclaimed water);
    g. Existing administrative processes for utility billing that could be adapted to include energy billing;
    h. Experience with the process of obtaining permits from senior governments;
    i. Experience with public consultation processes;
    j. Access to sources of urban wood waste;
    k. Practical knowledge of utility operations and maintenance; and
    l. Credibility as a utility provider for water and wastewater services that could facilitate contracting arrangements with owners of client buildings.

Acknowledgements

The authors are grateful to Allan Gornall, Environmental Planner for the City of Courtenay for the support and advice he provided during this study. In addition, we would like to thank the following people for their time and assistance:

Andrew Thomas, Manager of Facilities Management, North Island College

Bruce Pollock , Manager of North Island Substations, BC Hydro

Cecil Rhodes, Corporate Director Facilities Operations, VIHA

Craig Armstrong, Project Engineer, City of Courtenay

Darcy Walters, Senior Manager of Recreation Facilities, Comox Valley Regional District

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Paul Bouman, Senior Key Account Manager, BC Hydro

Peter Crawford, Planning Director, City of Courtenay

Sandy Gray, CAO, City of Courtenay

Tillie Manthey, Director of Financial Services, City of Courtenay

Tom Moore, Principal, Moore Architecture

Closure

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

Original signed and sealed, on file

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Senior Consultant, FVB Energy Inc.

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Mechanical Engineer, FVB Energy Inc.

Appendix I - Assumptions and Inputs

Criteria		**Units**	**Source / Notes**
Energy and Financial			
$12.02	Price of natural gas to large commercial clients	$/GJ of gas	FortisBC Large Commercial Rate 3, 2012
$13.35	Price of natural gas to small commercial clients	$/GJ of gas	FortisBC Large Commercial Rate 1, 2012
$1.50	Carbon Tax, natural gas basis	$/GJ of gas	
$1.25	Cost of carbon offsets to public organizations, gas basis	$/GJ of gas	
$25.00	Price of greenhouse gas offsets bought by public organizations after 2012	$/tonne	Carbon Neutral Government Regulation
$65.00	Cost of electricity	$/MWh	Blended rate, 2012.
$6.82	Cost of water	$/1,000 Imp.Gal.	Blended rate, 2012.
$45.00	Cost of purchased wood residues	$/BDT	
$10.00	Cost of ash disposal	$/BDT	
25	Amortization period	years	
4.65%	Interest rate		Municipal Finance Authority, 25 year term
2.1%	General inflation rate		

Criteria		**Units**	**Source / Notes**
Technical			
80%	Boiler efficiency, natural gas boilers		
70%	Boiler efficiency, biomass boilers		
40%	Moisture content of wood chips from wood waste		
12.0	Biomass heating value	GJ/tonne	
3.0%	Ash content of wood residues		
28	Emission factor, electricity	t CO_2e /GWh	BC Hydro
0.050287	Emission factor, natural gas	t CO_2e /GJ	BC Reporting Regulation Methodology Manual
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

Appendix II - Consulting Team

Stephen Salter, P.Eng. of Farallon Consultants Limited (www.farallon.ca) was the prime consultant and project manager for the study. Stephen developed sustainable energy options and screening-level analysis, modelled the energy and environmental performance of the sustainable energy system, evaluated sources of biomass, and surveyed potential district energy buildings.

Within FVB Energy Inc. (www.fvbenergy.com), Karl Marietta, MBA served as the Lead Contact and provided business case analysis. David Trigg, P.Eng., and Sean Casey, EIT performed modelling for District Energy System energy performance and cost.

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