TOWN OF LAKE COWICHAN

Economic and Sustainable Development Committee

Tuesday, May 9th, 2017 at 6:00 p.m. – Council Chambers

AGENDA

1. **CALL TO ORDER** — **Page #**

INTRODUCTION OF LATE ITEMS (if applicable)

2. **APPROVAL OF AGENDA**

3. **BUSINESS ARISING AND UNFINISHED BUSINESS**

(a) **Recent Items:**
  (i) Sustainable Waste - Update. — **3**

(b) **Ongoing Items Still Being Addressed:**
  (i) Marketing of Upgraded Centennial Park Facility.
  (ii) Cowichan Lake Area Event Calendar- Status.
  (iii) Possible expansion of Saywell Floating Dock.

4. **DELEGATIONS AND REPRESENTATIONS**

None.

5. **CORRESPONDENCE**

None.

6. **STAFF REPORTS**

None.

7. **NEW BUSINESS**

(a) City of Kamloops, re: Sustainable Kamloops Plan Foundations for Sustainability. — See past agenda

8. **NOTICES OF MOTION**

9. **PUBLIC RELATIONS ITEMS**

10. **MEDIA/PUBLIC QUESTION PERIOD**

11. **ADJOURNMENT**

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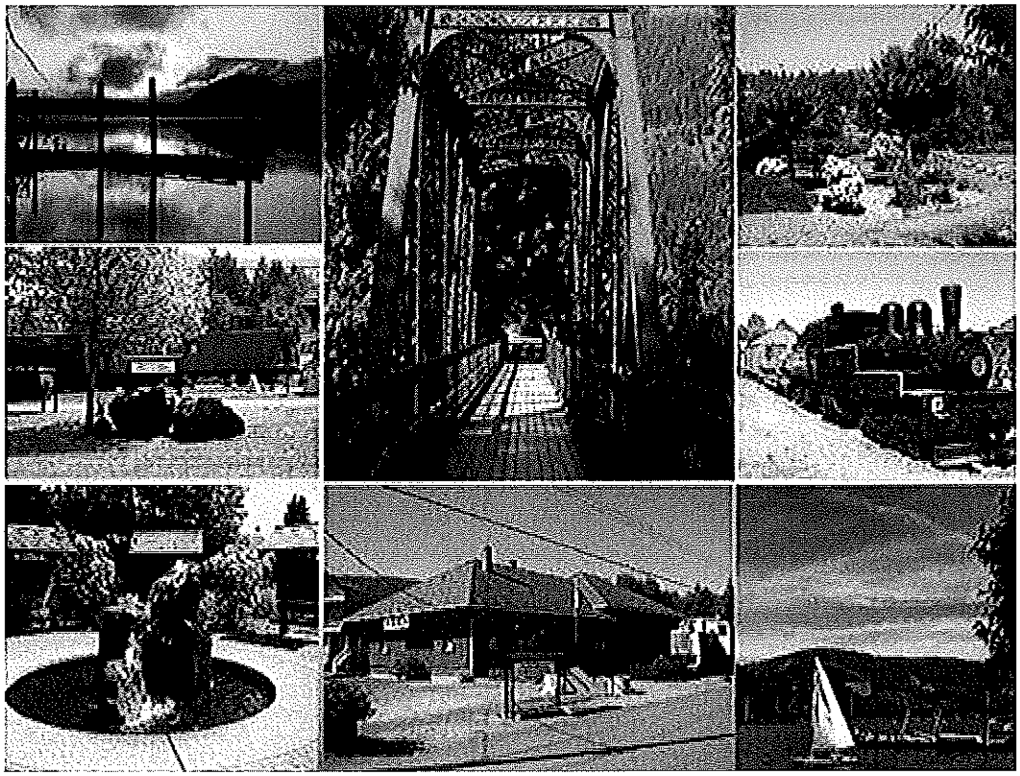
Options for Conversion of Organic Waste to Energy

Town of Lake Cowichan



Prepared for Mr. Joseph Fernandez, CAO
Town of Lake Cowichan

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Farallon Consultants Limited

March 28, 2013 (Final Draft)

Farallon
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Disclaimer

The information in this report has been compiled to offer a preliminary assessment of options for recovering energy from organic waste for the Town of Lake Cowichan. The author has prepared this document at the request of the Town of Lake Cowichan, solely for this purpose.

Reasonable skill, care and diligence has been exercised to assess the information acquired during the preparation of this report, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and factors associated with implementation of resource recovery are subject to changes that are beyond the control of the author. The information provided by others is believed to be accurate, but has not been verified.

This report includes pre-feasibility-level estimates of costs and revenues that should not be relied upon for design or other purposes without verification. The author does not accept responsibility for the use of this report for any purpose other than that stated above and does not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This report cannot be applied to other jurisdictions without analysis. Any use by the Town of Lake Cowichan, its sub-consultants or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

This report includes suggestions for questions the Town of Lake Cowichan could ask its wastewater treatment specialists regarding the possibility of removing a portion of the organic material from wastewater. The design of wastewater treatment facilities is an engineering specialty, and is beyond the scope of this report. The Town of Lake Cowichan must consult wastewater treatment specialists to review questions regarding any aspect of its plans for wastewater management. In addition, no criticism of prior work in this area by personnel associated with the Town of Lake Cowichan, its advisors, or consultants is implied.

Estimates of revenues from resources, including waste resources in this report do not consider questions of ownership of those resources. The estimates are included simply to allow options to be compared with one another. No firms or other entities identified herein have endorsed or agreed to proposed options that would require their participation. Resources identified from industry or other sources may be required by those sources for internal purposes, and therefore may not be available for the uses proposed in this report.

1. Executive Summary

The Town of Lake Cowichan engaged Farallon Consultants Limited and FVB Energy inc. to evaluate its options for recovering energy and other resources from organic waste.

The evaluation involved identifying the community's interests, surveying quantities of wasted resources, identifying uses for energy and nutrients which could be recovered, proposing suitable conversion technologies, and evaluating costs and benefits.

Regarding biomass in the form of wood waste, the option of district energy for two separate groups of buildings was evaluated. Because of the relatively small size of total energy demand, district energy based on biomass does not appear to be economically viable at this time.

Regarding organic solid waste, the study examined the option of using anaerobic digestion to generate electricity to offset part of the consumption of sewage lagoon aerators, of replacing electric heating in Palsson School with heat from biogas, and also the option of replacing propane to heat the Cowichan Lake Education Centre. The study also evaluated composting. Because of the small quantities of organic waste in the area, none of the four options appears to be economically viable at this time. Modelling showed that if an additional quantity of 500 to 1,000 tonnes per year of organic solid waste becomes available from other sources, then the anaerobic digestion options could become economically viable.

The study also considered the concept of using mechanical screening equipment to recover a portion of suspended solids from wastewater before it enters the Town's sewage lagoons. The goal of this concept would be to provide additional material for anaerobic digestion. Screening equipment of this kind is operated elsewhere by the Cowichan Valley Regional District. This concept also suggests that the Town of Lake Cowichan could consult with wastewater treatment specialists to determine whether removing a proportion of Total Suspended Solids and reducing Biochemical Oxygen Demand in advance of the sewage lagoons could potentially allow the Town to defer the planned expansion of the lagoons, and could results in other operating benefits.

2. Glossary

AD	Anaerobic Digestion
ADES	Academic District Energy System
BAU	Business as Usual
BCUC	BC Utilities Commission
BDT	Bone Dry Tonne, for example of biomass
Biogas	Raw gas from anaerobic digestion
Biomethane	Methane from current biological sources, such as upgraded biogas
CNG	Compressed Natural Gas
CO_2e	Carbon dioxide equivalent
COP	Coefficient of performance of heat pumps
CVRD	Cowichan Valley Regional District
DES	District Energy System
DHW	Domestic Hot Water
Digestate	Residuals from anaerobic digestion, comparable to compost
EF	Emission Factor
FOD	First Order Decay
GHG	Greenhouse Gas
GJ	Gigajoule
GWh	Gigawatt hours
GWP	Global Warming Potential
I&I	Inflow and Infiltration
IPCC	Intergovernmental Panel on Climate Change
LEED	Leadership in Energy and Environmental Design

LFG	Landfill Gas
MOE	Ministry of Environment
MW_e	Megawatts of electrical energy
MW_{th}	Megawatts of thermal energy
OFMSW	Organic Fraction of Municipal Solid Waste
OMRR	Organic Matter Recycling Regulation
SSO	Source-separated Organics (a component of municipal solid waste)

3. Lake Cowichan's Interests

The Town of Lake Cowichan engaged Farallon Consultants Limited and FVB Energy inc. to evaluate its options for recovering energy and other resources from organic waste.

Currently, the Town of Lake Cowichan collects solid waste with its own truck, for delivery to the Bings Creek Solid Waste Management Complex (transfer station) near Duncan. The Town of Lake Cowichan pays fees of $140/tonne to the Cowichan Valley Regional District (CVRD) for this service, and in 2011 the Town of Lake Cowichan disposed of 520 tonnes of mixed municipal waste by this means. Solid waste is transferred on behalf of the CVRD from the Bings Creek facility to the Roosevelt Regional Landfill in Washington State. The Roosevelt Regional Landfill is the fourth-largest landfill in the United States.

The Town of Lake Cowichan has expressed its interests in managing waste resources within the community as far as possible, minimizing the cost of managing wasted resources, and maximizing the value of recovered resources. In addition, the Town has asked to understand:

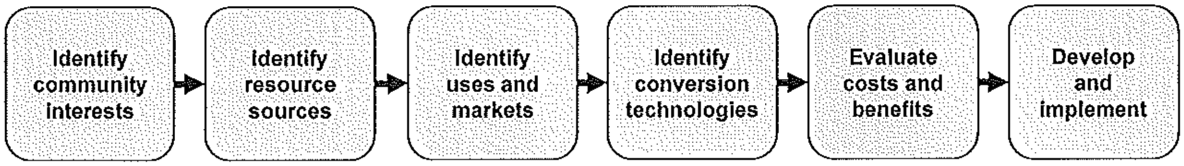
1. The local and regional energy requirements that could be satisfied with community energy;
2. Potential revenues and markets for energy products such as biogas, electricity and nutrients;
3. Any additional sources of organic waste such as industry, agriculture, and other communities;
4. Options for producing value from the community's resources, and for converting a liability (organic waste) into an asset, including;
    a. The feasibility of locating an anaerobic digester in Lake Cowichan
    b. The potential for cogeneration of electricity and heat
    c. Options for components of the organic waste stream that are not well suited for anaerobic digestion such as urban wood waste and invasive plant species (e.g. Scotch Broom)
    d. The highest and best use of options: economically, environmentally, and socially
    e. The potential for a community energy utility
    f. The potential for partnerships with existing energy utilities
    g. The pros and cons of private and public ownership of facilities
5. The environmental benefits of each option, such as:
    a. Greenhouse gas emissions and reductions
    b. By-products and other environmental impacts
    c. Other resource consumption (e.g. water, electricity)
    d. The environmental value of recovered energy and nutrients

6. The social benefits of each option such as local sustainable employment, as well as potential impacts from traffic, noise, and odours;
7. The economic costs and benefits of each option, including initial investments required, operating and maintenance costs, and revenue streams;
8. Regulatory issues that could help or hinder conversion of organic waste to energy;
9. The environmental, economic, social risks that each option represents today, and over the long term; and
10. How various options could be implemented.

4. Study Methodology

It can be tempting for communities choose a resource recovery technology first, then work to make the technology fit the community. The approach used in this study was instead based on the idea that technologies are a means to an end, and that the "ends" or needs and interests of the community must be understood before technologies are chosen. In this integrated approach, the community's interests and objectives are first defined, then the community's unique set of resources (including available waste) are evaluated, then markets for recovered resources are quantified. Only after these steps are conversion technologies considered and evaluated for their costs and benefits, and for their ability to meet the community's interests.

This approach is summarized by the diagram below.



Farallon Consultants Limited

Figure 1: Study Methodology

During this study, the following questions were asked:

1. What options exist for recovering energy and nutrients from organic waste?
2. What is the highest and best use for organic waste, which result in the greatest environmental, social, and economic value?
3. If additional organic waste is sourced from industry, agriculture, aquaculture, or neighbouring areas, would the economics of energy recovery improve?
4. Can facilities for organic waste management be integrated with other facilities (e.g. wastewater treatment facilities, industrial facilities, or commercial facilities) to reduce costs and improve benefits?
5. What are the economic, social, and environmental costs and benefits of these options?

Stakeholders from the Cowichan Valley School District, the Cowichan Lake Education Centre, the Town of Lake Cowichan, the Cowichan Valley Regional District, and local industry were consulted regarding sources of waste, and markets for recovered energy.

Options for converting wasted material into recovered resources were then developed, and reviewed on a preliminary basis with Town of Lake Cowichan staff. The costs and benefits of resource recovery options were then evaluated, including:

1. Economics, including initial cost, ongoing cost, savings, and net revenues;
2. Environmental aspects, including resource conservation and greenhouse gas emission changes based on Provincial (*BC Reporting Regulation*) and international standards (*Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories*); and
3. Social, including jobs created, community impacts, and intangible costs and benefits.

In this study it is assumed that the Town of Lake Cowichan has already committed to any additional costs of collecting organic solid waste. These costs would therefore be common to all options.

5. Lake Cowichan's Opportunities

A number of interesting opportunities existed at the time of this feasibility study, including:

1. Solid waste disposal currently costs approximately $73,000 per year, not including the cost of collection. If approximately one third of this waste can be diverted to local uses, then savings of approximately $24,000 per year would result.
2. The Town of Lake Cowichan's wastewater is treated in an aerated sewage lagoon, which is believed to reach capacity during the summer tourist season. The Town of Lake Cowichan is in the planning stages of increasing the capacity of the lagoons by adding a third cell and implementing phosphorous reduction. Design work is likely to begin in 2014, and the estimated capital cost for the expansion and improvements is $5 million.
3. Natural gas is not available in the Town of Lake Cowichan, and buildings are heated with more expensive sources such as propane and electricity. In 2010, electricity provided approximately 70% of all energy for residential and commercial buildings in the community.[1]
4. Municipal operations generate approximately 500 m^3 of wood waste every per year.
5. The Cowichan Valley Regional District (CVRD) has banned the open burning of wood waste.
6. The Town of Lake Cowichan's contract for recycling services will expires in August, 2013. The Town could then choose to open the bidding for collection services to include organic waste, or could arrange to collect organic waste with its own equipment and personnel.
7. Tourism brings 12,0000 to 13,000 visitors to the community each summer. Any novel resource recovery facility could also potentially become something of a draw for "eco-municipal tourism".
8. The sewage lagoons discharge to the Cowichan River, at an elevation approximately 20 metres below the level of the lagoons.
9. Land could be available for a resource recovery facility in the vicinity of the sewage lagoon.
10. The Town of Lake Cowichan's water consumption in 2012 was 821,800 m^3. Based on a nominal population of 3,100 this would suggest a per capita consumption rate of 726 litres/person/day. If the Town of Lake Cowichan's population increase from summer tourism is taken into account, the rate could be approximately 500 to 600 litres/person/day. In contrast, the average water consumption in the UK is approximately 150 litres/person/day.

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[1] Province of British Columbia (Climate Action Secretariat). 2010. Community Energy and Emissions Inventory, Town of Lake Cowichan. 6pp.

11. Land could be available for a small resource recovery facility in the Public Works Yard.
12. The Town of Lake Cowichan is considering moving its Public Works Yard to a new location a few hundred metres from the existing location.
13. Logging is active in the area, and roadside residuals which could be processed into wood chips suitable for a biomass boiler are abundant. Approximately 200 to 300 logging trucks pass through the Town of Lake Cowichan per day.
14. A private firm in the Town of Lake Cowichan will begin chipping urban wood waste under contract to the CVRD in 2013.
15. The Municipal Hall will be replaced as early as 2013 with a new 320 m^2 building.
16. The Town of Lake Cowichan's library is currently being replaced with a 327 m^2 building.
17. A cluster of heating loads exists in the area of the Municipal Hall, including:
    a. Municipal Hall
    b. New Library
    c. Evergreen Seniors Home

18. A cluster of heating loads exists in the area of the Public Works Yard, including:
    a. Public Works Yard
    b. Fire Hall
    c. Palsson Elementary School

19. Other heating loads include:
    a. Lake Cowichan Senior Secondary School
    b. The CVRD Arena
    c. The Cowichan Lake Education Centre

20. The Cowichan Valley School District is planning to replace the oil-fired system at the Senior Secondary School with a biomass system.
21. The Cowichan Lake Education Centre (www.cowichanlakecentre.ca) is operated by the Town of Lake Cowichan, and provides facilities and accommodations for up to one hundred people for conferences, workshops, and retreats. In addition, the Centre hosts a jobs training facility, and has 44 acres of land. The CLEC's original structures were built in 1956. The three largest buildings are heated with a central hot water system, fuelled by propane, and electricity provides the balance of heat.

6. Available Waste Resources

This section lists the waste resources available to the Town of Lake Cowichan.

6.1 Wet Organic Waste

The Town of Lake Cowichan's records indicate that a total of 520 tonnes of mixed solid waste is delivered by the Town of Lake Cowichan's truck to the Bings Creek Solid Waste Management Complex. CVRD solid waste is then transferred from the Bings Creek facility to the Roosevelt Regional Landfill in Washington State.

Although the Town of Lake Cowichan does not currently have information regarding the composition of its solid waste, based on composition studies from the Regional District of Nanaimo and Metro Vancouver, it is reasonable to assume that approximately 30% of mixed wastes consists of compostable organic waste, and that a further 4% consists of soiled, compostable paper.

The Town of Lake Cowichan also arranges for collection of recyclables through a private contractor, recovering 169 tonnes of material in 2011.

It is interesting that the Town of Lake Cowichan's population disposes of significantly less solid waste per person than other regions, as shown in the table below.

Table 1: Waste Disposal Rates

City	Population	Disposal Per Capita (tonnes/person/year)	Notes
Town of Lake Cowichan	3,100	0.165	1.
CVRD	77,000	0.415	2.
Metro Vancouver	2,400,000	0.662	3.

Notes

1. Based on Town of Lake Cowichan records of 520 tonnes of waste disposed per year.
2. Per the CVRD Solid Waste Management Plan.[2]

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[2] CVRD. 2006. Solid Waste Management Plan. 50pp.

6.2 Dry Organic Waste

The Town of Lake Cowichan's own operations generate approximately 1,000 m^3 (approximately 400 tonnes) of wood waste (biomass) every two years. In addition, sawmill residuals are available in the Duncan-Chemainus-Ladysmith area, and logging is active in the area, and roadside residuals which could be processed into wood chips suitable for a biomass boiler are abundant.

A private firm in the Town of Lake Cowichan will begin chipping urban wood waste under contract to the CVRD in 2013. Finally, invasive species such as Scotch Broom removed from the area could be included in the biomass feed stocks, to eliminate the risk of seed propagation.

For the purposes of this study, it was assumed that the Town of Lake Cowichan's own wood waste would be available for $10/BDT, that chipped urban wood waste originating in the CVRD could be available for $40/BDT, and that chipped forest residuals would be available for $60/BDT.

6.3 Liquid Waste

The Town of Lake Cowichan's wastewater is treated in an aerated sewage lagoon with two cells, which is believed to reach capacity during the summer tourist season. The Town of Lake Cowichan is in the planning stages of increasing the capacity of the lagoons by adding a third cell and implementing phosphorous reduction. Design work is likely to begin in 2014, and the estimated capital cost for the improvements is $5 million.

The outfall is situated at UTM 5408723 North, 424591 East, which is approximately 3.5 km downstream of Cowichan Lake. The outfall extends 9.1 metres into the Cowichan River, and the difference in elevation between the sewage lagoon surface and the Cowichan River is approximately 20 metres. The Town of Lake Cowichan's Engineering Department reports monthly flow rates as shown in the table below.

Table 2: Wastewater Flow Rates

Month	Flow (m^3)
January	61,891
February	41,612
March	55,919
April	39,641
May	26,445
June	27,350
July	28,984
August	30,893
September	29,939
October	24,368
November	67,728
December	105,058
Total	**539,828**
Average	**44,986**

The Engineering Department also reports that the Town of Lake Cowichan experiences significant inflow and infiltration during winter months.

Since the goal of this study is to optimize the recovery of value from wasted resources, the insoluble component of raw wastewater entering the Town of Lake Cowichan's sewage treatment lagoons was considered as a potential resource. The question is: how could this resource be recovered?

One manufacturer of pre-filters was contacted regarding the removal efficiency of their design. Salsnes Filter (www.salsnes-filter.com) states that TSS removal efficiencies of 40% to 80%, and BOD reductions of 20% to 40% are possible, using screens of 0.05 mm to 0.3 mm. Although the test data to characterize the Town's influent was not available, this study assumed a Total Suspended Solids (TSS) level of 200 mg/litre. Based on an Average Annual Flow of 1,479 m^3/day and an average removal efficiency of a pre-filter of 60%, approximately 65 BDT/year or 250 tonnes per year at 26% moisture of primary biosolids could potentially be recovered from raw wastewater before it enters the sewage lagoons.

The CVRD has experience with this kind of pre-filter, which is used in advance of a Membrane Bioreactor in the Lambourn Estates Sanitary Sewer System (see www.cvrd.bc.ca/index.aspx?NID=434). The Town of Lake Cowichan could consider asking its civil engineering consultants whether a pre-filter could also:

1. Reduce organic loading (TSS and BOD) on the sewage lagoons?
2. By reducing organic loading on the sewage lagoons, also potentially reduce the amount of electricity required for aeration?
3. By reducing organic loading on the sewage lagoons, also potentially reduce the rate of growth of sludge in the lagoons?
4. Sufficiently reduce organic loading on the sewage lagoons to the point where the existing capacity of the lagoons could accommodate a degree of future growth?

Since the focus of the current study is resource recovery, these questions should be answered by civil or environmental engineers qualified in this field.

For the purposes of this study, it was assumed that primary biosolids could be filtered from wastewater at the sewage lagoons.

Table 3: Summary of Available Organic Waste

Source	**Quantity** (tonnes/year)	**Quantity** (BDT/year)
Organic Fraction of Municipal Solid Waste	249	65
Primary Biosolids	177	46
Total	426	111

The quantities estimated are based on 26% solids in each case.

7. Demand for Recovered Resources

7.1 Energy

In addition to data provided for the Town of Lake Cowichan's own buildings, energy consumption data for the study was kindly provided by the CVRD, the Cowichan Valley School District, and the King George Seniors Affordable Housing Society. The table below provides a summary of this data.

Table 4: Summary of Building Energy Consumption

Cluster	**Owner**	**Annual Energy Consumption**			**Notes**
		Electricity (kWh/year)	**Propane** (GJ/year)	**Oil** (GJ/year)	
Municipal Core Cluster					
Evergreen Seniors Home	KGSASH	150,000			1.
New Library	Town	100,825			2.
Municipal Hall	Town	98,667			3.
Sub-total		**349,492**	-	-	
Public Works Cluster					
Palsson Elementary School	SD 79	233,000			4.
Fire Hall	Town	100,000	336		
Public Works Yard	Town	22,500		190	
Sub-total		**355,500**	-	**190**	
Arena Cluster					
Arena Cluster	CVRD	1,160,000	1,800		
High School	SD 79	556,000		2,330	5.
Sub-total		**1,716,000**	**1,800**	**2,330**	
CLEC	Town	**187,500**	**761**		6.

Notes

1. This building includes thirty-one units, and is owned by the King George Seniors Affordable Housing Society. The energy consumption included in this study is for heating of domestic how water only, since suites are heated by electric baseboards.
2. Estimated based on NRCAN values for comparable buildings.
3. Estimated based on NRCAN values for comparable buildings.
4. Peak winter demand is at 160 kW. The majority of this energy is consumed for space heating.
5. Peak winter demand is at 225 kW. Part of this energy is consumed by heat pumps, which also operate in cooling mode during summer months.
6. In the Cowichan Lake Education Centre , three buildings are heated by a central heating plant, fuelled by propane.

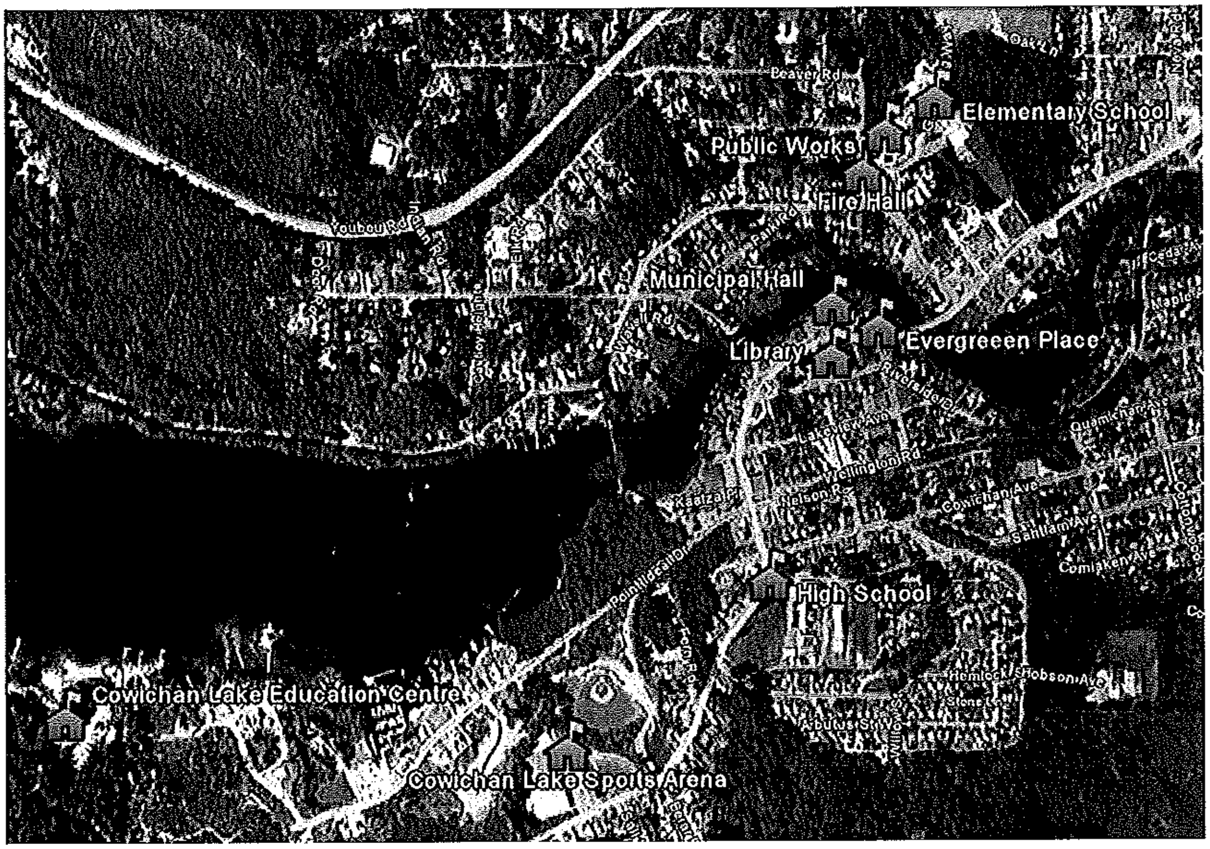

Figure 2: Location of Energy Loads

7.2 Compost

Compost can either be produced in a conventional, aerobic process or in an anaerobic digester. Processed material from an anaerobic digester is called digestate, and the concentration of nitrogen compounds in this material are higher than in conventional compost.

This study assumed that either digestate or compost, in the quantities likely to be produced from the Town of Lake Cowichan's organic waste, could be sold at an average price of $30 per tonne, and that the area's farms and wineries could easily absorb this material. This rate is comparable to the price for which the Comox Valley Regional District sells their Sky Rocket compost, which is produced from wastewater treatment biosolids and wood residuals. The $30 per tonne represents very good value to buyers, since it is lower than the market price of the phosphorous, potassium, and nitrogen content of compost or digestate.

8. Option One: Anaerobic Digestion of Wet Organic Waste

8.1 Configuration

Anaerobic digestion is a natural process of decomposing organic matter, and the first anaerobic digester was built in 1895. Anaerobic digestion can be thought of as a form of composting in which most of the carbon in organic waste is converted to methane and carbon dioxide, and which concentrates nitrogen, phosphorous, potassium, sulphur, and micronutrients in residuals (termed "digestate"). Digestate is an excellent slow-release fertilizer.

Anaerobic digestion produces raw biogas (approximately 65% methane, 35% carbon dioxide, and with trace amounts of hydrogen sulphide and sulphur dioxide). After sulphur compounds are removed, biogas can be burned for heat, burned for cogeneration of heat and electricity, or upgraded to biomethane for sale to a gas utility or to replace fossil fuels in vehicles.

In developing countries, simple anaerobic digesters as small as 1m^3 are used to provide fuel for cooking for individual homes. These digesters repay their modest initial investment in a few years, but the low cost of such digesters reflects the fact that they are not designed to comply with safety standards.

In North America, a number of safety standards, regulations, and codes of practice apply to the design and operation of anaerobic digestion. Digesters also tend to be custom-designed for a given feed stock and application, and when the costs of engineering a system to comply with safety standards, along with the cost of permitting are taken into account, it is not surprising that the economics of anaerobic digestion are favoured by scale.

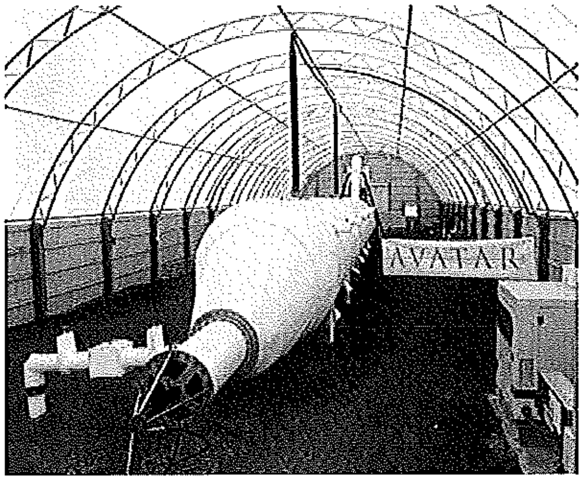

Figure 3: Small Scale Anaerobic Digester[3]

A small-scale digester designed to process organic solid waste and biosolids would consist of a single insulated vessel, likely fabricated from fibre-reinforced plastic. Sulphur gases would be scrubbed from raw biogas by simple biological means to reduce the hazards they present, and to reduce corrosion in a boiler or generator using the gas. Hydrogen sulphide is highly toxic.

The biogas scrubber would consist of a bioreactor which would produce a small quantity of solid sulphur, which could be blended with digestate to increase its value as a fertilizer.

Digestate from the digester would be dewatered, and stored for sale as compost in bulk.

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[3] Courtesy of Avatar Energy.

8.2 Potential Locations

8.2.1 Cowichan Lake Education Centre

Figure 4: Cowichan Lake Education Centre

A small digester located at the CLEC could displace all of the propane currently burned to heat

three of the Centre's main buildings. The advantages of locating a digester at the CLEC include:

- Scrubbed biogas could displace all of the propane currently burned by the Centre
- Space for a digester is available within the site's 44 acre property
- The Centre is involved in job training programs, and could apply for funding for labour to build and operate the digester
- Including this sustainable, and relatively novel (for Canada) source of energy at the Centre could enhance its reputation

The disadvantages of this location include:

- The Town of Lake Cowichan would need to review covenants on the Centre's land, and potentially negotiate this additional use with the Federal government
- Measures would need to be taken to minimize the risk that odours from the digester would affect the Centre's core activities
- Primary biosolids would need to be trucked to the Centre

8.2.2 Existing Public Works Yard

A small digester located at the Public Works Yard could produce more than enough energy in the form of scrubbed biogas to heat Palsson Elementary School. Although the school is heated with electric duct heaters, all make-up air enters at one point at the front of the building, before being distributed through ductwork within the school. This arrangement suggests that a hot water or glycol boiler could be located outside the school, to provide heat through new duct coils in the existing main duct.

The advantages of locating a digester at this location include:

- Public Works personnel have the necessary skills to operate a digester

- Energy could replace electricity at the school

The disadvantages of this location include:

- Significant, fail-safe measures would need to be included in the design, to prevent raw biogas or scrubbed biogas from accidentally entering the school
- The chimney of a boiler burning biogas would need to be located sufficiently far from the school's existing air intake to eliminate the risk of products of combustion entering the school
- Space at the existing Public Works Yard is limited
- Primary biosolids would need to be trucked to the Public Works Yard
- The surrounding community may object to the potential for odours

8.2.3 Wastewater Treatment Lagoons

Scrubbed biogas from an anaerobic digester at this location could run a 10 kW generator to displace purchased electricity for the sewage lagoon's aerators. Additional space may also be available in the future, if the City acquires land adjacent to the existing sewage lagoons.

The advantages of a small digester at this location include:

- The use of land in this area is compatible with the operation of a digester
- Biosolids would not need to be transported by truck to another location
- A net metering arrangement with BC Hydro would result in a 70% reduction of electricity purchased to operate the sewage lagoon aerators

8.3 Economics

Table 6: Summary of Costs and Benefits for Anaerobic Digestion and Composting, and Appendix A - Comparison of Anaerobic Digestion and Composting Options compares the costs and benefits of anaerobic digestion and composting. Depending on how biogas is used, anaerobic digestion on the relatively small scale studied here would result in estimated annual losses of between $35,000 and $57,000. Composting would result in estimated annual losses of $53,900.

This analysis does not take into account any potential benefit of deferring the expansion of the sewage lagoons, if it proves practical to improve the capacity of the existing lagoons by removing a portion of organic material in raw wastewater, as described in the Available Waste Resources section, above.

8.4 Social Costs and Benefits

An anaerobic digester would support local farms, keep any economic value of recovered resources in the Town of Lake Cowichan, and reduce the distance travelled by trucks hauling waste.

8.5 Greenhouse Gas Analysis

The estimate of decreases and increases in greenhouse gas emissions associated with diverting organic waste to either anaerobic digestion includes reductions from fossil fuel emissions, reductions in methane emissions from landfills, reductions in emissions from fertilizer production, and increases in emissions from small amounts of fugitive methane escaping from anaerobic digestion. Consistent with the *BC Reporting Regulation Methodology Manual,* carbon dioxide emissions from biogenic material (e.g. biomass) are considered to be carbon-neutral.

The greenhouse gas emission analysis in this study does not include changes to emissions which may arise from reduced loading of organic materials in the sewage lagoons, or changes to emissions associated with hauling solid waste.

8.5.1 Avoided Landfill Gas Emissions

Organic waste decomposes in landfills to produce methane over time, and landfill gas emission modelling is therefore based on a time-series calculation. Emissions were evaluated in this study on a steady-state basis to provide a simple comparison of the difference in emissions among different options.

Climate scientists believe that reducing methane emission reductions in the near-term is one of the most effective ways of slowing climate change, since methane degrades relatively quickly in the atmosphere (with a half-life of approximately 8 years), and since the value of early emission reductions is likely to be greater than reductions which might be achieved in the future.[4]

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[4] Cox, P. et al. 2010. Methane radiative forcing controls the allowable CO_2 emissions for climate stabilization. Current Opinion in Environmental Sustainability. Volume 2. Issue 5, Pages 404-408.

To estimate the methane emissions that would be avoided by diverting organic waste from landfills, the emissions from organic waste alone were estimated using the First Order Decay (FOD) method, per IPCC (2006) and Conestoga-Rovers & Associates Ltd. (2009):[5] [6] [7]

$$\textit{Methane Generation} = L_0 * (EXP(-k*c) - EXP(-k*T)) = \textit{tonnes } CH_4/\textit{tonne of organic waste}$$

Estimates of the efficiency of Landfill Gas collection systems depend on a wide number of assumptions.[8] Models of LFG collection efficiency depend on the methodology chosen (e.g. BC Ministry of Environment or IPCC), assumptions concerning the physical shape of the landfill, the quantity and composition of waste deposited historically, the choice of ultimate methane yield factors for each type of waste, the choice of rate constants for each type of waste, moisture conditions in the landfill, leachate and rainwater management practices, the type and extent of landfill cover, the delay between the time waste is deposited in the landfill and the time Landfill Gas collection piping is installed, whether landfill gas composition and gas flow rates are both measured continuously or only intermittently, among other factors.

The Roosevelt Regional Landfill was opened in 1962, and receives an estimated two million tonnes of solid waste per year. The landfill captures a portion of generated landfill gases for combustion in a generating facility with a capacity of 37 MWe. The landfill gas capture efficiency of the Roosevelt Landfill was estimated at 25%, in the absence of third-party reports.

The changes in greenhouse gas emissions from anaerobic digestion are summarized in Table 8: Summary of Greenhouse Gas Emissions in Appendix C - Estimate of Greenhouse Gas Emission Changes.

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[5] Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 2: Waste Generation, Composition and Management Data. 26pp.

[6] Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 5: Waste. Chapter 4: Biological Treatment of Solid Waste. 8pp.

[7] Conestoga-Rovers & Associates Ltd. 2009. Landfill Gas Generation Assessment Procedure Guidance Report (Prepared for BC Ministry of Environment.) Conestoga-Rovers & Associates Ltd., Richmond B.C. 81pp.

[8] Golder Associates Ltd. 2008. Cost Estimation Model for Implementing GHG Emission Reduction Projects at Landfills in British Columbia. Prepared for the BC Ministry of Environment. 41pp.

8.6 Environmental Costs and Benefits

An anaerobic digester would:

1. Result in modest greenhouse gas reductions of approximately 390 tonnes per year. For scale, the greenhouse emissions of the entire community of the Town of Lake Cowichan, including emissions from heating buildings and transportation, was 16,900 tonnes in 2010.[9]
2. Recover nutrients to provide a slow-release fertilizer for local farms, in the form of approximately 170 tonnes of digestate per year.
3. Conserve either 90,000 kWh of electricity or approximately 800 GJ of propane per year.

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[9] Province of British Columbia (Climate Action Secretariat). 2010. Community Energy and Emissions Inventory, Town of Lake Cowichan. 6pp.

9. Option Two: Composting of Wet Organic Waste

9.1 Configuration

The design and operation of a conventional aerobic composter is simpler than that of an anaerobic digester. If the Town of Lake Cowichan decides that it is worthwhile diverting and processing organic waste and biosolids in the community, but not worthwhile developing an anaerobic digester, then composting is a practical option.

In order to provide bulk, porosity, and to balance the carbon-nitrogen ratio in compost, an amount of wood mulch approximately equal to the weight of biosolids would be bought. Wood waste, biosolids, and organic solid waste would be mixed within the composter on a batch basis, and processed for fourteen days. Although this interval is compatible with biweekly curbside pickup of organic waste, primary biosolids may need to be stored in a dewatered state between batches.

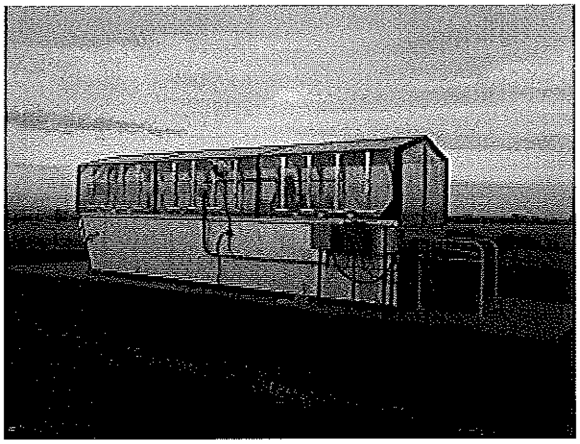

Figure 5: Small Scale Composter[10]

Compost would be processed to reach temperatures adequate to kill pathogens, as stipulated in the OMRR.[11] For example, compost would need to be maintained at a temperature of 55°C for approximately three days, or a temperature of 60°C for less than one day. A manufacturer of modular compost equipment was contacted during the study, and it appears that reaching these temperatures will be practical.

Finished compost could be stored on site, and sold in bulk.

9.2 Potential Locations

Potential locations for a conventional composter include the Cowichan Lake Education Centre, the Public Works Yard, or the site of the sewage lagoons.

9.3 Economics

Table 6: Summary of Costs and Benefits for Anaerobic Digestion and Composting and Appendix A - Comparison of Anaerobic Digestion and Composting Options compares the costs and benefits

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[10] Courtesy of Green Mountain Technologies.

[11] Province of British Columbia. 2007. Organic Matter Recycling Regulation (B.C. Reg. 198/2007).

of anaerobic digestion and composting. Composting would result in estimated annual losses of $53,900.

9.4 Social Costs and Benefits

A composter would support local farms, keep any economic value of recovered resources in the Town of Lake Cowichan, and reduce the distance travelled by trucks hauling waste.

9.5 Environmental Costs and Benefits

A composter would:

1. Result in modest greenhouse gas reductions of approximately 265 tonnes per year.
2. Recover nutrients to provide a slow-release fertilizer for local farms, in the form of approximately 380 tonnes of compost per year.

10. Option Three: District Energy Based on Biomass

Three clusters of heating loads were identified in the Town of Lake Cowichan:

1. The Public Works Yard, Fire Hall, and Palsson Elementary School
2. The Municipal Hall (to be replaced), the New Library, and the Evergreen Seniors Home
3. The Lake Cowichan Senior Secondary School and the CVRD Arena

Since suitable locations for an anaerobic digester are not available in the second and third clusters, modelling in this study was based on energy from biomass.

Preliminary estimates of the capital costs, annual costs, and revenues/savings for a small district energy system to serve the Municipal Hall, the New Library, and the Evergreen Seniors Home were developed. Because the energy loads are relatively small, a district energy system would not cover its initial and ongoing costs.

Preliminary estimates of the capital costs, annual costs, and revenues/savings for a small district energy system to serve the Lake Cowichan Senior Secondary School and the CVRD Arena were also developed. Since the Cowichan Valley School District plans to add a package biomass boiler to the high school, modelling was based on the option of increasing the size of this boiler to serve both the school and the neighbouring arena. Again, because the energy loads are relatively small, a district energy system would not cover its initial and ongoing costs.

The results of this modelling are summarized in Appendix B - Costs and Benefits of District Energy Options.

Although energy consumption in the Public Works Yard and Fire Hall is too low for district energy to be practical, the option of burning scrubbed biogas in a new boiler attached to the Palsson Elementary School was investigated, and the results are explained earlier in this report.

11. Option Four: Micro-hydro

The Town of Cowichan Lake's sewage lagoons discharge to the Cowichan River, at an elevation approximately 20 metres below the level of the lagoons. A preliminary estimate was made of the amount of electricity which could potentially be generated by means of a micro-hydro turbine located at the lowest possible elevation before the river.

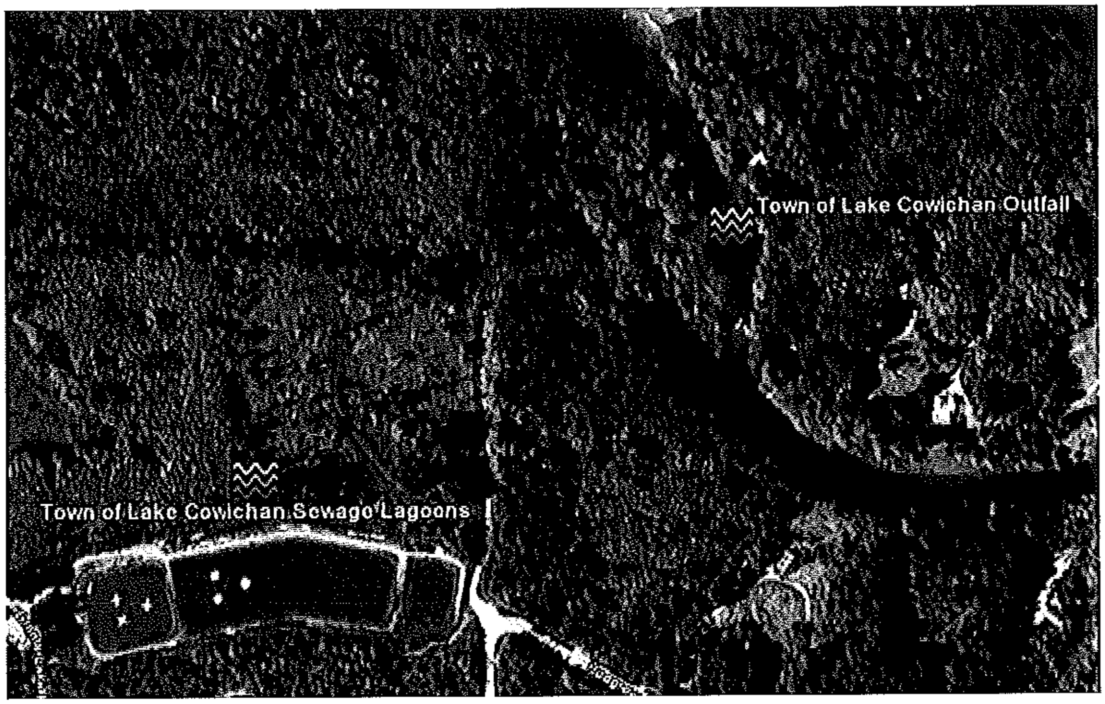

Figure 6: Location of Sewage Lagoons and Outfall

The simplest arrangement for micro-hydro from this source would be net metering, where the electricity generated would displace part of the electricity consumed by the sewage lagoon aerators.

Although this form of micro-hydro has been used elsewhere (for example in the Point Loma Wastewater Treatment Plant in San Diego), because of the relatively low flow rates of wastewater, its value for the Town of Lake Cowichan would be limited to demonstration value. The project would only result in a greenhouse gas reduction of 0.4 tonnes/year.

The table below gives a summary of the costs and benefits of this project. The project would involve significant regulatory approval processes, and the summary in the table below shows that project would not cover its costs.

Table 5: Summary of Micro-Hydro Potential

	Value	Units	Notes
Average Daily Flow	1,479	m^3/day	
Average Annual Flow	0.017	m^3/second	
Peak Daily Flow	0.041	m^3/second	1.
Static Head	20.0	m	
Distance	0.37	km	
Dynamic Head	18.2	m	
Turbine Type	Pelton		
Turbine Efficiency	78.5%		
Overall Electrical Efficiency	90%		
Electrical Power, Average	2.1	kW	2.
Energy Yield	16.3	MWh/year	
Capital Cost	$64,400		3.
Project Management	$3,000		4.
Engineering	$18,000		
Contingency	$16,000		
Total Capital Cost	**$101,400**		
Revenues	$1,300		5.
O&M Costs	$4,900		
Financing Costs	$7,200		
Net Annual Revenues	**$(10,800)**		

Notes

1. Estimated.
2. Based on average flows, dynamic head.
3. For the turbine and related equipment, including design, installation, and civil works.
4. Including construction supervision.
5. Based on electricity saved rather than sold.

12. Conclusions and Recommendations

District Energy Based on Biomass

The option of connecting the new Municipal Hall, Municipal Library, and Evergreen Place through a district energy system fuelled by biomass was modelled, and found to be not economically viable because the relatively small energy loads. As an alternative, when the Town of Lake Cowichan issues its Request for Proposals for the new Municipal Hall, specifications could include the requirement to provide heat with a biomass boiler located adjacent to the Hall, with electric heating back-up. Because of the small scale and unfavourable economics of any potential anaerobic digester, compost facility, or district energy system, it is unlikely that the Town of Lake Cowichan would be able to create a partnership with an energy utility.

Likewise, the option of connecting the High School and Arena through a district energy system fuelled by biomass was modelled, and found to be not economically viable, because the energy loads are relatively small compared with the distance between the two buildings.

Options for Wet Organic Waste

The amount of solid waste disposed of per capita in the Town of Lake Cowichan is relatively low, at 25% of Metro Vancouver's current rate. The Town of Lake Cowichan could consider looking into the question of whether significant amounts of waste (e.g. institutional, commercial, or industrial) are collected by other means. If the figures for the total amount of waste disposed of prove to be an accurate reflection of waste generated in the Town of Lake Cowichan, then other municipalities may wish to understand how this low rate was achieved, and to understand what lessons could be learned for their communities.

Conceptually, additional organic waste could be obtained by filtering primary biosolids from raw wastewater before it enters the Town of Lake Cowichan's sewage lagoons. There are two implications of this concept. First, primary biosolids could be mixed with organic solid waste and either digested in an anaerobic digester, or composted. While neither option is economically viable based on the amount of material currently available to the Town, the second implication is that the Town could consider, in consultation with wastewater treatment specialists, whether the reduced loading of organic material on the sewage lagoons could allow the Town of Lake Cowichan to defer part of the planned $5 million expansion to its wastewater treatment system.

Regarding options for organic solid waste, if the Town of Lake Cowichan is interested in developing an anaerobic digestion facility for its demonstration value, then the Town could consider a Request for Proposals to design and build a small-scale digester to either generate electricity for consumption by aerators in the sewage lagoons, or to displace propane in the Cowichan Lake Education Centre.

If the Town of Lake Cowichan does proceed with the idea of generating electricity for the sewage lagoon aerators, then the Town of Lake Cowichan should investigate sources of incentive funding for projects. For example for initiatives which decrease electricity consumption, would BC Hydro be willing to help offset costs that would displace electricity?

If the Town of Lake Cowichan does decide to proceed with a small-scale anaerobic digestion facility, it could consider finding additional sources of organic waste to improve the economics of a digester. For example, the Town could ask farmers in the Duncan area if they would be interested in contributing agricultural waste or manure to the digester, potentially dropping material off before collecting finished compost in one trip. The Town could also work the CVRD to learn if the regional government would be interested in diverting wet organic waste to a larger facility within the Town of Lake Cowichan.

If the Town of Lake Cowichan is not interested in a demonstration system, but is interested in maintaining control of organic solid waste, then the Town of Lake Cowichan could consider a Request for Proposals to design and build a composter which could be located at the sewage lagoons, to process electricity from organic solid waste and primary biosolids.

If the Town of Lake Cowichan is not interested in a demonstration system, and is not concerned about maintaining control of organic solid waste, then the Town of Lake Cowichan could consider a Request for Proposals for private firms to accept organic solid waste and primary biosolids, for processing into compost. The value to the Town of Lake Cowichan of this option would be the avoided cost of $140/tonne to dispose of the organic fraction of solid waste, and if reducing the organic loading on the sewage lagoons is possible and desirable through pre-filtering, then potentially the value of deferring the expansion to the sewage lagoons.

If the Town of Lake Cowichan does choose to develop a composter, or arranges for a private firm to compost material on behalf of the Town of Lake Cowichan, the Engineering Department could investigate whether technologies exist to remove phosphorous from treated wastewater in such a way that the removed phosphorous compounds could be blended with compost to increase its value.

Regarding loading of organic materials (TSS and BOD) in untreated wastewater, the Town of Lake Cowichan could ask the following questions of its wastewater treatment specialists:

1. What would be the costs and benefits of removing a portion of suspended solids by mechanical means (e.g. through pre-filters such as a Salsnes filter) before the lagoons?
2. Could this approach reduce the TSS and BOD loading sufficiently that the existing lagoons could meet current and future demand, especially after planned dredging is complete?

If it proves desirable to implement pre-screening in advance of the sewage lagoons, the Town of Lake Cowichan could ask the following questions of its wastewater treatment specialists regarding effluent flow rates:

1. The Town of Lake Cowichan's water consumption is relatively high, at over 700 litres/person/day not accounting for tourism. By contrast, in BC cities with water metering, per capital consumption is approximately 70% lower than cities without water metering, and averages 269 litres/person/day.[12] The average water consumption in the UK

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[12] Pacific Salmon Foundation and Fraser Basin Council. 2007. Water and salmon issues and options for conservation and governance improvements in the lower Fraser River. 38pp.

is approximately 150 litres/person/day.

   a. What would be the effect of the Town of Lake Cowichan investing in water conservation programs (e.g. subsidies for toilet and fixture replacements, water metering, and so on).
   b. What would be the effect on the growth of future demand if the Town of Lake Cowichan required water consumption performance standards for all new construction? Organizations such as the *POLIS Water Sustainability Project* (www.poliswaterproject.org) in Victoria could be consulted for advice and suggestions in this area.

2. What would be the costs and benefits of reducing the overall rates of inflow and infiltration into the wastewater collection system? What are the least expensive and most effective options?
3. What would be the costs and benefits of developing an engineered wetland on land adjacent to the sewage lagoons? Could such a wetland provide a degree of phosphorous removal?
4. What would be the combined effect of implementing a combination of, or all of, these approaches? Could the planned capacity expansion of the sewage lagoon system be deferred?

13. Acknowledgements

The authors would like to acknowledge the help of the following people, who were generous with their time and suggestions during this study:

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Kate Miller, Manager, Environmental Initiatives, Cowichan Valley Regional District
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Ron McKinlay, Manager of Facilities, Cowichan Valley School District
Ronnie Gil, Controller, Town of Lake Cowichan
Ross Forrest, Mayor, Town of Lake Cowichan
Samjeet Parmar, Johel Bros. Contracting Ltd.
Sam Beldessi, General Manager, King George Seniors Affordable Housing Society

14. Closure

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

Original signed and sealed, on file.

Stephen Salter, P.Eng., LEED AP

President, Farallon Consultants Limited

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16. Appendix A - Comparison of Anaerobic Digestion and Composting Options

Table 6: Summary of Costs and Benefits for Anaerobic Digestion and Composting

			AD	**AD**	**AD**	**Composting**
Scenario	Rate	Units	Public Works	CLEC	Sewage Lagoons	Sewage Lagoons
Energy Consumption, Palsson School		GJ/year	839			
Energy Consumption, CLEC		GJ/year		761		
Energy Consumption, WWTP		kWh/year			129,102	
Use for Biogas			Replace electricity for heating	Replace propane for heating	Electricity for sewage aeration	N/A
Estimated Biogas Production, Electricity Basis		kWh/year			90,250	
Estimated Biogas Production, Gas Basis		GJ/year	928	928		
Organic Waste Diverted from Landfills		tonnes/year	177	177	177	177
Primary Biosolids		tonnes/year	249	249	249	249
Compost Produced		tonnes/year	167	167	167	338
Estimated Capital Cost			**$783,000**	**$783,000**	**$565,000**	**$633,000**
Estimated Annual Revenues						
Savings, Disposal	$140.00	$/tonne	$24,800	$24,800	$24,800	$24,800
Revenue, Compost Sales	$30.00	$/tonne	$5,000	$5,000	$5,000	$10,100
Savings, Propane	$17.26	$/GJ		$13,100		
Revenues, Energy Sales/Savings	$94.46	$/MWh	$22,000		$8,500	
Savings, Carbon Tax	$1.50	$/GJ		$1,160		
Savings, Carbon Offsets	$1.25	$/GJ		$696		
Savings and Revenues, Total			**$51,800**	**$44,756**	**$38,300**	**$34,900**
Estimated Annual Costs						
Cost, Operations & Maintenance			$39,200	$39,200	$28,300	$25,300
Cost, Wood Residues			-	-	-	$2,500
Cost, Financing			$63,000	$63,000	$45,000	$61,000
Costs, Total			**$102,200**	**$102,200**	**$73,300**	**$88,800**
Annual Net Savings and Revenues			**-$50,400**	**-$57,400**	**-$35,000**	**-$53,900**
GHG Reductions		tonnes/year	(400)	(400)	(400)	(269)

17. Appendix B - Costs and Benefits of District Energy Options

Table 7: Summary of Costs and Benefits for District Energy

	Municipal Hall Area	**Arena/School Area**	**Units**
Energy Required for Heating	1,258	4,130	GJ/year
Energy Provided by Biomass	1,069	3,511	GJ/year
Total Biomass Required	143	468	tonnes/year
Capacities			
Average Capacity, Biomass	42	138	kW
Peak Capacity Needed	126	414	kW
Peaking/Back-up Capacity (Electric)	84	276	kW
Total Installed Heating Capacity	126	414	kW
Estimated Capital Costs			
Number of Building Connections	3	2	
Total Distribution System Length	200	800	m
Distribution System and Energy Transfer Stations	$310,000	$620,000	
Energy Centre	$420,000	$653,000	
Soft Costs	$154,000	$231,000	
Contingency	$183,000	$318,000	
Total Capital Costs	**$1,067,000**	**$1,822,000**	
Estimated Annual Costs			
Biomass Fuel	$4,200	$14,000	
Electricity	$3,400	$10,800	$/year
Administration	$5,000	$12,000	$/year
Insurance	$10,000	$20,000	$/year
Maintenance, Energy Centre	$21,000	$32,600	$/year
Maintenance, DES and ETS	$9,400	$18,600	$/year
Financing	$76,000	$129,000	$/year
Total Annual Cost	**$129,000**	**$237,000**	$/year
Estimated Annual Revenues/Savings	$37,700	$123,900	$/year
Estimated Net Annual Revenues	**$(91,300)**	**$(113,100)**	

18. Appendix C - Estimate of Greenhouse Gas Emission Changes

The table below shows a summary of the modest changes in greenhouse gas emissions which would result from the Town of Lake Cowichan's diversion of organic solid waste from landfilling to anaerobic digestion. The summary shows that the majority of benefits come from avoided landfill methane emissions.

Table 8: Summary of Greenhouse Gas Emissions

Source	**Activity Data**	**Units**	**Emission Factor**	**Units**	**GHG Changes**	**Notes**
Methane from Anaerobic Digestion	426	tonnes/year	1.000	g CH_4 per tonne of substrate	9	1.
Avoided Emissions, Displaced Propane	928	GJ/year	50.312	kg CO_2e/GJ	(47)	2.
Fertilizer Replacement	167	tonnes/year	0.066	g CH_4 per tonne of substrate	(11)	3.
Avoided Landfill Methane Emissions	177	tonnes/year	1.961	tonnes CO_2e/tonne of waste	(347)	4.
Total (tonnes of CO_2e per year)					**(400)**	

Notes

1. IPCC provides a range of 0 to 8 grams of CH_4 per wet kg of substrate, with a default value of 1 gram. The value of 1gram has been used here.
2. Based on CO_2: 50 kg/GJ, CH_4: 0.966 g/GJ, N_2O: 0.913 g/GJ.
3. Per Wood, S. et al (2004). This represents the avoided greenhouse gas emissions resulting from displacing artificial and mineral fertilizer with digestate/compost from anaerobic digestion.
4. This estimate is based on an assumed Landfill Gas capture efficiency at the Roosevelt Landfill of 25%.

19. Appendix D - Inputs and Assumptions

Criteria		Units	Notes
Energy			
$0.44	Price of propane	$/litre	Based on 2013 bulk prices.
$1.50	Carbon Tax, natural gas basis	$/GJ	
$1.25	Cost of carbon offsets to public organizations, gas basis	$/GJ	
$25.00	Price of greenhouse gas offsets	$/tonne	As bought by public organizations in BC.
$102.25	Price of electricity sold to BC Hydro through the Standing Offer Program on Vancouver Island	$/MWh	Does not include feed-in tariffs, a potential Clean Power Call premium, or peak time premiums.
$80.00	Price of purchased electricity	$/MWh	Blended rate to account for demand and capacity charges.
$10.00	Price of wood waste generated by the Town of Lake Cowichan operations	$/BDT	
$40.00	Price of chipped urban wood waste	$/BDT	
$60.00	Price of chipped urban wood waste	$/BDT	
Technical			
75%	Boiler efficiency, propane, seasonal		
15.0	LHV of wood chips from wood waste, 30% moisture	GJ/BDT	
72%	Boiler efficiency, biomass boilers, wood waste,		For biomass at 30% moisture
0.6556	Density of methane	kg/m^3	
0.061005	Emission factor, propane	t CO_2e/GJ	*BC Reporting Regulation Methodology Manual*

Criteria		**Units**	**Notes**
0.002790	Emission factor, diesel	t CO_2e/litre	*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*
28	Emission factor, electricity	t CO_2/GWh	Per BC Hydro Annual Reports
5.0%	Ash content of wood residues		
200	Bulk density of wood chips	kg/m^3	
Construction & Operations			
25%	Contingency rate		
10%	Engineering		As a percentage of capital cost.
5%	Construction supervision and project management		As a percentage of capital cost.
5%	Financing rate		
25	Amortization period	years	
$1.00	US/Canada exchange rate		
$30.00	Price of compost, 50% moisture	$/tonne	

20. Appendix E - Company Profile: Farallon

Stephen Salter, P.Eng. LEED AP® is the President of Farallon Consultants Limited (www.farallon.ca). Farallon specializes in industrial ecology, integrated resource recovery, sustainable energy, and greenhouse gas modelling and reporting to meet regulatory requirements. Farallon helps communities find practical ways to reduce their environmental impacts through conservation of resources and by recovering value from waste streams.

Farallon was established in 1991, and has worked with over one hundred industrial and municipal clients in Canada, the United States, and Chile. Stephen has given over fifty presentations on industrial ecology at conferences and public forums, and written articles on environmental management and industrial ecology, including a paper (*When Low Carbon Means Low Cost: Putting Lessons from Nature to Work in our Cities*) in the *International Journal of Social Ecology and Sustainable Development* (Oct.-Dec. 2011 Vol. 2, No.4).

Farallon is not an engineering firm with a narrow focus on a single technology or technical problem-solving approach. Instead, Farallon uses industrial ecology (also termed eco-industrial networking or industrial symbiosis) to uncover options for resource recovery that are not obvious when more conventional technology-driven approaches are used. After innovative options have been uncovered, Farallon often represents its clients to direct the work of specialist engineering firms as they move ahead with more detailed design of the chosen option.

Farallon's process involves first using creative (right brain) processes to identify innovative opportunities, followed by analytical (left brain) processes to evaluate technical feasibility, risk, social aspects, environmental costs and benefits, economic viability, and governance issues.

Farallon works with cross-functional teams and has access to specialists in building energy systems, alternative energy systems, resource recovery technologies, wastewater treatment infrastructure, ecology, agricultural science, economics, and governance. Farallon's work with communities and industry has shown that if the right questions are asked, and if the right system boundary is included in a study, then resource recovery options can pay for themselves. In this way, Farallon works to find options that are best, both economically and environmentally.

21. Appendix F - Company Profile: FVB Energy

FVB Energy Inc. (www.fvbenergy.com) brings extensive international experience designing and building district energy systems based on sustainable energy sources: a list of projects is available in the *Company Profiles* section of this proposal, and on the FVH website at:

http://www.fvbenergy.com/accomp/index.cfm.

FVB Energy Inc., specializing in community energy systems (district heating, district cooling and combined heat and power) was founded in Canada in 1991. With its main offices located in Toronto, Vancouver and Edmonton in Canada and in Minneapolis in the United States, FVB Energy Inc. is the North American subsidiary of the Stockholm-based district energy consulting engineering firm Fjärrvärmebyrån ab (FVB Inc.), which has been consulting internationally since 1970.

FVB's mission is to help clients find the best energy solutions for their communities or buildings now and in the future. Clients include utilities, municipalities and institutional complexes, such as hospitals, universities and military bases. FVB has developed our planning, marketing, engineering and operations consulting services based on sound knowledge of how district energy can be made to work in real-world situations.

FVB Energy Inc. brings the benefits of Northern European experience and expertise in district energy systems together with North American business and marketing expertise to assist its clients in energy system planning, development and implementation. The firm's senior staff have more than 100 years of district energy and combined heat and power management experience at successful operating companies. FVB is committed to maintaining a professional attitude that stresses close working relationships with community leaders, the client's staff and public groups, and the creation of a residual body of knowledge and skills at the local level.

Fjärrvärmebyrån ab (FVB Inc.) was founded in Sweden in 1970. It has consulted in over 30 countries and now has over a hundred employees with a broad range of technical skills relevant to DE, biogas and process technology.