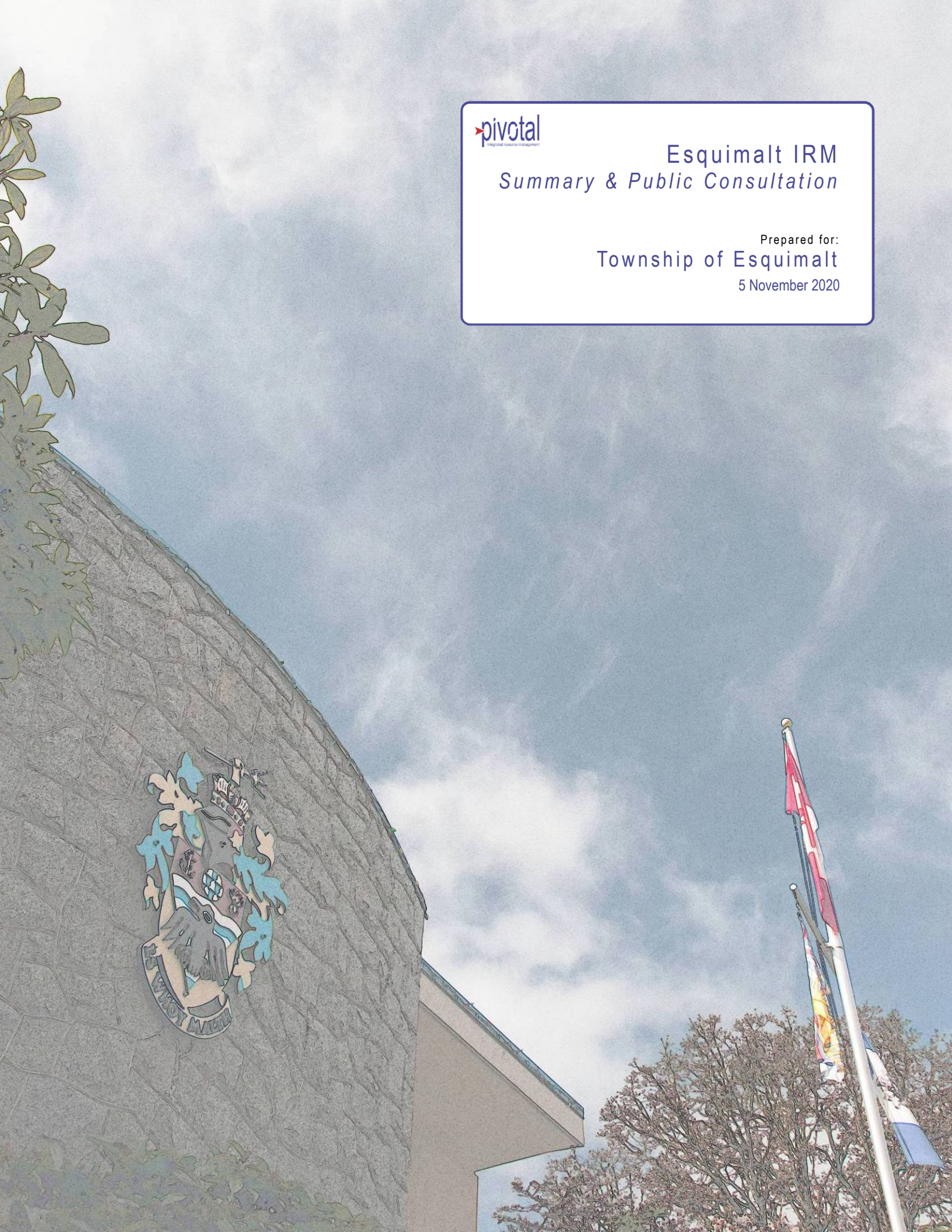

Esquimalt IRM

Summary & Public Consultation

Prepared for:

Township of Esquimalt

5 November 2020

Jeff Miller
Director of Engineering & Public Works
Township of Esquimalt
1229 Esquimalt Road
Esquimalt, BC,
V9A 3P1

5 November 2020

Dear Mr. Miller,

ESQUIMALT IRM - SUMMARY & PUBLIC CONSULTATION

We have pleasure in submitting the IRM Summary & Public Consultation Report, which summarizes both the technical assessment of IRM and results of public engagement.

This summary was originally published to assist with public engagement but has been updated to include the results of consultation and feedback from Council, the Environment Committee and staff. Amendments have largely been to summarize the engagement results, with associated updates. Engagement from 266 participates indicated strong support for an IRM facility.

We will be happy to answer any questions arising from this or any other material prepared during the Study and trust this meets your needs.

Kindest regards,

Yours truly,

Graeme Bethell
President
Pivotal IRM Inc.

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cc

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Figures & Tables

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1 Executive Summary

1.1 Purpose & Scope of Work

The Township of Esquimalt commissioned a study of the potential to assess how and whether waste management can be improved and resources recovered with Integrated Resource Management (IRM), using gasification. The scope considered: (a) the technical aspects of solid and liquid wastes generated in the Township; (b) business case options including financial considerations; and, (c) public consultation and engagement.

The study was mainly spurred by climate change and greenhouse gas emissions reduction, and an interest in moving towards more sustainable and beneficial approaches to waste management. Central to the scope is the Township's declaration of a Climate Emergency and commitment to becoming GHG neutral by 2050 and achieving a 30% reduction in GHG emissions by 2030 a number of technologies were compared and a key requirement to assess the financial impact of options was undertaken.

1.2 Summary Findings

The study found that IRM has the potential to achieve or exceed environmental targets with a net reduction in taxpayer costs or possible taxpayer dividend, with strong public support for developing an IRM facility. The main findings included:

General

- Dividend of up to ≈$360/door, net average, potentially $226m net over 30 years;
- Reduced trucking with no odour or noise, and simpler waste separation for residents with less garbage bins.

Environmental

- Potential to exceed 30% of community and 100% of corporate GHG reduction targets;
- Equivalent to removing ≈970 cars/year;
- ≈91% landfill diversion;
- Improved recycling;
- Generate clean energy to displace fossil fuels. Produce sterile fertilizer & sequester carbon;
- Simplest, most economic GHG reduction option available.

Public Engagement

- Strong support for an IRM facility with low objection – 85% showed very strong to strong support while less than 8% objected to the project ;
- High percentage (78%) showed they were aware of the potential benefits such as GHG reductions;
- High support (70%) for the proposed Public Works Yard site with low (6%) overall objection based on risk.

Intangible

- European examples attract new business and enhance education, training, and eco-tourism, raising community profile and enhancing public pride;
- Broader economic stimulus & jobs with local re-investment and re-spending benefit.

In summary, the study concluded there is appreciable potential for environmental and financial benefits in proceeding with an IRM facility, while noting that as with all such public infrastructure projects, the project will require careful management. Public consultation was meaningful with an acceptable and representative response rate, showing strong support for an IRM facility and approach using gasification.

Council will wish to consider the cost/benefits and net potential advantages, but we conclude the potential is sufficiently persuasive to merit recommending proceeding further. Should Council wish to proceed the next steps will depend on a variety of factors, initially oriented to risk mitigation and management.

2 Background

2.1 What is IRM and Why Gasification

Integrated Resource Management (IRM) is an approach to managing water, energy and waste that aims to maximise their use and value as resources, in ways that reduce costs to homeowners, recover heat and other resources, and reduce greenhouse gases (GHGs), other emissions and discharges. IRM mostly uses energy generation from waste residuals left over, after recycling.

IRM is a fully integrated life cycle assessment of ways that resources can be recovered from waste, to maximize the benefits to the environment and homeowners. This allows the community to compare financial and environmental impacts so that informed decisions can be made on the best direction for the community.

Choice of technology or technologies has a direct impact on yield and performance, viability and risk. Some technologies also cope with a wider range of materials. Choice of systems and integration is thus important.

Composting, anaerobic digestion and similar approaches to waste disposal typically address some or all of the organic portion of the waste stream and are not complete, standalone solutions. Incineration, pyrolysis and gasification can address organics but also address a wider range of other wastes. Incineration creates pollution (toxins and smoke, which contains particulates) and thus requires appreciable equipment to handle this. Incineration doesn't scale easily to smaller applications such as Esquimalt needs and are not popular as a community solution. Pyrolysis and gasification both avoid burning and producing toxins and smoke, but with a typically similar cost to gasification, pyrolysis is less efficient, i.e. the technology typically with the highest yield, broadest adaptability and scalability, is gasification (Figure 1).

Figure 1: Test gasifier, California

Internationally, gasification systems have over 1,000 years of combined operational experience, so are well proven, with examples handling municipal wastes but not exactly

Esquimalt's waste. However combinations of testing, manufacturer yield guarantees and other approaches are considered acceptable to address this risk.

In short, gasification is a process where waste is heated to produce a syngas, which can be used to produce heating, cooling, biochar and other products. The syngas is considered "green" and the energy "renewable" because over 85% of Esquimalt's waste is biogenic, i.e. it comes from natural and organic sources, not fossil sources.

2.2 Context

To understand whether IRM makes sense we have to consider: how waste is currently managed in the region and what the wastes consist of; what the regulations are; how the community might grow – and how much waste there might be in the future.

Historical Background

Historically, waste has been landfilled because land was cheap, available and out of sight. Recently however, landfill emissions have raised concern – toxins seep into groundwater; Greenhouse Gas (GHG) emissions are rising; and there will be up to 50 years' of maintenance responsibilities once Hartland landfill closes, at taxpayer expense.

Spurred by rising costs, contamination and emissions, with land becoming more expensive and less available, and rising waste volumes as populations grow, increasing emphasis is being placed on diversion. Both older and new technologies are being considered to solve the problems.

Regulations

Provincial regulations allow municipalities to decide how to manage their wastes and the region is responsible to incorporate these into a regional plan. If Esquimalt decides its own waste plan, this would then be included in the regional plan. An example similar to this is Dockside Green, which has its own sewage treatment plant and recycling, which the regional plan was amended to allow for.

IRM can proceed providing it meets some regulatory requirements:

a) Recycling has to meet or exceed recycling thresholds set by the Ministry of the Environment and Climate Change Strategies' (MoE) 5R's guideline. Regional and local diversion and recycling meet this requirement;

b) Disposal level must be at or below 350 kg/capita/yr and the planned system must achieve at least 60% energy recovery yield while meeting emissions requirements. These criteria can be met;

c) CRD will need to amend the regional Solid Waste Management Plan (SWMP) to include an IRM energy recovery facility; and,

d) Community support is required.

In summary, an appropriately planned IRM plant has the ability to meet BC's

regulatory structure and be permitted.

Liquid Waste

Liquid waste can be used to recover treated water and energy, however consideration of energy recovery from sewage has currently been deferred, largely because sewage flows are uncertain until the new treatment plant opens at McLoughlin Point. Recovery of water and energy from sludge has been deferred for the same reason, but should be feasible to phase in at a later date, once flows and availability are more certain.

Solid Waste

Currently wastes in the Capital Region are sent to a number of sites, not just to Hartland Landfill. These include sites in the Cowichan Valley, Nanaimo Regional District, Greater Vancouver and Washington State. Most of these centres are landfills but some recycle separated wastes such as food scraps, yard and garden wastes. Two recipients incinerate the wastes.

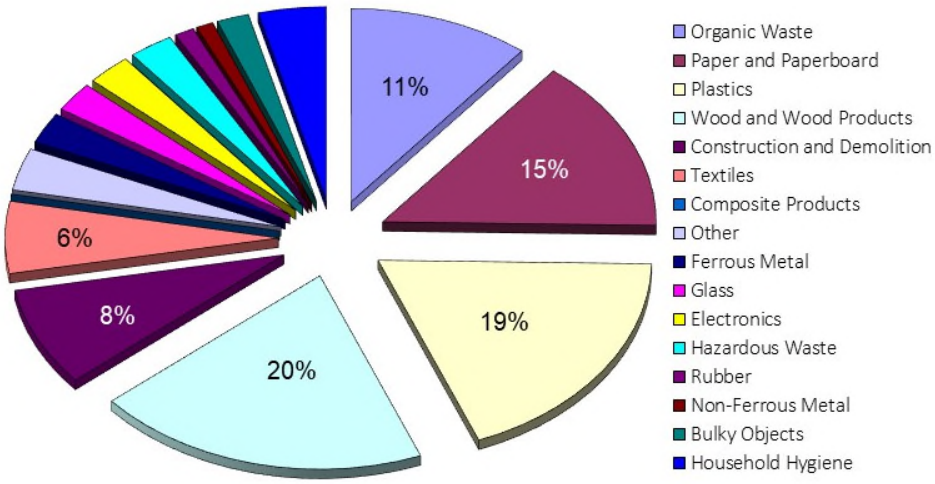


Figure 2: CRD 2016 solid wastes by dry weight

There has been an increasing effort to recycle and divert wastes from landfills. CRD's latest study (2016) shows that advances are being made, but almost half the organic wastes are still being landfilled, as are most other wastes, shown in Figure 2 (which excludes 'Blue Bin' recycling).

Because waste is often made of composite materials, it is difficult to separate the materials so they can be fully recycled. An example of this is coffee cups (which often mix paper with a plastic liner) or meat packaging (which mixes polystyrene and plastics with organics and paper).

The European Union provides contrast to understand both local progress and the potential for using waste, as the EU started with waste diversion and resource recovery since the early 1970s and is advanced. Figure 3 shows that the estimated current ≈43% diversion being achieved is low compared to most EU countries, but that up to 100% diversion has been achieved, largely by integrated (IRM) approaches using thermal conversion

technologies. An example of this is in Gothenburg Sweden, click here to see a short video explaining this.

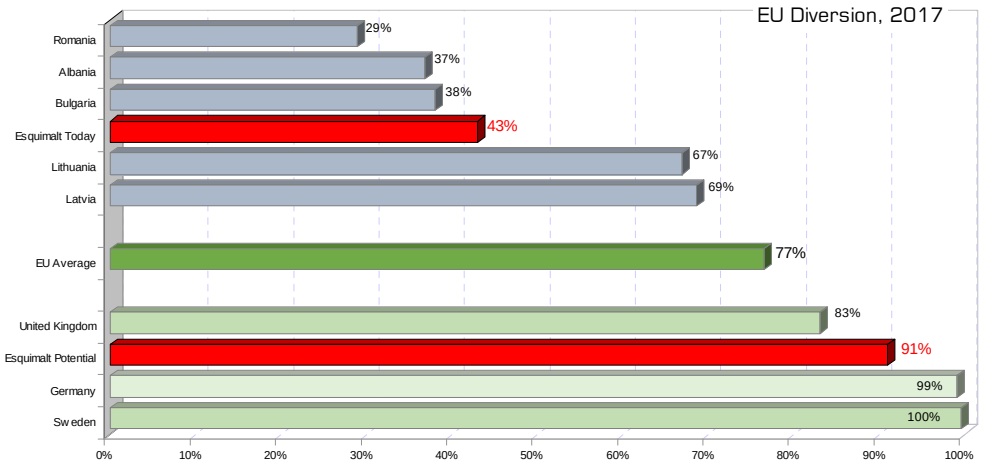


Figure 3: Diversion comparison, Esquimalt⇔EU

CRD has commenced public engagement for a new solid waste management plan so should Esquimalt decide to adopt IRM as its direction, it is timely for this to be included in the new regional plan.

Esquimalt's Waste Streams & Potential

The Township collects residential refuse (garbage) and kitchen (food) scraps largely from single family homes and small apartments, while private haulers collect the same from businesses and large apartment buildings. Yard and garden waste is dropped off at a recycling centre adjacent to the Public Works Yard on Canteen Road. This waste is currently transferred to Hartland landfill where some is sent for processing in the Lower Mainland and the remainder is landfilled (Figure 2).

Township of Esquimalt, 2019/2020

	Tonnage		Moisture	Dry	
Yard & Garden	1,778	27%	40%	1,067	24%
Food waste	566	9%	60%	227	5%
Subtotal	2,344	36%	45%	1,293	29%
MSW	1,054	16%	25%	790	18%
Total	3,398	52%	39%	2,084	47%
Plus: private hauled wastes	3,100	48%	25%	2,325	53%
Total current estimated volume	6,498	100%		4,409	100%
Total current estimated volume, dry tonnes per day, public only				5.7dtpd	
Total current estimated volume, dry tonnes per day, combined				12.1dtpd	

Figure 4: Esquimalt solid waste volumes

Figure 4 shows that in 2019/2020 the Township collected ≈3,400 tonnes of 'wet' waste, while private haulers collected ≈3,100 tonnes waste, i.e. a 50/50 split in collection. Wastes collected by the Township equate to ≈182kg/person, rising to ≈347 kg/person once private wastes are included, which meets provincial diversion guidelines to be able to consider energy recovery from waste.

Figure 5: Biochar

Energy recovered by the IRM plant would be supplied to the Township's municipal centre and the biochar produced (Figure 5), it is typically used as a sterile soil supplement because it retains fertilizers and water, while sequestering carbon. It can also be used as an air or water filter for buildings, swimming pools and fish tanks. This is a considerable benefit in reducing GHGs while supporting environmental restoration, and is an appreciable potential revenue contributor.

Community Growth

Figure 6 shows that Esquimalt has grown at ≈0.3% per annum in the long term whereas the region as a whole grew at an average of ≈1% per annum. However from 2005 to 2016, Esquimalt grew at ≈1.0%, which is representative of the region.

	Population					
Community	**1991**	**1996**	**2001**	**2006**	**2011**	**2016**
Central Saanich	13,684	14,611	15,348	15,745	15,936	16,814
Colwood	13,468	13,848	13,745	14,687	16,093	16,859
CRD	299,550	317,989	325,754	345,164	359,991	383,360
CRD Core (CALWMP)	239,138	250,487	256,227	271,654	283,977	303,542
Esquimalt	16,192	16,151	16,127	16,840	16,209	17,655
Highlands	1,094	1,423	1,674	1,903	2,120	2,225
Indian reserves	3,214	3,806	4,667	4,670	5,282	5,244
Langford	15,642	17,484	18,840	22,459	29,228	35,342
Metchosin	4,232	4,709	4,857	4,795	4,803	4,708
North Saanich	9,645	10,411	10,436	10,823	11,089	11,249
Oak Bay	17,815	17,865	17,798	17,908	18,015	18,094
Saanich	95,583	101,388	103,654	108,265	109,752	114,148
Sidney	10,082	10,701	10,929	11,315	11,178	11,672
Sooke			8,735	9,704	11,435	13,001
Victoria	71,228	73,504	74,125	78,057	80,017	85,792
View Royal	5,996	6,441	7,271	8,768	9,381	10,408

Source: CRD &Statistics Canada

Figure 6: CRD demographics, 1991-2016

The Township anticipates that the community may reach buildout over the

next 10+ years, and reach a maximum of ≈25,000 population, which is considered practical for projecting waste volumes.

The combined waste volumes indicate that a 15 tonne per day plant would be needed at the start but will expand to ≈25 tonne per day at buildout. The plant's expansion can be phased and expanded in stages to meet population growth. Phasing reduces initial cost, however, some additional capacity will be needed to address maintenance downtime.

Climate Change

Esquimalt Council has declared a Climate Emergency, to elevate the importance of initiatives that will reduce carbon. The Township's Corporate annual balance is 1,005 tCO_2e and the emissions for the entire community are 37,644 tCO_2e, according to provincial inventories. As a main objective of IRM is to reduce GHGs, this is a key part of the assessment.

3 IRM Assessment

3.1 Options

The Ministry of the Environment requires consideration of options to use the "best available technology" in decisions, which means also considering the purpose – i.e. what wastes need addressing. An extended assessment is included in the Technical Report, summarized below.

Previous Technology Reviews

Resource recovery technologies were reviewed by CRD during Core Area Liquid Waste Management planning and by CRD's IRM Task Force. The focus of these studies was primarily on wastewater aligned technologies, and the main focus was not on integration of waste streams, even though CRD's IRM Task Force and Technical Oversight Panel noted that IRM could be beneficial. Advanced Gasification was put forward by West Shore Innovation Days, and CRD noted that IRM has the potential to impact every aspect of solid waste management in the region, but it has yet to progress.

Main Technology Options

Anaerobic digestion is an accepted technology selected by the region for sewage sludge treatment (Figure 7), although this could extend to organics processing (≈11% of the region's wastes, per Figure 2). Other options such as biofuels could handle more, but would need several systems to cover available wastes and the technology is not well advanced. It would also not be easy to locate plants in Esquimalt.

Figure 7: Planned digester, Hartland Landfill

A technology supported during prior reviews is Advanced Gasification (an example of which is shown in Figure 8), which can handle a broader range of wastes, including compound wastes. Digestion and gasification were thus compared using CRD's assessment for the proposed

Figure 8: Advanced Gasifier, Louisiana, USA

digester at Hartland Landfill, shown in Figure 9, adjusted to equate plant size. This shows Advanced Gasification is financially preferable, potentially yielding a dividend whereas digestion is expected to require continuing taxpayer support.

Aspect	Anaerobic digestion	Advanced Gasification
Feedstock suitability	≈11% of volume Organics only	≈75% of volume Most solid wastes
Recovered, saleable resources	Biogas for heating/RNG	Heating, cooling, biochar
Capital cost per tonne processed, life cycle	≈-$232 per tonne	≈-$91 per tonne
Operating cost per tonne processed, annual	-$3.0m/yr	-$1.6m/yr
Total net life cycle cost/revenue, undiscounted, current $$, after debt	≈-$2,154 per tonne	≈+$122 per tonne
Annual tCO2e reduction	Not assessed by CRD	≈8,500 tCO2e
Life cycle CO2e reduction	Not assessed by CRD	≈425,000 tCO2e

Figure 9: Technology comparison

Waste Options

As noted previously, Esquimalt's wastes are collected by the Township and private companies, raising the question of whether to size a plant to process purely the Township's collected wastes, or all wastes. While it would be possible to process more wastes than purely Esquimalt's, we evaluated the impacts of these two main options: (a) Figure 10 summarizes the net annual tCO_2e GHG reduction and tCO_2e sequestration; and, (b) Figure 11 shows the dividend per home. These indicate both a financial and environmental benefit in handling all the wastes generated in Esquimalt, not just the Township-collected wastes.

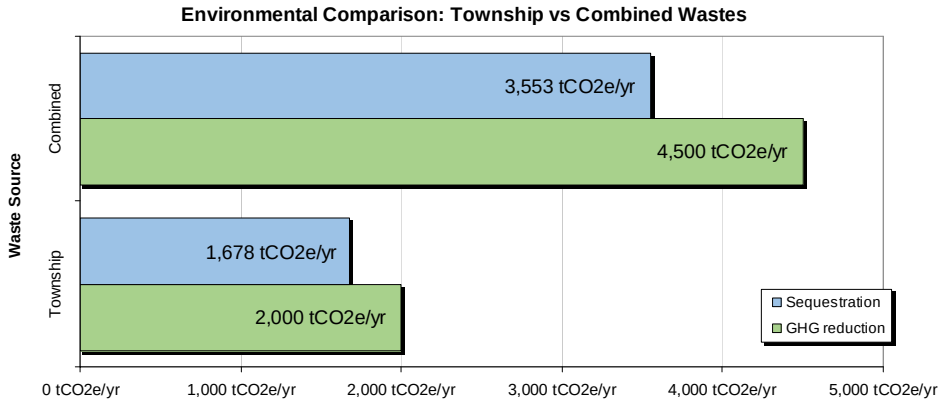


Figure 10: Environmental waste comparison

Notably Figure 11 shows that as the community grows and the plant reaches capacity, the dividend could be up to ≈$360 per home, net. While this is likely to be used to pay for other services and avoid higher taxes, it is indicative of the likely benefit to taxpayers, net of the investment needed for building the plant.

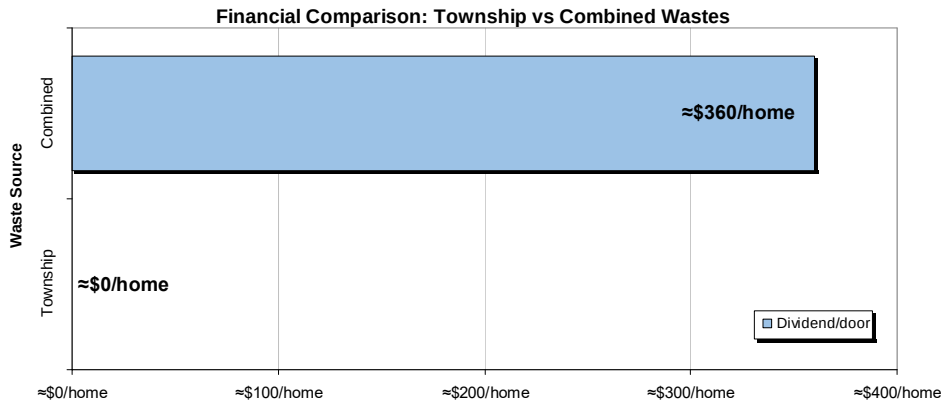


Figure 11: Financial waste comparison

Energy & Resource Recovery

Because a significant part of an IRM philosophy is maximising reuse of recovered energy and resources, plants need to be located close to energy consumers.

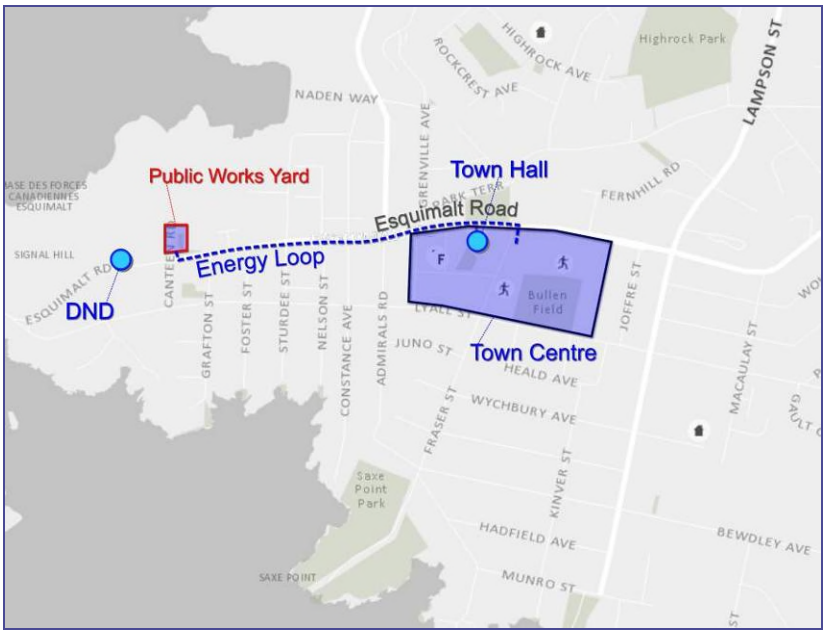


Figure 12: IRM site and energy users

Figure 12 shows an IRM plant could be located at the current Public Works site on Canteen Road, with a District Energy System connecting with Esquimalt's core. The loop would be buried along municipal streets with service connections to buildings that would be supplied with both heating and cooling. This was assessed for the Township in a 2013 study by Kerr Wood Leidal which identified ample consumers for energy. Should the project proceed, we recommend this be updated as part of an integrated Net Zero study for the core, to further reduce GHGs and lower energy costs

in Esquimalt.

While other sites may exist and be feasible, the Public Works Site is well located to distribute energy recovered from waste and is owned by the Township. This site is preferred and has been assumed for modelling.

Site & Traffic

The Public Works Yard (Figure 13) is a recommended choice for the plant, located at the intersection of Esquimalt and Canteen Roads. This is well situated to minimize the cost of supplying recovered energy to Esquimalt's core, using a ≈1km energy loop, or to other potential major consumers.

Phasing and the ability to expand the plant have been considered and it is likely that projected growth can be accommodated. The site is currently used for parking, which would be relocated within the site if alternative parking is unavailable.

Figure 13: Public Works Yard

We do not expect any noticeable or significant change in traffic caused by the plant. We estimate up to three trucks per day would supply waste. These are already circulating in the community so would not generate new traffic, but instead of going to Hartland, would go to the plant. There may be at most 3-5 additional employee cars visit the site during the day. The traffic impact is thus expected to be negligible and as this would reduce traffic going to Hartland, trucking costs would be expected to be lower, as would GHG emissions.

Conclusion

IRM technologies have recently been extensively researched by CRD and we have referenced assessments of over 90 MSW gasifiers operating in total, with the equivalent of over 1,000 years of use. MoE regulations needing to be satisfied and our review indicates the technology should comply with the Ministry's requirements. Advanced gasification addresses the largest portion of the waste streams and is less expensive and more efficient, as well as being more compatible to recovering energy in Esquimalt, which has site limitations restricting effective use of other alternatives. We conclude that although the Township directed an assessment based on gasification, that Advanced Gasification is the best option for Esquimalt's needs, assumed to be located at the Public Works Yard with a ≈1km District Energy System supplying the core to recapture and reuse green energy.

3.2 System & Approach

To ensure odours from waste are controlled, the plant will have a negative pressure feedstock processing and storage centre, where garbage is unloaded behind closed doors and air is filtered to eliminate odours. Large recyclable and inert materials will be removed and recycled, then the waste will be processed in a chipper/shredder, blended, dried to ≈20% moisture ratio, cooled and stored, ready for gasification (Figure 14).

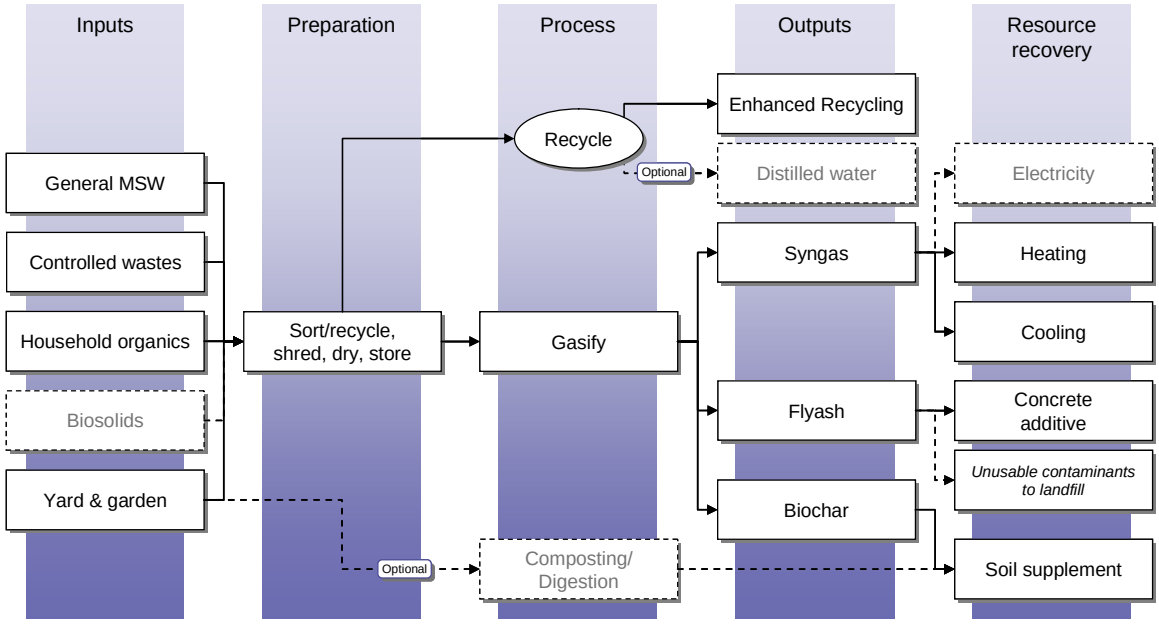


Figure 14: Gasification general process

Gasifiers vary widely and in the IRM Technical Report provided to the Township we identified the Advanced RotoGasifier manufactured by TSI, Lynnwood, WA, as the preferred technology, due to its track record and robust feedstock handling. Working with a specific technology and manufacturer improves costing and performance information for the business case.

3.3 Analysis

Pivotal uses a proprietary computer model to assess IRM projects, developed with input from sector experts. The model combines both environmental and financial aspects to calculate the full net life cycle, using financial and environmental standards. The model is used to run scenarios, each of which has 105 cash flows, plus GHG projections over 150 years (to assess GHG life cycle).

Because population and waste growth is uncertain, we assessed scenarios with population growth of 0.3%, 1% and 1.7% per annum, comparing the results given either (a) just using the waste collected by the Township; or, (b) Combined Township and broader community wastes. Figure 15 shows the main scenarios run, with the base models for each of these assuming a publicly-owned project.

Scenario	Growth	(a) Township	(b) Combined
1 Minimum	0.3%/yr	≈3,800 t	≈7,200 t
2 Moderate	1.0%/yr	≈4,700 t	≈9,000 t
3 High	1.7%/yr	≈5,900 t	≈11,300 t

Figure 15: Scenario summary

The method of procurement and delivery is not yet determined, and because factors such as risk and investment can vary, we also ran initial private partnership estimates for each of the six scenarios shown in Figure 15, for a total of twelve scenarios. The private sector models have been provided separately but in summary, we anticipate probable private sector interest only in the combined waste scenario, subject to how the contracts are structured.

Because growth (in both population and waste) is not predictable, a "just-in-time" approach was devised using multiple smaller gasifier units so the plant can be expanded as and when needed. This avoids incurring capital cost for a population that might never happen, but also avoids today's taxpayers having to fund anything that is not absolutely necessary based on what we know today.

Figure 16 summarizes the main indicators for the "moderate" growth curve, for both the "Township only" waste collected, and the "Combined" wastes for the whole community. The combined waste scenario, highlighted in green, is recommended.

	Township	Combined
Scenario	2a	2b
Population growth %	1.0%	1.0%
Total capex	$17.3m	$21.3m
Annual O&M	-$1.5m	-$1.7m
Waste volume	4,670 t/yr	8,930 t/yr
Life cycle profit/loss	$47m	$226m
Simple payback	≈14yrs	≈6yrs
Taxpayer dividend/subsidy/yr, 1st 10 yr avg	≈$0/home	≈$360/home
Total mwt, life cycle	249,000 mWht	528,000 mWht
Total GJ, life cycle	897,900 GJ	1,901,700 GJ
Life cycle biochar, tonnes	17,100 t	36,300 t
Life cycle tCO2e redn/increase	101,185 tCO2e	223,139 tCO2e
Life cycle vehicles less/more	13,200 cars	29,100 cars
Life cycle sequestered carbon, tCO2e	50,330 tCO2e	106,594 tCO2e
Life cycle landfill diversion, tonnes	140,100 t	267,900 t

Figure 16: IRM analysis summary

- Although both 2a and 2b are viable, 2a may only achieve breakeven or become viable as it approaches projected capacity and will likely require taxpayer support up to that point (≈18 years), whereas 2b is anticipated to be viable from the start of operations. Note also that each model has external savings (e.g. meeting corporate emissions targets, landfill diversion benefits and other savings), not fully accounted for in Figure 16.

- Both Township and combined waste options have heat recovery and CO_2e benefits, with 2b being much superior over the 30 year projection period.

- We estimate Option 2b has the potential to reduce the entire community's GHG emissions by ≈12%, and reduce the 2030 target by ≈30%. The potential for carbon sequestration, at no extra cost, is important given alternatives and the Township's declaration of a Climate Emergency. Few options exist able to essentially extract carbon from the atmosphere by ≈3,600 tCO_2e annually, at no cost.

- The major resources recovered are heating, cooling, and biochar with primary revenues from biochar, tipping fees and energy sales. The most sensitive of these is biochar sales, however most of the revenues can be pre-contracted and the value confirmed prior to committing to the project, to limit risk.

- Landfill diversion is achieved under all options and is desirable given rising costs and limited capacity at Hartland Landfill. IRM is expected to divert ≈9,020 tonnes per year from the landfill – and if adopted across the region, would extend the existing landfill's life to 2186 (166 years).

- At buildout, a plant addressing the combined Township and other community wastes is estimated to potentially yield a "rebate" to taxpayers in the order of ≈$360/home. Few other waste management options exist with the potential to yield a rebate to taxpayers.

3.3.1 Risk

A basic risk assessment and scenario testing was undertaken to identify the main issues that could affect a decision on whether to proceed further.

All waste treatment systems have technology risk – the potential for the systems to fail or underperform. Usually these are handled by technology guarantees, and is true for the gasifier, the manufacturer is willing to guarantee the system and its design performance at the yield in the business case. Steps to address this are relatively simple and require laboratory and physical testing of actual sample wastes. A demonstration test with local wastes was successfully undertaken in 2017, shown in Figure 17, proving the system works with similar wastes to those found in Esquimalt.

Figure 17: Demonstration test of local waste

Projection risk – the likelihood that population and waste grows to meet predictions – has been managed by adopting a "just-in-time" phased system design and pricing. While this adds cost in the long term, it reduces it initially and means that projection risk is reduced if not eliminated.

Any project of this scale involves contract and construction risks. These are normally handled through fixed price contracting, bonding, warranties, guarantees and other mechanisms. This risk will be monitored through construction and procurement can be structured to address and manage this risk.

Should the Township decide to pursue a combined waste strategy addressing all of the community's wastes, contracts will need to be put in place with haulers. We confirmed there is interest in this, thus reducing this risk and although it cannot be completely eliminated during the 30 year plant life, strategies exist to manage it in the long term. This helps mitigate volume and contract risk.

Revenues in the model have been relatively conservatively determined, for example we have excluded the possibility of selling electricity so BC Hydro revenue has been ignored. Aspects such as tipping fees and carbon credits have also not been aggressively determined. The model is more sensitive to biochar revenues so work was undertaken to confirm this aspect, and a rate of US$2,000/tonne applied whereas retail rates for biochar are currently sold for US$5,000/tonne. This is an item for early risk management, which can be achieved through sample testing and pre-contracting, i.e. sales would be confirmed and contract signed so the value is known, before committing to proceeding with the project. Similar approaches would be adopted for other revenues, where possible. A more detailed comment on this item has been provided but the system is not ultimately reliant on biochar revenues and can exceed breakeven without this.

In terms of operational risk, budgets have been assumed based on experience with other plants, and the systems themselves are not pressurized, so do not require certified boiler engineering professionals. Training and shift staffing have been assumed with standard allowances for maintenance, so we do not currently identify this risk as especially sensitive.

In conclusion, while there are risk concerns with this system, the same is true with other systems and the risks are considered manageable, with most capable of being mitigated in whole or part before final commitment to construct. Feedstock supplies, construction and technology performance, guarantees and revenue contracts can be managed before proceeding and we have not identified risks that cannot be managed or are sufficiently significant to reject proceeding at this stage.

3.4 Next Steps

We expect further consideration will be needed depending on the Township's review of the study's findings. Should Council decide to proceed we recommend a focus on de-risking, by establishing an advisory committee to address risks, safeguard project and taxpayer value.

The next steps would be to concurrently confirm the IRM approach meets MoE requirements and has their support; secure feedstock supply; partner with CRD to amend the Solid Waste Management Plan to include a waste to energy IRM project for Esquimalt and confirm how the Township will continue to support CRD's landfill and recycling; and confirm regulatory and development approval processes. Then undertake essential laboratory testing of the waste as well as run a physical test of the waste mixture to confirm suitability and guarantees.

During this time, feasibility would be continually monitored and a decision will be needed on whether to proceed with a Detailed Development and Implementation Feasibility Assessment, and Implementation Plan. The procurement model would be decided and the financials would be updated as new information is provided. The Township would then be in a position for one final decision on whether to proceed to development or not.

4 What IRM Means For Residents

This summary is mainly intended to inform residents and to aid with community engagement, so technical terms have been minimized, but a separate Technical Report has been prepared with greater detail and is available for those with an interest in the technical aspects. In that context, the following provides a simplified summary based on the recommended option – which addresses all of the wastes generated in the entire Township.

Perspective	Comment
Homeowners	Residents currently separate kitchen scraps and other wastes but this is expected to reduce to Blue Box items and a single combined garbage can. The facility has the potential to limit homeowner costs, or may provide a small tax rebate to residents. No additional garbage trucks are expected to be needed. The garbage trucks are already circulating within the community and we anticipate up to ≈3 trucks per day will visit the site. Because the facility is sealed, there will be no odours. The gasifier has low level noise from the chamber rotation, below allowable limits and thus not an issue.
Financial	The facility is expected to cost ≈$15m initially, expanding to ≈$21m over time (±15%), with eventual operating and maintenance costs of ≈$1.7m annually. There may be up to $226 million net revenues, over the life of the project. This is equal to a homeowner dividend (or rebate) of ≈$360 per home per year, potentially with more beyond the first 30 years of operation. Grant and funding programs are likely to be available but have not been assumed. Homeowner costs can be reduced or eliminated using outsource contracting, however this is likely to reduce potential dividends and may affect resource recovery and GHG reduction. The maximum benefits are likely to be obtained by the community owning the project.
Environmental	The plant is expected to divert up to ≈9,000 tonnes of waste annually from Hartland Landfill. If IRM is adopted across CRD, the current landfill capacity is estimated to be extendable to 2186 at no extra taxpayer cost.

Perspective	Comment
	GHGs are estimated to be reduced by up to ≈4,500 tCO_2e annually, equivalent to ≈12% of the entire community's carbon footprint. This is ≈31% of the 2030 community GHG reduction target and would eliminate the corporate carbon footprint. The plant is anticipated to remove ≈107,000 tCO_2e from the atmosphere using biochar, which is usable as a sterile soil supplement and sequesters carbon.
Resource recovery	Recovered resources contribute to revenue generation and carbon reduction. The recommended option is anticipated to recover ≈17,600 MWh of heat annually, which displaces using natural gas and oil. This can also be used for cooling, thus supplementing or replacing air conditioning systems. The plant is anticipated to produce ≈1,210 tonnes of biochar, usable as a fossil-free sterile soil supplement, which equates to ≈3,550tCO_2e GHG reduction per annum. As BC Hydro is not currently purchasing clean energy, electrical energy generation has not been assumed. This can be added later if feasible, as the plant complies with clean energy guidelines. Water and other resources could also be recovered. This has not initially been assumed due to viability but can be added later if feasible.
Technology	The design assumes multiple gasifier units operating 24/7/365, expandable to cope with increasing waste volumes over time, as the community grows. The recommended plant location is the Public Works Yard, located at the junction of Esquimalt and Canteen Roads, which is owned by the Township.
Governance	As proposed the facility will be owned and operated by the Township with options to outsource operations to a qualified operator. Alternatively the facility can be financed and operated under a concession or similar contract where Esquimalt shares in the revenue potential but risk is reduced. Unless taxpayers fund landfill expansion, Hartland Landfill is scheduled to close between 2045 and 2048. Expansion would increase GHGs and require both taxpayer investment and long term taxpayer support, and would not contribute to landfill diversion or GHG reduction objectives. It would also conflict with provincial and federal objectives, programmes and regulations. The carbon dioxide reduction and sequestration potential is considered the most significant single opportunity for the Township to achieve its 2030 and 2050 carbon reduction goals.
Intangible benefits	There is potential for intangible benefits that stimulate economic development, as shown by examples in Europe. This attracts like-minded

Perspective	Comment
	businesses, enhances education, training, eco-tourism and investment. Experience elsewhere is that residents increase active participation in quantifiable climate change action, generating community involvement and pride.

5 Public Consultation

5.1 Communication and Engagement Overview

The Township of Esquimalt collaborated with Pivotal IRM Inc. who engaged Pratt Consulting to design and carry out a process of communication and public engagement as an important phase of this IRM project. The initial plan was to host an open house featuring World Café style participation stations, along with an online survey but due to COVID-19, it was decided to use greater online and other information, a webinar, video and survey, combined with other communication efforts.

Communication activities to inform the public about the project and the opportunities to participate included the following.

General Information

Project information was provided on the Township's website, so that residents and business owners could become informed before completing the online survey, included:

- The original presentation to Council on July 6, plus Mayor and Council comments after the presentation;
- A Project Overview (3 pages);
- Esquimalt IRM Frequently Asked Questions (8 pages);
- A Summary Report (24 pages);
- The full Technical Report (90 pages).

Print media

- A media release, generating articles in The Lookout September 23, 2020 and in Black Press September 27
- Advertising in The Current, delivered to homes and businesses throughout Esquimalt, from September 29 to October 9
- Advertising in The Lookout, with 3,000 printed copies distributed and a digital copy posted to the Lookout website and shared via CFB social media channels

Social Media

- Regular posts on Facebook, Instagram, and Twitter by Esquimalt communications staff
- Facebook and Instagram ads, with 9,319 views and 218 link clicks
- Twitter ads, with 1,830 views and 11 link clicks

Campaigner direct email	▪ September 21 -184 emails opened and 28 links clicked ▪ September 30 - 141 opened; 47 links clicked ▪ October 9 - 138 opened; 40 links clicked
Other Communication	▪ A 90-minute webinar on September 22, with 54 registrations; 36 participants in actual attendance, and 105 subsequent YouTube views ▪ Information on the Township's homepage carousel, and a webpage with 729 unique views from September 27 – October 9 ▪ An informational video, with 146 YouTube views ▪ Additional communication and outreach included postcard distribution and booth at Esquimalt Farmers Market on September 17, 2020.

Public communication and engagement was directed by Township staff, in collaboration with Pivotal IRM and Pratt Consulting. Staff received survey responses – to provide independence and ensure confidentiality – and provided the compiled results to the team for reporting.

5.2 Public Survey

A total of 266 people participated in the online survey generated. Of these, 230 (86%) completed it, contributing a total of 639 comments.

Four questions were asked with respondents invited to comment on each question and provide general comments. Not all respondents chose to answer all the questions and not all chose to comment on each question or provide a general comment.

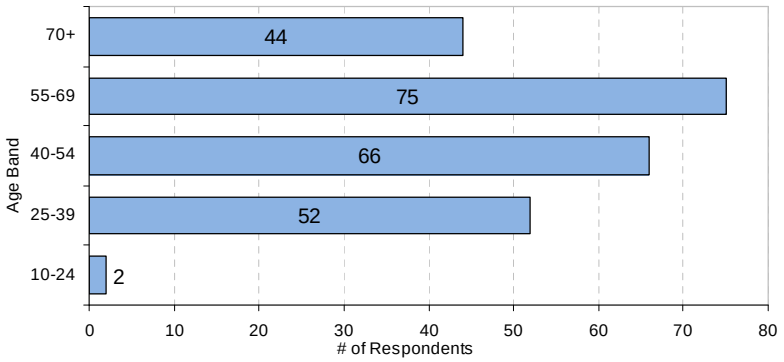


Figure 18: Respondents' age

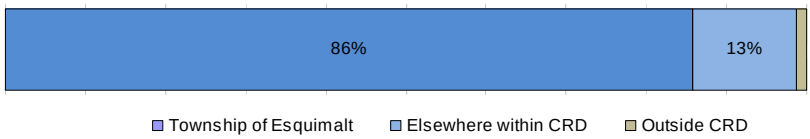


Figure 19: Respondents' residence

As Figure 18 illustrates, most survey respondents' indicated ages were mid-life or older adults, with the largest response from the 55-69 age range. Respondents indicated they were 51% female, 44% male, and 5% other or "prefer not to say".

In total 878 comments were contributed, 73% of which arose from questions with 27% being general comments. Figure 19 shows the response rate from Esquimalt residents was high at

86%, with 13% from elsewhere in the CRD and 1% outside the CRD. Approximately 8% indicated owning a business in Esquimalt.

Comments and responses were unattributed to ensure privacy and neutrality. A separate report provided to staff documents all comments with those noted below being indicative of the most common observations. A response rate of ≈2% of the population of Esquimalt suggests the survey is likely to be reasonably indicative of the wider opinions of residents.

5.2.1 Q1: Overall Support

Q1: What is your level of support for Esquimalt creating an integrated resource management facility?

Responses : 266		Comments : 199
Choice	**Total**	**%**
1. Strongly in favour	176	66%
2. Somewhat in favour	51	19%
3. Neutral	18	7%
4. Somewhat opposed	8	3%
5. Strongly opposed	13	5%

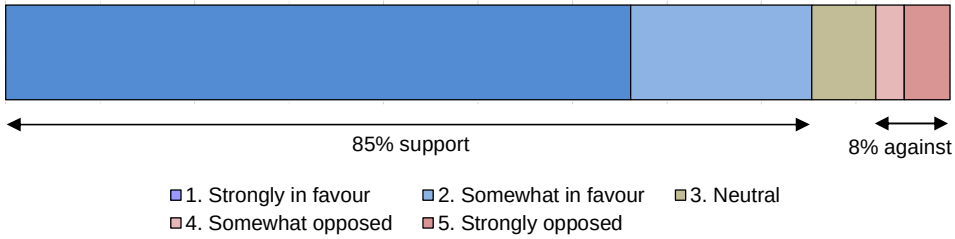


Figure 20: Survey - overall support

Asked "*What is your level of support for Esquimalt creating an integrated resource management facility?*" a large majority indicated support. Of 266 respondents, 66% were strongly in favour, 19% were somewhat in favour, 7% indicated neutrality, and 8% indicated somewhat or strongly opposed. Thus, ≈85% were supportive and 8% against the project which is a high level of support.

In total 199 comments were contributed. Supportive comments typically focused on climate change, landfill diversion, environmental leadership, and the financial business case. For example, one said: "*This is win-win based on the information presented. Lower GHG emissions, addresses Hartland landfill restrictions, and possibly even generates income.*" Neutral and opposed comments typically focused on risk and/or alternative resource management strategies such as composting.

5.2.2 Q2: Perception of Benefit

Q2: How much do you think IRM in the Township of Esquimalt would be of benefit, to residents and/or to the environment?

Responses : 252 Comments : 146

Choice	Total	%
1. Very high benefit	99	39%
2. High benefit	97	38%
3. Some benefit	32	13%
4. Low benefit	15	6%
5. No benefit	9	4%

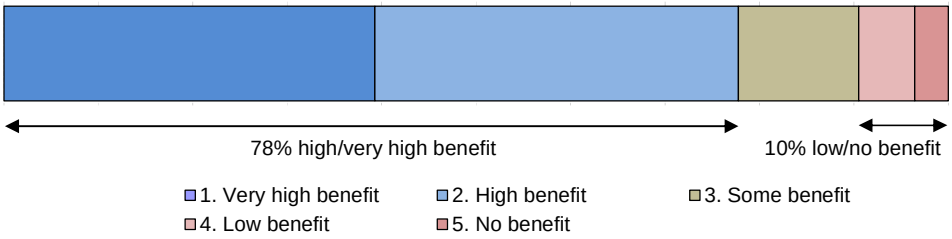


Figure 21: Survey - perception of benefit

Asked "*How much do you think IRM in the Township of Esquimalt would be of benefit, to residents and/or to the environment?*" 39% of the 252 respondents indicated very high benefit; 38% high benefit; 13% some benefit; 6% low benefit; and 4% indicated no benefit. This means ≈78% were positive to the benefits with ≈10% sceptical, which is a high level of support.

In total 146 comments were contributed. Like the commentary on overall support, participants typically mentioned factors such as reduction of GHGs, generation of energy, and potential financial benefits. One said, "*Regardless of potential financial benefits, the reduction of landfill and using waste to heat the core is a great benefit.*" Some comments indicated skepticism or concern about possible tax implications.

5.2.3 Q3: Concerns

Q3: What is your level of concern about this Township of Esquimalt IRM initiative?

Responses : 249 | Comments : 147

Choice	Total	%
1. Not at all concerned	90	36.1%
2. Slightly concerned	74	29.7%
3. Somewhat concerned	54	21.7%
4. Highly concerned	15	6.0%
5. Extremely concerned	16	6.4%

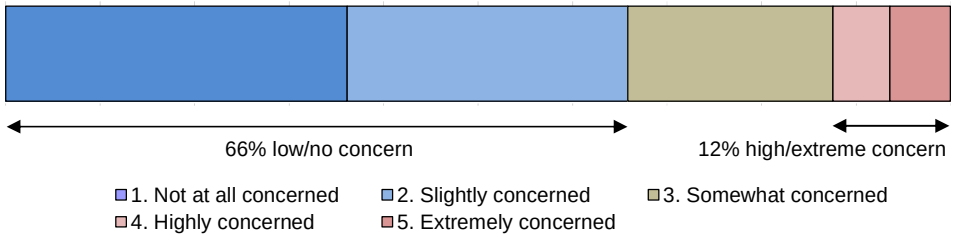


Figure 22: Survey - concerns

Regarding the level of concern about the initiative, 36% clicked "not at all", 30% indicated slightly, 22% indicated somewhat, 6% indicated highly, and another 6% indicated extremely concerned. This means ≈66% had low or no concerns, with ≈12% with high or extreme concerns, i.e. over five times the respondents had low concerns compared to those with substantial concerns. This indicates support, but with concerns, which is common for projects of this type.

A total of 147 comments were contributed, with most being supportive but others noting capital costs, technological uncertainty, and possibilities for mismanagement. For example, one participant wrote: "*Strong benefits, few downsides, risks can be managed with private sector shouldering the risk.*" Another commented that: "*Major project will be costly, easily mismanaged, new technology may not provide positive returns.*" Some expressed concern about neighbourhood impact and others indicated a need for more information.

The comments provide a focus for additional work to mitigate concerns, information and engagement. Comments pointed more towards a need to manage, given overspend experienced with other projects in the region, but with few comments pointing towards outright objection based on risk.

5.2.4 Q4: Facility Location

Q4: Do you agree with locating the IRM facility on the yard/garden and parking portions of the Public Works Yard located on Canteen Road?

Responses : 248 Comments : 147

Choice	Total	%
1. No, not this site	16	6%
2. Not sure	58	23%
3. Yes, support site	174	70%

Figure 23: Survey - facility location

This question asked whether respondents felt the Public Works Yard is an acceptable location for a plant. As shown in Figure 23, ≈70% of the 248 survey participants indicated they agree with the location, with ≈23% indicated being unsure and ≈6% indicating disagreement. This means there is a strong level of support for using the Public Works site.

A total of 147 comments were contributed, with a main tone that the central, non-residential location is agreeable. For example, one participant stated: "*It makes logistic sense. Close to where the energy it produces will be used.*" Some posed questions to be addressed – and/or indicated a need for more information. For example, one wrote: "*not enough project details presented to assess sound, odour and any associated emissions.*"

5.2.5 Other Feedback

The final question was whether respondents had "*any other feedback, concerns or ideas you would like to share about the Township's consideration of IRM?*" Responses reflected a similar mix to other questions, with a number indicating enthusiastic support. The majority of comments were positive and supportive, such as:

- Keep up the good work!
- The Township should move forward with it!!
- Let's move on this opportunity.
- I would like to commend Council for their research and preparation work on this project, and for their sincere concern for waste management.

Some reiterated caution or a need for more information, for example:

- Ensure that the revenue stream generation estimates are legitimate and factor in true lifecycle costs for the facility.

- More public engagement and education is needed.
- More work on business case and financial impacts needed, with taxpayers voting on it.
- Would like to know how this will impact property taxes and utility/waste bills.

5.3 Public Consultation Conclusions

The communication and engagement effort was rigorous despite the constraints of COVID-19. The combined use of news media, social media, other online communication, with an email campaign, provided multiple opportunities for Esquimalt residents and business owners to become aware of the initiative and the opportunity to participate. The wide range of report formats made available on the web site, ranging from brief and accessible to detailed and technical, created transparent access to project information.

The webinar provided an interactive format in which participants could engage directly with the consultant team. The recorded version of the webinar, along with the backgrounder video and FAQ sheet, provided additional opportunities to become informed and engaged.

This communication activity contributed to a high volume of survey participation. The mix of participants was reasonably diverse, with higher participation by older adults and females. Thanks in part to geographically targeted communication, just 14% of respondents indicated residing outside Esquimalt. The survey thus strongly represents Esquimalt residents' views.

Overall, the survey results suggest that a large majority of residents and business owners are in favour of this IRM project proceeding.

Survey comments mostly contributed positively, whether supportive or otherwise. Suggestions covered further research, analysis of cost and revenue projections, risk management and community engagement. These will inform next steps should the decision be taken to proceed.

In summary the transparent access and varied communications, wide exposure and good level of both response and interest, led to a high level engagement. Combined with the clear majority of responses received favouring the project across all questions, leads us to conclude that Esquimalt residents support proceeding with the proposed initiative.

6 Overall Conclusions

The assessment of waste volumes and system potential indicate that an IRM system is expected to be viable and benefit the Township in reducing GHGs. The recommended site while compact appears likely to be suitable and is well located for development of a District Energy System deploying sustainable energy to the Town Centre. This formed the basis of Public Engagement, which indicated strong support for the concept.

Projects of this nature always have risks and in the Next Steps section on page 17 we recommend a focus on de-risking that will help mitigate and manage risks before final commitment to the project, should Council decide to proceed.

Rather than duplicating the study's conclusions in this section, the overall findings are provided in the Executive Summary on page 2.

Appendix 1: Team & Limiting Conditions

Study Team & Acknowledgements

This report was prepared by Graeme Bethell, M.Sc., QEP, a pollution prevention, utility management and gasification specialist; Chris Corps, B.Sc., a Land Economist specialising in complex business cases, feasibility and viability assessments for sustainable land development and energy projects; and James Pratt, RPP, a public consultation specialist; with technical assistance from Michael Wolinetz, a greenhouse gas quantitative and assessment specialist; and Albert Bicol, P. Eng., an international energy systems and sustainable energy master planning and development specialist. Information on gasification yield, performance, testing and pricing was kindly provided by Dr. Matt Summers, P.Eng, of West Biofuels Inc. in California and by staff at TSI Inc., of Washington State, including VP Andrew Johnson and Matt Hoffman P.Eng. Their contributions are gratefully acknowledged.

The authors acknowledge that the Township of Esquimalt exists on unceded Lekwungen lands, home of the peoples now known as the Esquimalt and Songhees Nations.

We are grateful to the Township of Esquimalt for providing information for the report and guidance on options, and waste haulers active in the region for assessing wastes in Esquimalt and information on different waste types. Lastly we are grateful for kind assistance of system manufacturers and providers for their help assessing how to optimize systems and in pricing options.

Assumptions & Limiting Conditions

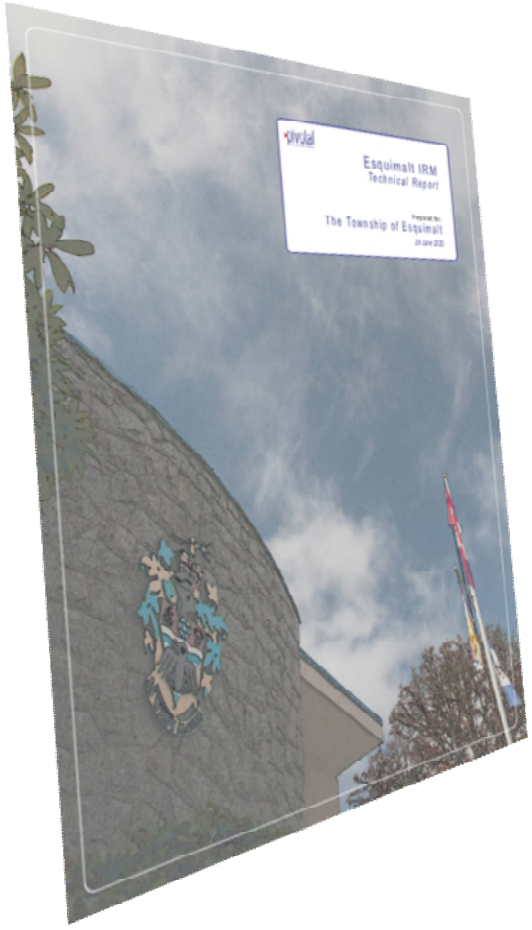
The information in this document was compiled for the purpose of providing a preliminary assessment of the potential for implementing IRM of waste streams generated in the Township of Esquimalt using gasification. The authors have prepared this document at the request of the Township, solely for this purpose.

Information in this report from which conclusions have been derived has been provided by the Township and third parties. While reasonable skill, care and diligence have been exercised to assess the information acquired during the preparation of this report, no guarantees or warranties are made concerning the accuracy or completeness of this information, although the information provided by others is represented to be accurate by the suppliers. This document, the information it contains, and the basis on which it relies and factors associated with implementation of resource recovery from gasification are subject to changes which are beyond the control of the authors.

IRM requires an inter-disciplinary approach. As a result, components of the document were prepared by professionals in one field who are not qualified in the other fields of study. While diligence has been applied to the assessment, the scope of this report did not allow for full inter-disciplinary cross-verification of all components.

This report includes screening-level estimates which should not be relied upon for design or other purposes without verification, for example through detailed feasibility studies and especially as recommended by the authors. The authors do not accept responsibility for the use of this report for any purpose other than that stated above and do not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This report is intended to provide a preliminary assessment to meet the purposes of this study and cannot be applied to other jurisdictions or applications without conversion, analysis and confirmation with the authors. Any use by any entity or client, consultants, 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.

Parties seeking to rely on this report should not do so without first satisfying themselves to the accuracy and extent of the contents, which have been prepared for the specific purposes of the client.



Esquimalt IRM

Technical Report Summary

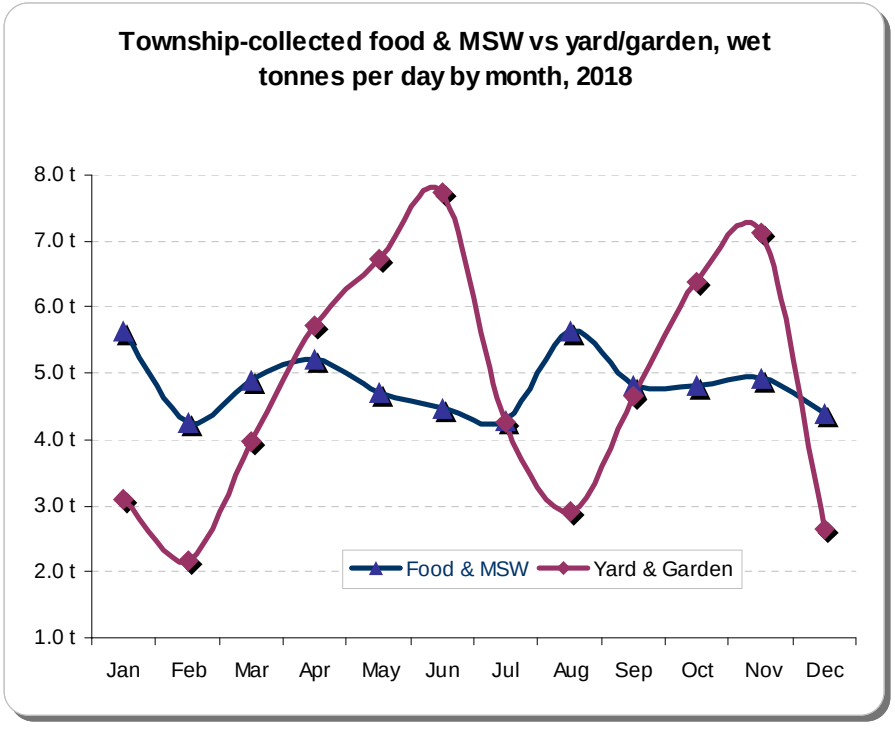
30 June 2020

Graeme Bethell
Chris Corps

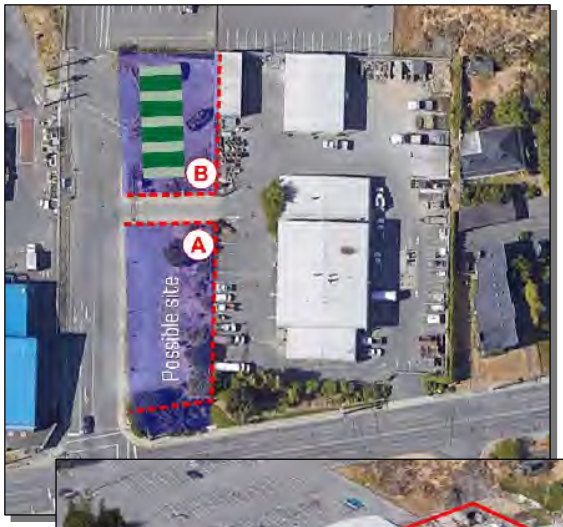
pivotal
integrated resource management

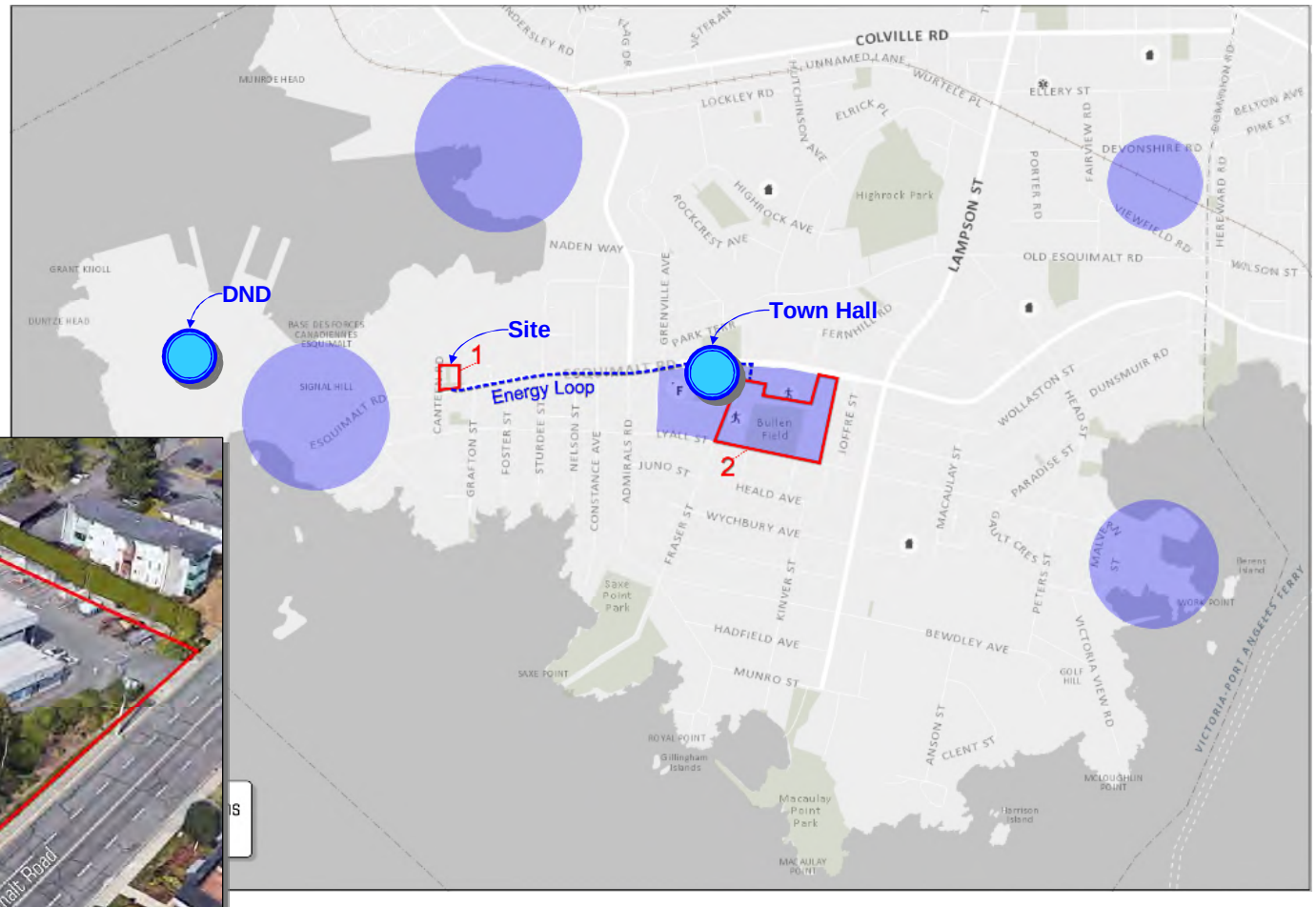
Study Overview

- Assess IRM using gasification
  - Integrating waste streams
  - Factors: statutory, financial & environmental
- Main aspects identified
  - Township collects ≈52% of community waste
  - Volume flows are uneven
  - Population & waste growth uncertain
  - Site: Public Works Yard or Recreation Centre
  - Key findings
    - Cost to taxpayers
    - GHG reduction
    - Heating & cooling, not electricity
    - Landfill diversion
    - Carbon sequestration

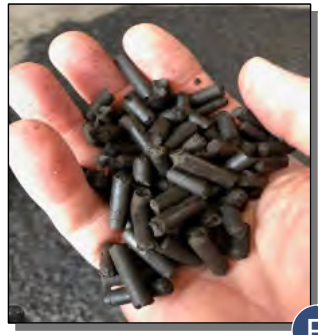


Recommended : Public Works Yard





RotoGasifier Examples : "Best Available Technology"



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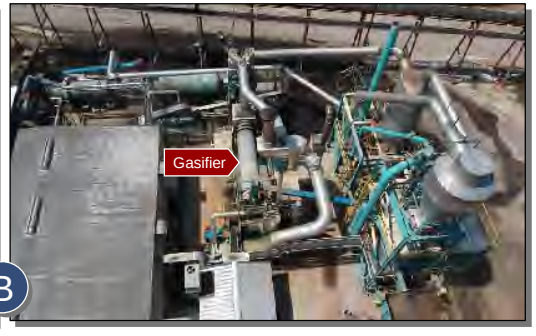
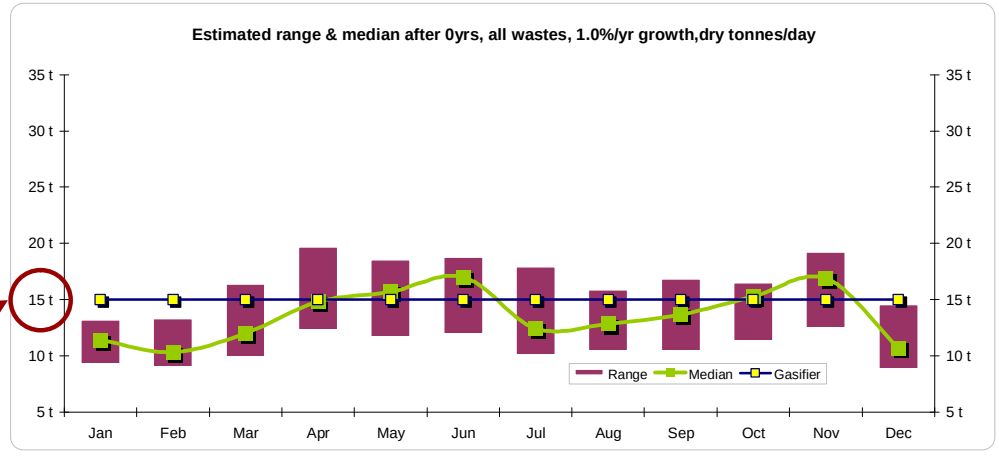


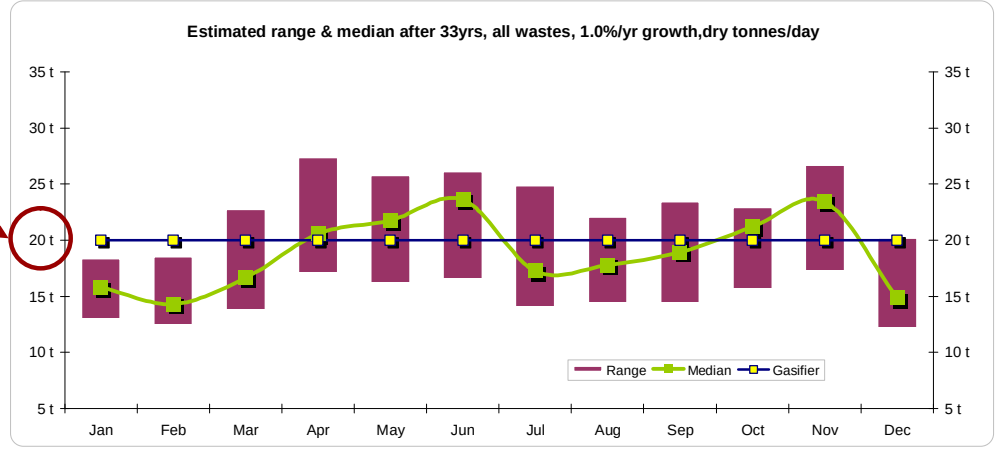
C

D

Plant Size

- Waste
  - Waste meets MoE targets (≈350kg/person/yr)
  - Current: 3,400 t/yr Township, 6,500 t/yr combined
  - Affected by recycling changes
- Population growth
  - From ≈0.3% to ≈1.7% per annum
  - Buildout estimated at ≈25,000 or ≈1%pa growth
- Approach: adapt & phase
  - Multiple smaller units
  - Expand/adapt, as/when needed
  - Just-in-time is cheaper, less risk





Key Findings – Recommended Option

- Combined Esquimalt wastes
  - Township-only is possible but marginal
- Financial
  - Cost: Initial: ≈$16m; Buildout: ≈$21m
    Payments: ≈$4.1m/yr (O&M: ≈1.7m/yr)
  - Savings: ≈$226m total net, 30 years
    ≈$360/home/yr (1st 10 yrs)
- Environmental & resources
  - Diversion: ≈9,000t/yr (buildout)
  - Energy: ≈528,000 mwh thermal (life cycle)
  - GHGs: ≈4,500t/yr (buildout)
    ≈12% of community GHGs, ≈4½x corporate
  - Sequestered: ≈3,500 tco_2e/yr (buildout)

Conclusions & Recommendations

- Viable, environmentally beneficial
  - Likely 10-15 tonnes/day & upwards
- Next steps
  - Community engagement
  - Township only or entire community wastes
  - Site/location preference
  - Key mitigation aspects
    - Statutory, supply, testing, performance guarantee
    - Grants, funding & revenues
    - Procurement workshop
    - Design, phasing & plan

IRM Overview

In 2019, Esquimalt Council declared a Climate Emergency targeting a 30% greenhouse gas (GHG) reduction by 2030 and carbon neutrality by 2050. In support of this, a study of Integrated Resource Management (IRM) was commissioned, which concluded that GHG reductions are possible and could reduce taxpayer costs.

Council is inviting feedback from residents and this document provides an overview of what's involved.

WHAT IS IRM AND WHY GASIFICATION?

Waste contributes ≈11% of GHGs in Canada. Integrated Resource Management (IRM) helps reduce GHGS by extracting maximum use and value from waste to reduce taxpayer costs, recover heat and other resources, and reduce other emissions.

Esquimalt has a wide range of wastes (Figure 1) so addressing them is complex. Composting, anaerobic digestion and similar approaches only address ≈11% of the waste and there is little demand for the output. Biofuel and similar approaches either don't handle enough of the waste stream, or are still developing or difficult to locate in Esquimalt.

Incineration, pyrolysis and gasification can address up to ≈91% of Esquimalt's wastes. Incineration requires pollution management that has previously raised concerns and systems have lower yields and recovery than alternatives. Both pyrolysis & gasification avoid burning or producing toxins and smoke, but pyrolysis is less efficient. Internationally, gasification systems processing waste have over 1,000 years' combined operations, so the option assessed for Esquimalt uses Advanced Gasification, which is high-yielding. Gasifiers heat waste to produce a syngas, used to generate heating, cooling and other products.

IN SUMMARY

WHAT & WHY

- A different approach to managing waste;
- Reduce GHGs and taxpayers' costs.

RESIDENTS' BENEFITS

- Dividend of up to ≈$360/door, net average;
- Could generate $226m over 30 years;
- Small, local plant – reduces trucking;
- No odour or noise;
- Reduced & simpler waste separation, less bins.

ENVIRONMENTAL BENEFITS

- Exceed Corporate carbon reduction targets;
- Reduce the community's overall GHGs by ≈12%;
- Equivalent to removing ≈970 cars/year;
- Up to ≈91% landfill diversion;
- Improved recycling;
- Generates clean energy to displace fossil fuels;
- Produces sterile fertilizer & sequesters carbon;
- Simplest, most economic GHG reduction option.

INTANGIBLE BENEFITS

- Examples have attracted business, jobs, enhanced education, training, and eco-tourism;
- Raises community profile, enhances civic pride;
- Creates broader economic stimulus & jobs with local re-investment and re-spending effect.

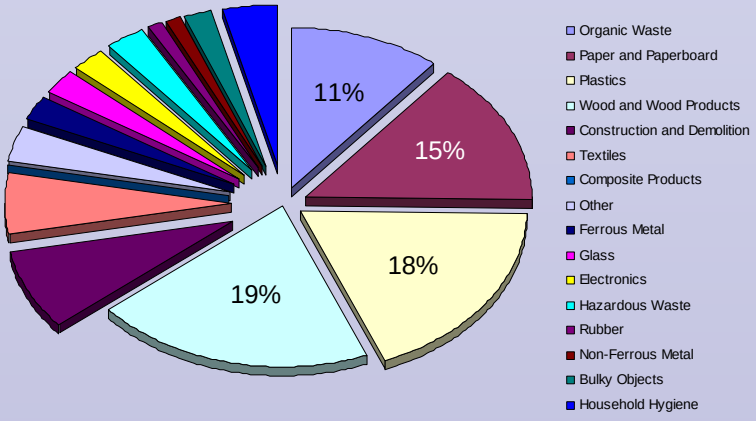


Figure 1: Waste composition, dry volume

16 November 2020

Developed for the Township of Esquimalt by:

Pivotal IRM Inc.,
4464 Markham Street, Suite 2202G, Victoria BC V8Z 7X8 Tel: (250) 478-8820 www.pivotalirm.com

CONTEXT

Currently, recycling handles metals, plastics, glass and other materials through Blue Box recycling. Almost ≈6,500 tonnes of waste is collected annually (≈347 kg/person). Garbage is landfilled at Hartland Road in Saanich with yard and garden wastes received at Canteen Road, and separated organics mostly sent to the Lower Mainland for composting. With Hartland landfill nearing capacity and costs rising, change is needed to address waste and is important to reduce GHGs.

FINDINGS

IRM plants process waste and recover resources that have value and most of Esquimalt's wastes can be converted and the resources recovered. Various options were assessed, with the recommended option summarized as follows:

General

The recommended plan assumes a gasification plant operating 24/7/365, expandable as needed to cope with increasing waste as the community grows. This lowers costs and helps reduce risk.

The recommended site is an unused portion of the Public Works Yard located on Canteen Road. No additional trucks are needed (the trucks are already circulating), with deliveries up to three times per day.

There are no odours from gasifiers and the plant would be under an acre, housed in a modern industrial building. A flue stack would be required, similar to existing major buildings in Esquimalt.

Figure 2: Systems in California & Louisiana

While the current waste management approach could continue for a few years longer, Hartland Landfill is scheduled to close by 2048, which is expected to raise costs. An IRM facility can avoid most of this risk and cost and exceed other options for reducing GHGs.

Environmental & Resources

At buildout, the plant is expected to divert up to ≈9,000 tonnes of waste annually from Hartland Landfill with GHG reductions of ≈4,500 tonnes of carbon dioxide equivalent (CO_2e) annually, equivalent to taking 970 cars off the road and eliminating the Township's corporate carbon footprint.

The plant is expected to produce ≈1,210 tonnes of biochar, usable as a natural (fossil-free) sterile soil supplement, sequestering ≈3,550 tonnes of CO_2e GHGs per annum.

Emissions are similar to natural gas boilers and the plant is anticipated to recover ≈17,600 MWh of heat annually, which will replace natural gas and oil. Electrical energy generation has not been assumed but can be added later.

Financial

The facility has the potential to yield ≈$226 million surplus over its life cycle, equal to a maximum average taxpayer benefit of ≈$360 per home per year.

The plant is expected to cost ≈$15m to build, expanding to ≈$21m over time (±15%), with operating and maintenance costs of ≈$1.7m annually. Grants may be available but are not assumed. Annual revenues are projected to average ≈$5.8m/yr once the plant hits capacity.

Summary Metrics - Recommended Option	*Scenario 2b*
General	
Estimated total capital cost (upper range costing)	≈$21.3m
Estimated annual O&M cost	≈$1.7m
Tonnes/yr landfill diversion	≈9,000 t/yr
Public sector model	
Internal Rate of Return (before debt)	22%
Total net taxpayer profit (30yr life cycle)	≈$226m
Taxpayer dividend per yr, avg 1st 10 yrs	≈$360/home
Private sector model	
Leveraged IRR (30% equity, net of debt)	48%
Total net profit after debt, leveraged (30yr life cycle)	≈$235m
Environmental & resource recovery	
GHG tCO2e/yr reduction	4,500 tCO2e/yr
CO_2e reduction, life cycle vehicles equivalent	29,100 cars
Total biochar tonnes/yr	1,210 t/yr
Sequestered carbon (30yr life cycle)	≈107,000 tCO2e
Face yield, mw thermal	≈2.00 mw
Total recovered mw thermal (30 yr life cycle)	≈528,000 mWht

Figure 3: Summary metrics

Procurement

The largest financial and environmental benefits would be obtained by the Township building the plant, which means having to manage the risk if the benefits are important. Other options such as a limited concession can reduce risk, with ownership reverting to Esquimalt. While this would reduce risk, it would also reduce potential revenues.

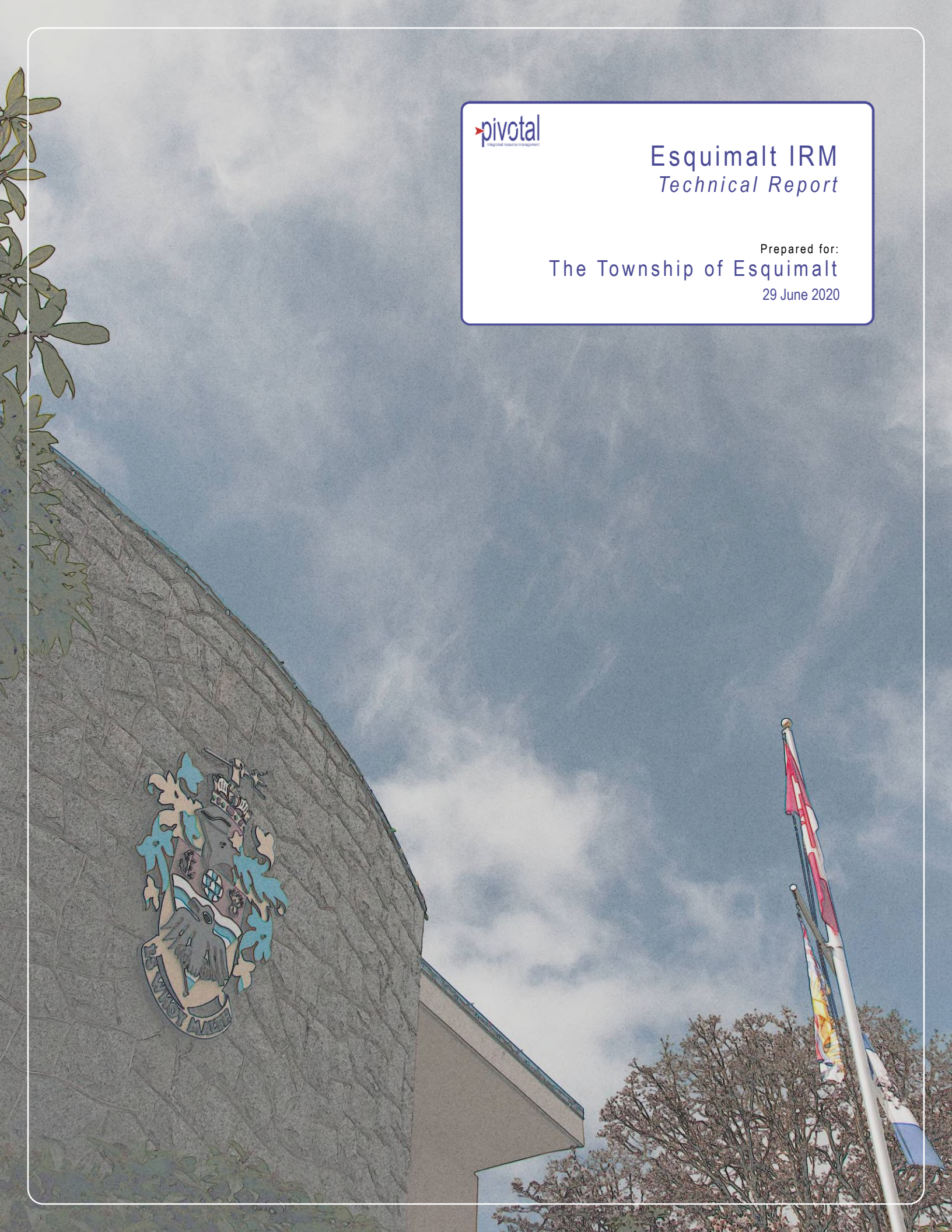
Other Benefits

Comparable systems in Europe have generated employment and stimulated economic development by attracting environmentally-minded businesses in education, training, and eco-tourism, and has had a positive impact by raising community profile, identity and pride. It retains more investment in the community, increasing the local re-spending effect.

FEEDBACK

The Township of Esquimalt is inviting your feedback with online information available from the Township's project web site. This includes a brief explanatory video, this Overview and a more detailed Summary of the project, the detailed Technical Report with presentation to Council and the Mayor and Council's comments. Technical information on IRM and gasification is available from Pivotal's library.

A webinar will be held with details posted on the project web site. Please look out for us at the Esquimalt Farmer's Market or complete the Survey. Your feedback is welcome.



Esquimalt IRM

Technical Report

Prepared for:

The Township of Esquimalt

29 June 2020

Mr. Jeff Miller
Director, Engineering and Public Works
The Township of Esquimalt
1229 Esquimalt Road
Esquimalt, BC V9A 3P1

29 June 2020

Dear Mr. Miller

ESQUIMALT IRM - TECHNICAL REPORT

We are pleased to submit the IRM Technical Report for your review and consideration, which we understand will be presented to Council on 6th July, 2020. We trust this assists and as there is much to digest in this study, will be pleased to answer questions or expand on aspects as required.

Yours truly,

Graeme Bethell
President
Pivotal IRM Inc.

Chris Corps
CEO
Pivotal IRM Inc.

Pivotal IRM Inc.,
4464 Markham Street,
Victoria,
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Table of Contents

Links are clickable in electronic versions of this document.

Figures & Tables

1 Executive Summary

During the planning process for CRD's McLaughlin Point sewage treatment plant planning, it became clear that Esquimalt's community supports Integrated Resource Management, which arose from a provincial study and initiative published in 2008. After CRD decided not to pursue IRM, Council commissioned the current study to assess whether and how it might implement IRM for Esquimalt's wastes, given community support.

Summary Metrics - Recommended Option	*Scenario 2b*
General	
Estimated total capital cost (upper range costing)	≈$21.3m
Estimated annual O&M cost	≈$1.7m
Tonnes/yr landfill diversion	≈9,000 t/yr
Public sector model	
Internal Rate of Return (before debt)	22%
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Face yield, mw thermal	≈2.00 mw
Total recovered mw thermal (30 yr life cycle)	≈528,000 mWht

Figure 1: Key Metrics - Recommended Option

Our main conclusion is that IRM can be implemented in Esquimalt and that this can reduce taxpayer costs, lower Green House Gases and sequester carbon, recover resources and maximize landfill diversion, which if more broadly adopted regionally, could extend Hartland Landfill's existing capacity to 2186. IRM has the potential to generate a profit, net of both capital and operating costs, and become a new source of revenues for the Township. There would be small additional employment and more money would remain and be re-spent in the community.

The Township collects ≈52% of the identified waste streams and while a plant could be implemented solely addressing this waste, it may only achieve breakeven. However private haulers are willing to contribute their wastes, which improves economies of scale, raises viability and which we recommend pursuing. A plant can be phased, starting at ≈$15m, rising to ≈$21m as the community grows. Optionally the cost could be reduced or even eliminated, depending on: (a) procurement approach; and, (b) grants.

We recommend the Township's Canteen Road Public Works site as a plant location and that the Township can meet the Ministry of the Environment and Climate Change Strategy (MoE) 5Rs pollution prevention strategy. The analysis has assumed use of this site and would need updating if a different site is chosen. Reviews by CRD (and this study) concluded Advanced Gasification is a suitable technology, as required by the Ministry's regulations to proceed.

IRM was originally conceived to viably maximize carbon reduction and resource recovery. Esquimalt has set a target of being corporately carbon neutral with 38% reduction by 2030 and carbon neutral by 2050. At full operation the net projected GHG reductions would be ≈4½ times the Township's corporate GHG profile or ≈12% of the entire community's GHG profile, i.e. ≈4,500 tCO_2e annually (≈223,000 tCO_2e over its lifetime), while potentially

yielding a dividend to taxpayers of ≈$360 per home, which equates to a net life cycle profit/dividend of ≈$227m. The recommended option can also sequester ≈107,000tCO_2e over the project's life cycle, which means IRM could be carbon negative – i.e. beyond carbon neutral – while reducing taxpayer cost, net of debt and all other costs. This is a considerable benefit and achievement, but we caution will only be achieved with diligence.

We assessed options using the wastes collected by the Township, or by adding privately collected wastes. This would address the community's overall wastes and produce a more complete plan, but the extra volume would also improve efficiency, maximizing landfill diversion, financials, GHG reduction and resource recovery. An optimized IRM plan can potentially achieve the highest landfill diversion rate we are currently aware of in BC.

We concluded that not pursuing IRM will increase Esquimalt taxpayers' costs, because the regional use of anaerobic digestion requires continual taxpayer funding, while only dealing with ≈11% of Esquimalt's wastes. By contrast IRM can address 100% of the wastes currently collected by the Township and the revenues from IRM can avoid taxpayer support. Not pursuing IRM with Advanced Gasification will also miss the opportunity to maximize resource recovery, cannot optimize GHG reduction, and may either sub-optimize or miss the opportunity to sequester carbon.

Should Council decide to proceed further, we recommend a number of steps before making a major financial commitment. Key to these is testing, which is needed to prove that the system will work with the actual proposed wastes and to secure a manufacturer's guarantee. Comment on next steps is expanded in the report.

Experience with Advanced Gasification in Europe is that it stimulates economic development, attracting like-minded businesses and boosting eco-education, training and eco-tourism. In a European example it provided the community with a tangible connection to climate action and in Esquimalt for instance, might be by using a sterile biochar that removes carbon from the atmosphere. These and related aspects will be explored during public consultation.

In closing it is important to note that engagement was undertaken to confirm key aspects such as the potential to contract with haulers, manufacturer pricing and procurement options with alternate service delivery. Implementation is thus considered feasible and if undertaken appropriately, is expected to be both financially and environmentally beneficial for the Township and Esquimalt taxpayers.

2 Assumptions & Limiting Conditions

The information in this document was compiled for the purpose of providing a preliminary assessment of the potential for implementing IRM of waste streams generated in the Township of Esquimalt using gasification. The authors have prepared this document at the request of the Township, solely for this purpose.

Information in this report from which conclusions have been derived has been provided by third parties. While reasonable skill, care and diligence have been exercised to assess the information acquired during the preparation of this report, no guarantees or warranties are made concerning the accuracy or completeness of this information, although the information provided by others is represented to be accurate by the suppliers. This document, the information it contains, the information and basis on which it relies and factors associated with implementation of resource recovery from gasification are subject to changes which are beyond the control of the authors.

IRM requires an inter-disciplinary approach. As a result, components of the document were prepared by professionals in one field who are not qualified in the other fields of study. While diligence has been applied to the assessment, the scope of this report did not allow for full inter-disciplinary cross-verification of all components.

This report includes screening-level estimates which should not be relied upon for design or other purposes without verification, for example through detailed feasibility studies and especially as recommended by the authors. The authors do not accept responsibility for the use of this report for any purpose other than that stated above and do not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This report is intended to provide a preliminary assessment to meet the purposes of this study and cannot be applied to other jurisdictions or applications without conversion, analysis and confirmation with the authors of this report of any use and limitations of application of any information in this report. Any use by any entity or client, consultants, 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.

Parties seeking to rely on this report should not do so without first satisfying themselves to the accuracy and extent of the contents, which have been prepared for the specific purposes of the client.

3 Background

3.1 Introduction

The purpose of this study is to evaluate and assess the potential for an Integrated Resource Management (IRM) approach to manage waste streams generated by the Township of Esquimalt, which comprise: (a) liquid waste and liquid waste energy; (b) solid wastes collected by the Township – comprising MSW, food scraps, yard and garden wastes; and, (c) solid wastes collected by private haulers – which are similar to Township-collected wastes but are collected from businesses and higher-density development. The Township wishes to assess the potential implementation of an IRM system to see whether it can create additional benefits for the community from these waste streams.

In summary the Report comprises:

- A background on IRM, including a brief explanation of what it is, as well as existing work and reviews, and other contributory information;
- A general review of pertinent technology, Esquimalt's demographics, current waste volumes and an analysis of whether IRM makes sense for Esquimalt, alternate technological approaches and aspects contributing to IRM;
- An IRM assessment, including a description of project scenarios, analysis of possible locations, costs, revenues, intangible aspects, risk, procurement and other pertinent aspects;
- The report findings, covering IRM results based on financial, environmental and recovered resources, scenario selection and phasing, conclusions and recommendations.

A number of supporting appendices are included, containing further information referenced in the report.

Note that we have attempted to use laymen's terms to allow a broader range of readers to understand this document but inevitably some aspects are technical.

3.2 What is IRM

Integrated Resource Management or "IRM" is an approach to managing water, energy and waste that aims to maximise their use and value as resources, in ways that reduce costs to taxpayers (or even create profit) and reduce greenhouse gas emissions (GHGs) and pollution. IRM was created in 2008 as a result of a BC provincial study on how to maximize resource

recovery from waste, for the Ministry of Community Service and the BC Cabinet Committee on Climate Change.

IRM is defined as a fully integrated life cycle assessment and comparison of options by which resources can be recovered from waste, to maximize the benefits to the environment and the taxpayer. The life cycle options analysis allows the community to then determine the best options, thus bringing together the full financial and environmental impacts of options so that informed social decisions can be made (i.e. "Triple Bottom Line"). IRM thus makes the financial and environmental consequences transparent, so meaningful and informed public engagement can plan the best direction. Figure 2 summarizes Pivotal's IRM process.

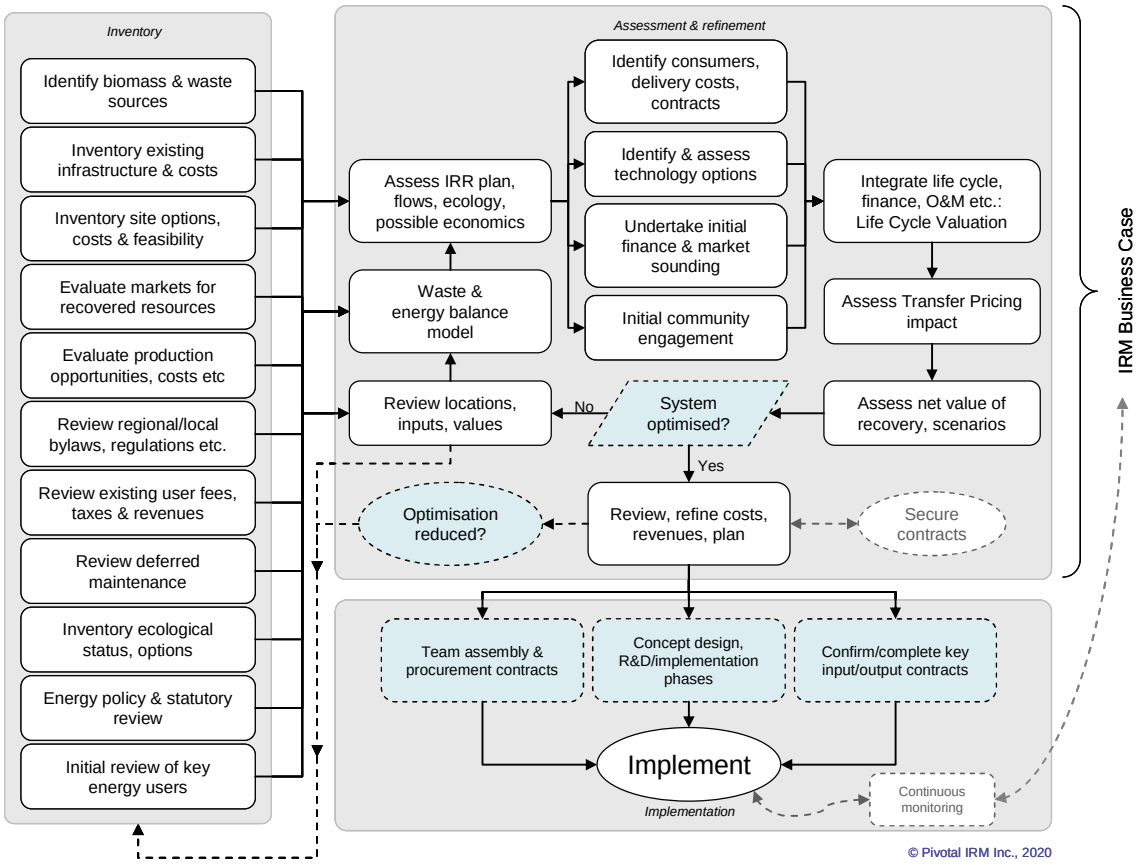

Figure 2: IRM Process Overview

IRM principles are primarily driven by the United Nation's Brundtland Commission on sustainable development,[1] whose main conclusion was that:

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

Pivotal's IRM model has been independently audited and uses international standards to assess life cycle both environmentally and financially, so the full impact to future taxpayers

[1] For a summary see Wikipedia.

and the environment is clear. Our analysis and this report are aligned as closely as possible to internationally accepted valuation standards, to facilitate financing and transparency.

3.3 Prior IRM Studies

3.3.1 Resource Recovery Study

In April 2013 Kerr Wood Leidal (KWL) completed a study of potential resource recovery opportunities with a focus largely on wastewater. Resource recovery options included:

- Heat Recovery from raw sewage and effluent;
- Biogas from anaerobic digestion used to generate heat and/or electrical power, or upgraded to biomethane to replace natural gas;
- Reclaimed water from treated effluent;
- Biosolids from digestion combusted as fuel or applied to the land as fertilizer;
- Nutrient recovery from phosphorus (struvite).

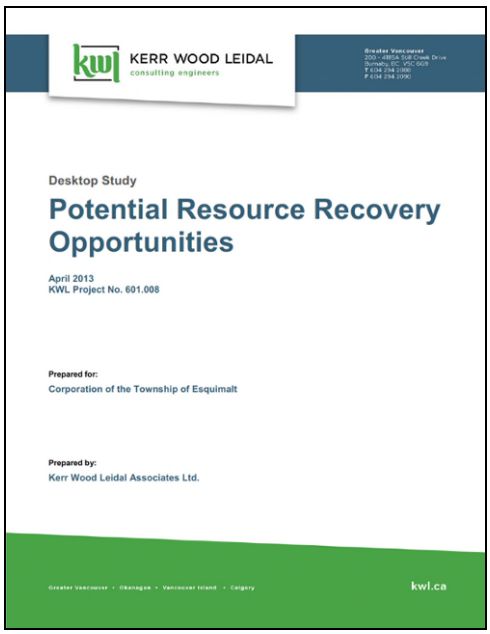

Figure 3: KWL Resource Recovery Study, 2013

KWL concluded that the most readily available resources would be: heat from raw sewage or treated effluent; biogas combustion or upgrading to sell the biogas to the natural gas grid; and dried biosolids combusted in solid-fuel boilers. As it originated from a wastewater perspective, the study excluded consideration of solid waste and related IRM options.

The study recommended further assessment of a District Energy System (DES) to replace conventional heating and cooling, and assessment of a purple pipe system to distribute reclaimed water, including for use in irrigation systems. These have current application. It recommended assessing a Compressed Natural Gas (CNG) fuelling station fuelled by biomethane from the anticipated anaerobic digester.

KWL's report is now out of date for three main reasons: (1) the community rejected anaerobic digestion in Esquimalt so the associated resources and generation potential are located at Hartland, so their benefit is unavailable in Esquimalt; (2) other aspects such as land application of biosolids have been rejected – although CRD recently allowed temporary application; and, (3) KWL assumed sewage flows ≈50% higher than have since proven to be available, according to CRD's latest data on sewage flows, which means the study's main key assumption has proven to be an over-estimate. The study is thus largely not applicable without being re-commissioned, although aspects such as the DES continue to have relevance and are considered in this study. The energy advisors to our team, who specialize in Net Zero projects, recommend that KWL's DES and related linkages to the IRM plant need to be reviewed at an early stage, should this project proceed further.

3.3.2 Ministry of the Environment Study

We were also asked to comment on a report prepared for MoE by Stantec in 2011 which reviewed 'waste to energy alternatives,' mainly focused on incineration. The study appears to have mostly relied on a 2008 US DOE report and for example, did not consider any Advanced Gasifier systems from Europe or similar systems in Japan, which were in operation and included plants that had received international awards or were EU centres of excellence. While the report noted that gasification was a rapidly advancing technology, the study was limited in scope and omitted consideration of technologies recommended to CRD by their experts, so has limited application for Esquimalt's purposes.

3.3.3 IRM Task Force Study

Following provincial encouragement to consider IRM for CRD's liquid waste treatment project, CRD formed an IRM Task Force to assess how IRM might be implemented. The Task Force engaged technology providers and independent experts who recommended gasification, but CRD ultimately did not pursue this, which they explained was because provincial funding was linked to the production of Class A biosolids, which are produced by anaerobic digesters, not gasifiers.

Provincial legislation gives municipalities the primary responsibility and pre-eminence to decide how they want to deal with waste. Regional Districts have the responsibility for authoring a waste management plan for the region, which then has to reflect what communities want. Esquimalt is thus able to adopt an IRM approach if it chooses, which will in due course be reflected in the regional solid waste management plan. We contacted MoE for confirmation of this and they directed us to the documentation confirming it.[2]

The primary objective of the IRM Task Force was to determine whether IRM could provide financial and environmental benefits. The Task Force's overall conclusions were that IRM was feasible and would provide financial and environmental benefits.[3] The Task Force concluded that a structure was desirable to avoid jurisdictional conflicts – such as the municipal authority on waste but regional responsibility to plan – and supported a pilot project to treat biosolids, kitchen scraps and MSW. The concept was that a technology demonstration would address questions and risk, however the Task Force was disbanded before this could progress.

The Task Force and Technical Oversight Panel had nevertheless sought proposals from possible IRM providers, including gasification suppliers. It concluded that IRM could integrate solid and liquid wastes managed by CRD while also maximising resource recovery including generation of energy and even generate a possible revenue stream.

Further research was undertaken by HDR Consultants in August 2017 (RFEOI 16-1894) where proponents indicated that gasification could deal with MSW, kitchen scraps, biosolids and mixed wastes as single streams or in mixed recipes. Finally CRD confirmed that IRM has "*the*

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[2] See BC MOE waste management web site.

[3] See Report From The CRD Integrated Resource Management Task Force.

potential to impact every aspect of solid waste management in the region."[4] CRD ultimately decided not to pursue IRM. Other work has been undertaken on IRM within CRD's liquid waste management project, with additional comments provided starting on page 15.

3.4 Climate Change

The Township has completed Climate Action Revenue Incentive Program (CARIP) Public Reports for 2017, 2018 and we are advised 2019 is in preparation. These summarize plans and action to be taken to reduce corporate and community energy and greenhouse gas (GHG) emissions and report on progress towards achieving carbon neutrality. We also reviewed Esquimalt's community emissions total, available from provincial data.

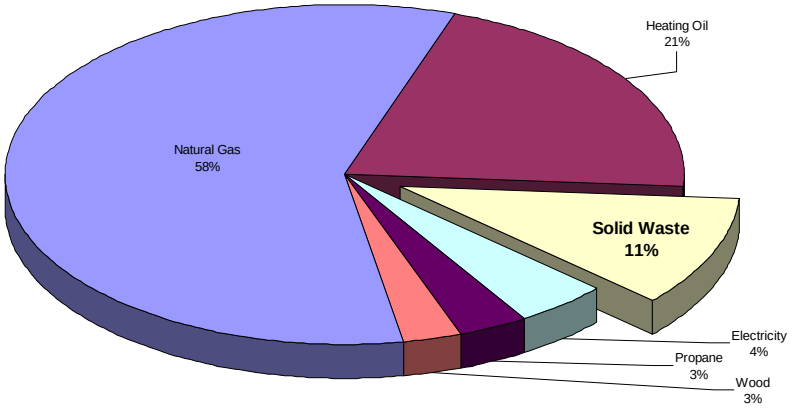

Figure 4: Esquimalt GHG Sources

As the Township's carbon reporting is available separately, we summarize that:

- Esquimalt's overall total GHGs published in the province's Community Energy & Emissions Inventory ("CEEI") 2012[5] as 37,644 tCO_2e. This is the total emissions from all documented activities in Esquimalt;

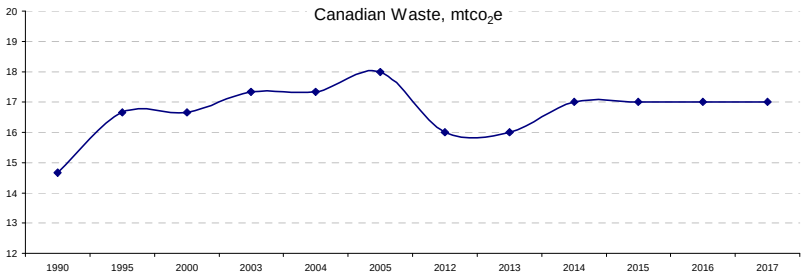

Figure 5: Canadian GHGs From waste, 1990-2017

- Esquimalt has established goal of reducing community GHG emissions by 38% by 2030 and to become carbon neutral by 2050;
- CEEI data shows 2017 Esquimalt waste as being 6,223 tonnes or 2,459 tCO_2e;
- Esquimalt has a municipal corporate annual balance of 1,005.25 tonnes per annum CO2e that it needs to eliminate to become carbon neutral.

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[4] CRD ERM 17-30 at page 2.

[5] We note that although an accepted calculation of tCO_2e, we consider it incomplete as some components are omitted. Esquimalt's actual total GHGs are expected to be higher than the provincial totals. See CEEI web site and data.

In summary for IRM to eliminate the Township's corporate operations' GHG profile, reductions have to exceed 1,005 tCO_2e. To eliminate the total emissions for the entire community, GHG reductions have to exceed 37,644 tCO_2e.[6] In that context it is worth noting the commitments by the World Green Building Council and United Nations that all buildings need to be Net Zero Energy or carbon neutral by 2050, and that IRM contributes to these resolutions.[7]

While Figure 4 shows that Esquimalt's waste contributes ≈11% of the overall community GHG total, IRM has the potential to replace heating – which is often provided by natural gas and heating oil. Thus, using energy recovered from waste to displace fossil fuels has the potential to reduce the community's carbon profile to a greater degree than shown by Figure 4. All scenarios prepared by us indicate the potential to eliminate the Township's corporate GHG profile while the percentage GHG reduction for the whole community varies depending on plant size.

Consideration also has to be given to increasing heat impacts from climate change. CRD's projections[8] indicate rising temperatures year-round with reduced rainfall in summer months. Rising temperatures will tend to shift demand away from heating towards increased cooling – both of which can be provided from gasification of waste and are included in our models. CRD also projects greater storm events during winter, spring and fall, which is expected to worsen sewage influent and infiltration. During the June-September months from which the Average Dry Weather Flow ("ADWF") are calculated[9] volumes are projected to fall by ≈20%, but temperature dilution from I&I may reduce energy recovery potential.

Efforts to reduce emissions from waste have resulted in increased waste separation and sorting so organics – a major GHG contributor – can be managed differently to reduce their GHG impact. Unfortunately Figure 5 shows that emissions from waste have been fairly stable recently, despite waste separation and landfill diversion efforts. Local trends are similar, since CRD's data shows that organics diversion has been risen to ≈39% between 2009 and 2016 (Figure 21), at appreciable cost (in some instances exceeding $400/tonne as compared with landfilling at $110/tonne, unsorted). Although this will have improved since CRD's last study, this means ≈61% is still being landfilled. Multiple communities have experienced difficulties with converting food waste into compost[10] and a Vancouver biomass expert notes that demand and price for compost is low. This has resulted in companies becoming marginal or failing[11] – as shown for example in Richmond, Duncan, Saanich and at Duke Point. The main challenges are summarized as: (a) community pressure – both for and against; (b) odour – the largest challenge; (c) separated organics being contaminated, e.g. with plastics; and, (d) lack of profitable markets for the resulting compost.[12] This is discussed further as part of section 4.1 *Technology Review,* on page 15.

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6 Source: BC Provincial CEEI reports.

7 See United Nations' Sustainable Development goals and the World Green Building Council's Net Zero site.

8 Climate Projections for the Capital Region, CRD, 2017

9 Per Stantec memo to CRD, 2017: "*...average dry weather flow (ADWF)... is the sum of the base sanitary flow plus the flows attributed to groundwater infiltration during the... period from June 1st to August 31st.*"

10 See for example online articles #1, #2, #3, #4, #5, #6, #7.

11 A Richmond facility attracted the most complaints and largest fines in BC history, was facing fines of up to $1m/day and had a cleanup cost was estimated at ≈$24m.

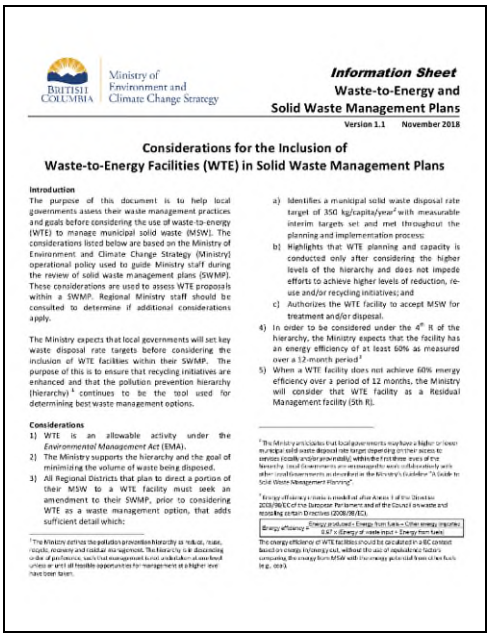
12 As examples of this: The operator of a (now closed) Saanich plant reported as much as 50% of the organics had to be rejected due to contamination. A composting operation at Duke Point, Nanaimo had to be refinanced and was resold twice and contracts were restructured. A Duncan site processing Saanich waste is under pressure from odour complaints. Smaller farm compost operations in Saanich also report contamination problems.

3.5 Regulatory

The key main regulatory processes that IRM will be required to meet are: (a) the Ministry of the Environment and Climate Change Strategies' (MoE) pollution prevention 5R's guideline, aimed to maximizing recycling, reuse etc.; (b) MoE's facilities and emissions regulations; (c) compliance with regional waste management plans; and, (d) Esquimalt's community support and approvals.

3.5.1 5R's Guidelines

MoE's guidelines for the management of wastes is based on a pollution prevention hierarchy to Reduce, Reuse, Recycle, Recover and Residuals Management. This prioritizes levels by which municipalities should approach waste management, i.e. options for any material should be considered at each level, before moving down the hierarchy. The purpose is to ensure waste management practices maximize recycling before considering a waste to energy recovery solution. The policy is also to encourage use of the hierarchy as a tool to determine best waste management practices.



Ministry of Environment and Climate Change Strategy

Information Sheet
Waste-to-Energy and Solid Waste Management Plans
Version 1.1 November 2018

Considerations for the Inclusion of Waste-to-Energy Facilities (WTE) in Solid Waste Management Plans

Introduction

The purpose of this document is to help local governments assess their waste management practices and goals before considering the use of waste-to-energy (WTE) to manage municipal solid waste (MSW). The considerations listed below are based on the Ministry of Environment and Climate Change Strategy (Ministry) operational policy used to guide Ministry staff during the review of solid waste management plans (SWMP). These considerations are used to assess WTE proposals within a SWMP. Regional Ministry staff should be consulted to determine if additional considerations apply.

The Ministry expects that local governments will set key waste disposal rate targets before considering the inclusion of WTE facilities within their SWMP. The purpose of this is to ensure that recycling initiatives are enhanced and that the pollution prevention hierarchy (hierarchy)[1] continues to be the tool used for determining best waste management options.

Considerations

1) WTE is an allowable activity under the *Environmental Management Act* (EMA).
2) The Ministry supports the hierarchy and the goal of minimizing the volume of waste being disposed.
3) All Regional Districts that plan to direct a portion of their MSW to a WTE facility must seek an amendment to their SWMP, prior to considering WTE as a waste management option, that adds sufficient detail which:
   a) Identifies a municipal solid waste disposal rate target of 350 kg/capita/year[2] with measurable interim targets set and met throughout the planning and implementation process;
   b) Highlights that WTE planning and capacity is conducted only after considering the higher levels of the hierarchy and does not impede efforts to achieve higher levels of reduction, re-use and/or recycling initiatives; and
   c) Authorizes the WTE facility to accept MSW for treatment and/or disposal.
4) In order to be considered under the 4th R of the hierarchy, the Ministry expects that the facility has an energy efficiency of at least 60% as measured over a 12-month period.[3]
5) When a WTE facility does not achieve 60% energy efficiency over a period of 12 months, the Ministry will consider that WTE facility as a Residual Management facility (5th R).

[1] The Ministry derives the pollution prevention hierarchy as reduce, reuse, recycle, recovery and residual management. The hierarchy is in descending order of preference, such that management is not undertaken at one level unless or until all feasible opportunities for management at a higher level have been taken.

[2] The Ministry acknowledges that local governments may have a higher or lower municipal solid waste disposal rate target depending on their access to services locally and/or provincially, within the first three years of the Ministry. Local Governments are encouraged to work collaboratively with other Local Governments as described in the Ministry's Guideline "A Guide to Solid Waste Management Planning".

[3] Energy efficiency criteria is modified after Annex II of the Directive 2008/98/EC of the European Parliament and of the Council on waste and repealing certain Directives (2008/98/EC).

Energy efficiency = (Energy produced − Energy from fuels − Other energy imports) / (0.67 × (Energy of waste input + Energy from fuels))

The energy efficiency of WTE facilities should be calculated in a EU context based on energy in/energy out, without the use of equivalence factors comparing the energy from MSW with the energy potential from other fuels (e.g., coal).

Figure 6: MoE W2E Guidelines[13]

Much of the waste in BC is collected by private haulers who either deposit it at a regional landfill or at a regulated facility typically other than a landfill, such as a Blue Box recycling centre which are available across BC. Under current waste management plans resource recovery has primarily been focused on composting programs for kitchen scraps and other organics with a few municipalities and regional districts using anaerobic digestion to recover biogas to heat the digesters and/or for electrical production.

There are no examples where thermal (gasification) treatment is being used to produce synthesis gas (syngas) for the recovery of electricity or heating/cooling. This is unfortunate because energy production is higher than Anaerobic Digestion but toxic chemicals and pathogens are destroyed, GHG emission reductions are significantly higher, the resulting biochar is more valuable than compost as a soil amendment or filtration medium and the process also generates revenue streams from the sale of energy, GHG credits and biochar.

The CRD has enacted Bylaws for managing biosolids using anaerobic digestion to produce biogas, which will be used to maintain optimum temperature of the digesters. We understand the current proposal is to barge residual biosolids to the Lower Mainland for burning with coal in a cement kiln as the final disposal measure, however it would be possible for this to be diverted to Esquimalt's gasifier if this was acceptable to the community. We understand final

[13] See MECC web site.

contracts have not yet been signed and barging is an appreciable cost for CRD and accepting these in Esquimalt could reduce costs. CRD's plan is not final at the time of writing and may be worthy of discussion, but only if accepting these wastes is acceptable to the community.

3.5.2 Facilities and Emissions Regulations

In order to consider energy recovery, MoE expects that local governments will follow the 5R's guidelines, which outline the primary elements for approval of a proposed waste to energy recovery facility (Figure 6):

- Municipal and Regional waste disposal rates must be at or below MoE's guideline rate of 350 kg/capita/yr before considering the inclusion of an IRM energy recovery from waste;
- Partner with their Regional District to amend their regional Solid Waste Management Plan (SWMP) to include the IRM energy recovery facility;
- The proposed IRM facility's energy recovery efficiency must be a least 60% for the selected technology;
- The proposed IRM facility's emissions must meet the Operational Certificate requirements of a waste to energy mass burn incinerator;
- There must be adequate public consultation of the proposed IRM energy recovery project before approval can be provided.

In summary the disposal rate and energy yield meets 5R's guidelines. IRM gasification is also expected to meet MoE's emission standards. Therefore, we conclude the Township and its proposed use of Advanced Gasification is able to meet and exceed Ministry guidelines.

3.5.3 Solid Waste Management Plan

The current CRD Solid Waste Management Plan (SWMP) has commenced the process to be updated and they expect a draft of the new SWMP will be presented to the CRD Environment Committee and the Board in the fall, which provides adequate time for the Township to submit their intention to have an IRM facility, to be included in the new SWMP. In preparation, the Township should confirm community support for an IRM approach.

The primary issues MoE requires assessed include:

- Best Available Technology - Several reviews of alternative energy recovery technology options have been undertaken by CRD and the IRM Task Force that demonstrate the Township has approached this project in a manner to ensure that the IRM facility will use best available technology. The independent review by CRD confirmed Advanced Gasification as a technology but per request, we have included a technology review and comparison starting on page 15;
- Financial Viability - Extensive TBL financial modelling has been undertaken to ensure that the selected IRM approach maximizes resource recovery and is the most cost effective option available;

- Air Emissions Compliance - From the manufacturer's records and from previous waste testing the selected IRM option shows compliance with all environmental air emission regulations for municipal waste incinerators. Calculation of actual air emissions from Esquimalt's waste is planned to be undertaken at the next stage of the project and there are no indications this will not comply;
- Site Specific Issues – MoE requires site-specific issues to be considered, which are explained in greater detail later. Note that several gasifiers have been approved in BC[14] and all meet site specific requirements set out in their permit authorizations. There are no issues currently known that suggest an IRM facility in Esquimalt would not be compliant and permitted;
- Public engagement – Engagement through the West Shore Innovation Days, the IRM Task Force public engagement, and the engagement to follow as part of this study contribute to meeting MoE's requirements for public engagement. Prior engagement has demonstrated support, hence this study;
- Biochar Value - Biochar production from the IRM facility will be tested prior to final selection to confirm its use as a soil amendment and its potential to be used as air or water filter medium where the market is much more valuable.

In summary, the Township's proposed IRM direction appears consistent with and able to meet or exceed current provincial government requirements, as the technology has been reviewed and what is being proposed is the best available. This study confirms IRM using gasification can provide optimum resource recovery and is the most cost-effective approach. The Township's per capita waste levels appears to comply with the 5R's guidelines enabling it to proceed to energy recovery. Combined, this confirms that Esquimalt has met the initial Provincial requirements to proceed with the detailed planning and assessment of an optimized IRM facility in Esquimalt to be part of the Regional SWMP.

3.5.4 Municipal Development Permits

Esquimalt's Development Permitting (DP) process arises from the development application procedures and fees outlined in Bylaw 2791 which sets out the process for the development of an IRM facility and addresses:

Timing – A development permit application must be submitted to the Director of Development to commence the permitting process. This application would include a selected site; description of the complete IRM facility with inputs/outputs; GHG profile; MoE approval process; public consultation outcomes and conceptual designs. We have allowed ample time for this to take place by providing a two year planning and preparation allowance in modelling.

Site zoning – zoning requirements are outlined in Appendix A of Bylaw 2791 and in this case the IRM facility will require Industrial Zoning. If the zoning has to be changed to allow gasifier operations, it will trigger a requirement for a site profile to be undertaken under the Contaminated Sites Regulations, which may increase costs slightly and extend the timeline for overall permitting requirements.

[14] For example in Victoria, at UBC in Vancouver and UNBC's northern campus in Prince George.

Application for Development – A detailed project description will have to include all features of the pre-development phase including concept design, site geology, lot size, zoning and MoE's Environmental Impact Assessment (EIA). The EIA would include a description of the technology chain from feedstock receiving and processing to the gasification system and thermal oxidation/heat exchanger with air emissions treatment. It will also include the impacts from onsite construction, commissioning followed by long term operations.

Public consultation – A public consultation process must be conducted with residents within 100 m of the proposed site as per Appendix B of Bylaw 2791. The consultation process must be carried out in accordance with the terms of the DP process adequately advising residents of the public consultation meetings via mail and flyers, provide details of where, when and at what location consultations are to occur as well as outline the opportunities to provide input.

Development application fees – The development permit fees are outlined in Appendix B of Bylaw 2791 and are likely to be in the order of $25,000.

3.6 Grants

All levels of government manage grant and funding programs to encourage research development and demonstration of clean energy technologies in Canada. Canada's investment in clean energy is an important part of building a clean economy and therefore, grants are available.

There are multiple grant sources and programmes change frequently, so while some may end, typically others replace them. Suitability, availability and application will need to be reviewed should the project proceed further. A list of identified current grants is included in *Appendix 4:Grants* on page 83. Other grants become available periodically without notice, for example at the time of writing, there is discussion that COVID-19 economic stimulus grants may be made available for green infrastructure, which an IRM plant should qualify for.

While grants are generally designed to be beneficial, they usually involve meeting goals and objectives from the grant programme's objectives that may not entirely align with a specific project's capabilities or even the community's purpose. They also usually require cost sharing and often involve third parties, for example with federal/provincial grants. Application and approval thus usually adds risk, cost and sometimes considerable delay. Some grants have criteria that are an aimed at other technologies or processes and may thus be an imperfect fit for gasification, while other grants can be smaller than the cost of applying for them. There is also usually extra reporting so the grantor can document that their objectives are being achieved and the money expended correctly. In short while grants are often attractive, they are not always as helpful as they might seem.

The main difficulties with grants are that they can raise costs, cause delays, increase uncertainty and risk. We have for current purposes assessed system viability without relying on grants, but included a general comment about the impact that grants may have on viability. We generally recommend clients do not rely on grants and even avoiding them if possible.

4 Analysis

This section reviews pertinent IRM technologies, proceeding to narrow this down to and compare anaerobic digestion with gasification and from this, identifies the best available technology option. We then analyse population statistics and growth projections in order to estimate future volumes of both liquid and solid waste streams, to assess possible resource recovery opportunities. While the scope of work for this study focused on gasification due to prior work by the community, during meetings with staff it became clear that the study needed to confirm and comply with MoE requirements, so technology options were reviewed and documented accordingly. The section concludes with a review of what is needed to understand feedstock characteristics from initial laboratory and physical testing, to the process train and possible output products.

4.1 Technology Review

4.1.1 Possible Options

In order to consider energy recovery from waste, the Province requires a review of suitable technologies and that the process to consider them has met it's 5R's process. As appreciable work has been undertaken by CRD on technologies, we have thus undertaken a brief review of how Esquimalt came to support IRM with a preference for gasification, including technology assessment, community exposure and feedback, with summary comments on technologies.

CRD assessed liquid and solid waste treatment technologies for the Core Area Wastewater Treatment Plant at McLaughlin Point, from 2006 to 2016. Since 2006 CRD has held at least six proposal calls including Requests for Information, Requests for Expressions of Interest and one Request for Technical Innovation, i.e. technologies have been exhaustively reviewed previously but none have proceeded. CRD's studies mainly focused on recovering resources from biosolids but proposals were able to service both liquid and solid waste streams.[15] During this time and because Esquimalt was the focus for plant location, the community provided comment on options, which led to local community support for IRM and gasification, consistent with provincial encouragement to adopt Integrated Resource Recovery – similar to IRM but omitting financial assessment. CRD's studies thus provide background on technologies, albeit with main focus on residuals management, and are summarized below.

CH2M Hill, Associated Engineering and Kerr Wood Leidel provided advice to CRD between 2006 and 2009, where a range of technology options were considered. With regard to biosolid residuals, these included low technology options such as willow coppice land

[15] CAWTP Assessment of Biosolids Treatment Appendix L, page 16, Table 3.1, CRD 2016.

applications. Significant community resistance to land application was based on the potential for contamination,[16] and in 2011 CRD Board banned biosolids land application. Proposals calls and options for alternate technologies were constrained as a result and although the province stated that other options would be considered, and despite community resistance that included protests and marches to the Legislature, CRD retained focus on digestion without having resolved biosolids residuals.

From 2009 through 2015 Stantec considered 21 options and in 2016 MoE approved CRD's plan for thermophilic anaerobic digestion and drying the biosolids. Under this, the West Shore communities developed Westside Solutions' Innovation Days chaired by Esquimalt and Colwood Mayors, which held a proposal call and received a range of presentations on technologies, which covered wastewater treatment and biosolids management, i.e. solid residual organic wastes, for which the two main technologies advanced were incineration and Advanced Gasification. CRD did not ultimately follow on the recommendations, but Innovation Days included public participation over multiple days and resulted in community support for IRM and gasification.[17] These contributed to the Township's current direction.

In terms of solid waste studies locally, in 2011 CRD, the Regional District of Nanaimo and Cowichan Valley Regional District commissioned a study[18] assessing options for a large W2E system serving all three regions. It is unclear why a centralized system was stipulated given decentralized systems are feasible, as documented by CRD elsewhere. The stipulation for a centralized plant added both capital and ongoing costs, and increased GHGs. This would only have been needed for incineration-based options, which the study favoured. Other factors in the study also constrained the conclusions, e.g. generation of methanol. Cost was thus increased by these scope limitations and direction (e.g. forcing three regions' waste to be transported centrally, even to Gold River). The study's scope and assessment limitations resulted in unfavourable conclusions and the direction was not pursued.

Composting is an option for organics processing, and is consistent with "cradle-to-cradle" approaches providing the resulting compost is usable, but this has been challenging as previously noted.[11] For composting to be useful, the product must have utility or it fails to support cradle-to-cradle or reduce carbon emissions – the primary objectives. In that regard a local hauler reports that there is no demand for compost and that they have four years' unsold supply on hand. A community watchdog reports that Saanich peninsula farms will not take organics due to community concern about contamination and toxins, i.e. there is limited or no demand for the composted products even if they are free (Class A Biosolids are potentially problematic for similar reasons). These comments apply to food production lands however, as two farms using compost for non-food production report challenges and additional costs separating contaminants within the compost or using the compost viably. The impact on lands using compost if they are returned to food production is unknown.

Whether well founded or not, we conclude there are challenges using compost in this region. Given the foregoing and as composting has a nutrient approach similar to anaerobic digestion, but without the potential to yield other products, composting has not been considered further but anaerobic digestion is a suitable option for consideration.

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[16] CRD's experts noted that land application might have 22 years' life before contamination would be problematic (Brown & Caldwell 2009, ss3.2.1.2).

[17] Other than Innovation Days, public support was also indicated during McLoughlin Point rezoning, in several publications and with presentations from groups including Esquimalt Residents' Association, RITE Plan and STAG.

[18] See Tri-Regional Study, AECOM, 2011.

A number of other technologies are in the development stage and may become technologies suitable for consideration in waste management, such as Biofuels generation. For example demonstration-scale projects in Alberta and Nova Scotia are progressing, but have not proven themselves stable enough to date, or have the financial substance to guarantee both performance and yield, such they can prove and then underwrite, performance with Esquimalt's waste streams.

4.1.2 Selected Technologies

The nature, volume and composition of Esquimalt's waste, combined with the rejection of incineration and problems with composting, leave few acceptable technology options.

Analysing CRD's 2016 composition study we find that organic wastes are ≈11% of total dry wastes received at Hartland but ≈21% of the wet volume (Figure 7 and Figure 21). Because of the high moisture content, engineers often focus on technologies able to handle wet waste and do not always consider how the water can be inexpensively recycled and maximise the energy, which is in the dry portion of the waste. Doing so would halve the volume being managed, but also significantly reduce capital and operating costs, by concentrating on the solid fraction of the waste – the part that contains the energy and resources. The water itself is also a recoverable resource if treated.

	Digester			Gasifier		
CRD waste category	Y/N/R	Wet	Dry	Y/N/R	Wet	Dry
Organic Waste	Y	28,485 t	9,970 t	Y	28,485 t	9,970 t
Paper and Paperboard	R			Y	20,790 t	13,514 t
Plastics	N			Y	19,305 t	17,375 t
Wood and Wood Products	N			Y	22,950 t	18,360 t
Construction and Demolition	R			R		
Textiles	N			Y	7,965 t	5,576 t
Composite Products	N			Y		
Other	N			N		
Ferrous Metal	R			R		
Glass	R			R		
Electronics	R			R		
Hazardous Waste	N			N		
Rubber	N			Y	1,080 t	1,080 t
Non-Ferrous Metal	R			R		
Bulky Objects	N			N		
Household Hygiene	N			Y	9,315 t	3,726 t
Total suitable		**28,485 t**	**9,970 t**		**109,890 t**	**69,599 t**
Yes, handles it		21%	11%		81%	75%
No, doesn't handle it		51%	58%		6%	8%
Recycle		28%	32%		13%	17%

Figure 7: Technology Comparison by Waste Category[19]

The focus on solid waste "as is" rather than drying it, often results in waste separation and selecting anaerobic digestion, which although rejected by the community for the Viewfield Road location, is still a valid technology and generally an improvement over composting. We should note however that because of the focus on 'wet' solutions such as digestion, analyses almost always: (a) does not assess or manage the water content of solid wastes separately; and, (b) omits consideration of other options such as gasification, which could halve plant size. Most studies do not mention or assess over 90 gasification systems operating in Europe and Asia processing MSW, scraps and biosolids with an equivalent total of more than 1,000 years' operation. One manufacturer for example, has 28 systems with 57 gasifiers operating since 1980. Omitting consideration of these plants affects decisions as it means only technologies advanced for consideration are chosen, in turn increasing taxpayer cost and reducing the potential for resource recovery.

The primary two options considered for Esquimalt's current purposes are thus anaerobic digestion and Advanced Gasification. Their ability to handle wastes is compared in Figure 7,

[19] Source: CRD 2016 Solid Waste Stream Composition Study, analysis by Pivotal.

which uses CRD's 2016 waste composition assessments, which will likely be similar to Esquimalt's waste composition.

Note that while Figure 7 shows gasification can handle a wide variety of wastes, this does not preclude them being handled by recycling, as this gradually improves. Some provinces have found that the economics of recycling are proving unviable with little demand for products, so Figure 7 shows that gasification provides the option to address waste streams if recycling is unworkable, or if new recycling methods become available, those wastes can be extracted and recycled as and when this becomes possible and desirable. Notably, gasification is less reliant on waste separation or dry wastes, which is critically important for anaerobic digestion or incineration for example. This may be attractive for some residents.

We comment on the technologies as follows:

- **Anaerobic digestion** uses bacteria to digest organic compounds in sewage to primarily produce biogas, usable to generate heating, cooling and power. Approximately 11% of CRD waste is suitable for anaerobic digestion (Figure 7), which have been extensively reviewed by CRD as part of the new liquid waste system. The biogas is typically burned to heat the digesters and operations building, and to provide hot water, but can be cleaned up to be saleable as a Renewable Natural Gas ("RNG") at as much as ten times the cost of natural gas. However this biogas will be used to maintain a suitable operating temperature in the digester, so the only potential GHG offset is likely to be from avoidance of landfill off-gassing. CRD's 2016 business case for the Hartland digester indicated no plan to sell methane yield Renewable Natural Gas and did not provide an assessment of the carbon footprint of the project.[20]

Figure 8: Planned Anaerobic Digester, Hartland Landfill

Figure 9: Digester, Annacis Island

  Biosolids are produced as a residual from digestion, which has historically been used for soil augmentation. However there is rising concern that this can contribute to soil toxicity, due to increasing volumes of chemical and pharmaceutical materials in waste, which digestion does not destroy. Pharmaceuticals also disrupt the biological processes in the digester,

[20] CRD more recently indicated they may sell digester methane by redirecting landfill gas to heat the digester (which was previously used to generate and sell green electricity). Landfill capture was also expanded recently, funded by CRD taxpayers, but no viability assessment was available. As both the digester and landfill capture are taxpayer-funded costs, the viability of RNG production is unclear but is accepted to be a cost not a profit.

resulting in sub-optimal performance. Residuals from digestion are typically ≈50% of the initial feedstock and may not be permissible for local land application, so need to be landfilled or incinerated, resulting in potential residual GHGs and costs. Currently CRD is planning to transporting these residuals to burn them as part of cement manufacturing in the Lower Mainland. Digestion is thus not in itself a complete solution for the wastes it process and requires additional technologies to be added.

The net energy yield from the biogas and residuals disposal has been calculated[21] to be 239GJ net per day (2.1 MW/tonne). Air emissions from biogas combustion are permitted in BC. Note that because digestion only addresses ≈11% of the waste stream, digestion and recycling combined leave ≈63.5% of the waste stream unaddressed, once residuals are taken into account.

Digesters typically require extensive land area (Figure 8) as they comprise multiple units typically containing up to ≈30 days' supply of gas. They are located in less populated areas due to risk of odour and explosion, which can be managed but adds risk.[22] Locating a plant in Esquimalt is complex due to site limitations and was firmly rejected by the community when CRD proposed this for the Viewfield Road site.

Figure 10: RotoGasifier, Louisiana

- **Gasification** is a chemical and physical process where the feedstock is heated in a controlled chamber with minimal oxygen to produce a synthesis gas ("syngas"), usable to generate heating, cooling and power. Feedstocks need to be carbonic in nature to produce energy making them suitable for a range of wastes. As opposed to incineration (which burns waste, requiring extensive air emissions control systems), gasification is a quasi-manufacturing process that minimizes the need for emissions control systems and is operated to avoid generating toxins.[23]

Figure 11: Dockside Green Energy Plant

Approximately 75% of CRD waste flow is suitable for gasification. Residuals are primarily biochar and fly ash, which are usable and saleable. Gasification and recycling combined,

[21] See CRD biosolids web pages.

[22] See for example: odour articles #1 #2 #3; explosion articles #1 #2 #3.

[23] By contrast half the cost of incineration plants are typically their emissions control systems to manage particulates and toxins.

should be able to treat the entire municipal waste load, when combined with Blue Box recycling and Extended Producer Responsibility programs for paints and other household hazardous materials.

In terms of energy recovery, gasifiers generate syngas (synthesis gas – a mixture of gasses) used for heating, cooling and other purposes. Output has been measured at ≈ 3.23 MW/tonne, with syngas emissions similar to natural gas boilers whose emissions are permitted in BC.

Gasifiers do not require large areas (e.g. Figure 10, where a unit roughly double in size to Esquimalt's needs occupies a site similar to Esquimalt's Public Works Yard). Gasifiers generate little noise, odour and emissions, which means they can be located in urban areas with little impact to adjacent uses. A gasifier is located in Dockside Green adjacent to residential development (Figure 11).

4.1.3 COMPARISON

In 2017 The Chair of CRD's IRM Task Force asked us to compare the life cycle cost of anaerobic digestion with gasification for biosolids management, using CRD budget projections provided to the Task Force. We have updated this with gasifier revenues, operating and maintenance costs described in sections 5.3 and 5.4 starting on page 43. Feedstock delivery is excluded and the summary is after debt in current dollars, i.e. excluding inflation.[24] The results are tabled in Figure 12 and show that whether on a cost basis ("Annual payments") or net cost basis ("Cost/revenue per tonne"), gasification is financially superior. Note that these costing were not developed by Pivotal but use actual bid costs and CRD's business case for the digester, with budget calculations from CRD's engineers for the gasifier, which are high, i.e. more accurate costing would further improve the gasifier's financial advantage.

	2016 Digester	2016 Gasifier
Capital plant	-$127.0m	-$50.0m
Pmts 25yrs @ 4%	-$7.8m/yr	-$3.1m/yr
O&M	-$3.0m/yr	-$1.6m/yr
Annual payments, yr 1	-$10.8m/yr	-$4.7m/yr
Revenues, yr 1		+$5.7m/yr
Net costs/revenues/yr, yr 1	-$10.8m/yr	+$1.0m/yr
Cost/revenue per tonne/yr	-$1,291/tonne	+$122/tonne

Figure 12: Technology Financial Comparison

A technology comparison summary is provided in Figure 13 with comments as follows.

- Gasification is a cheaper solution both in initial and ongoing costs, life cycle costs and costs per processed tonne. Gasifiers can potentially be profitable whereas digesters require ongoing taxpayer-funded financial support;
- Gasification is a more complete solution. Whereas digestion leaves 63% of the waste stream needing to be addressed gasification should be able to convert it all;
- Gasification has a higher energy recovery yield at ≈3.23MW/tonne of waste compared to digestion at ≈2.1MW/tonne;

[24] Discounted cash flows have not been used as these distort the financial results for projects of this type.

- Gasifiers are scalable and can be phased. Digesters are more difficult to phase or scale and more reliant on projections being accurate;
- Digesters are usually located in remote areas due to odour and explosion potential, and Esquimalt has limited location options of this type. The community rejected digestion in 2013 for biosolids processing, with public meetings mainly citing odour, traffic and explosion concerns for the proposed location in an industrial neighbourhood with adjacent residential. By comparison gasification is simpler to locate as it requires smaller sites, thus improving location options; avoids odour production (as it is not a biological process with long storage durations); and experts in Europe and the USA confirm no gasifier has exploded in recorded history. For both digestion and gasification traffic would not change as the trucks are already circulating the community;
- In terms of risk, digesters' main risks are odour, explosion, finance and technology. Gasification has less operational risks but increased technology risks, with lower finance risk as the systems are cheaper to both develop and run. Both systems' risks are manageable and both the technologies and the yields can be guaranteed by substantial, qualified companies, thus addressing risks (subject to procurement approach);
- Digestion requires greater taxpayer support than gasification.

	Aspect	Anaerobic digestion	Advanced Gasification
01	Site size	Large, usually multiple acres	Small - ≈1 acre for small plant
02	Location	Remote desirable	Can be urban
03	Typical location	Rural or away from population	Industrial or light industrial
04	Risks (see text)	Odour, explosion, sensitive to inputs, underperformance, life cycle cost, taxpayer support, soils amendment contaminents	Underperformance, taxpayer support, life cycle profit, technology history
05	Viability	Requires continual taxpayer support	Can be viable, taxpayer support minimal/contingent, if underperforming
06	Feedstock suitability	≈11% of volume Organics only	≈75% of volume Most solid wastes
07	Wastes not addressed by technology	≈63%	≈8%
08	Proven with proposed feedstocks	Expected to be possible with organics; unsuitable for wider waste streams	Satisfactory initial tests with MSW, organics, biosolids; more tests desirable
09	Phasing & expansion	Difficult/no	Yes, 6-10 months fabrication lead
10	Performance guarantee	Potentially but adds cost	Potentially but adds cost
11	Residuals	Half of feedstock	None
12	Recovered, saleable resources	Biogas for heating/RNG	Heating, cooling, biochar
13	Energy yield per tonne	2.1 mw/tonne or 7.6 GJ/tonne	3.2 mw/tonne or 11.6 GJ/tonne
14	Soils amendment yield/tonne	None - being incinerated	250-300 kgs per tonne, sterile
15	Capital cost per tonne processed, life cycle	≈-$232 per tonne	≈-$91 per tonne
16	Operating cost per tonne processed,	-$3.0m/yr	-$1.6m/yr
17	Total net life cycle cost/revenue, undiscounted, current $$, after debt	≈-$1,291 per tonne	≈+$122 per tonne
18	Est. extra costs/revenues	Unknown cost to handle unaddressed waste; at minimum landfill tipping fees	Landfill tipping fees for any improperly sorted residuals
19	Annual tCO2e reduction	Not assessed by CRD	≈7,600 tCO2e
20	Life cycle CO2e reduction	Not assessed by CRD	≈380,000 tCO2e

Figure 13: Technology Comparison

In summary while digestion is a better known solution, on almost all indices Advanced Gasification is better suited to address Esquimalt's needs.

MoE requires technologies be reviewed as part of waste planning and decisions concerning implementing energy recovery, which has been undertaken by several engineering companies for CRD over the past decade. CRD has held at least six expressions of interest, requests for information and proposal calls on this matter. The IRM calls resulted in the IRM Task Force recommending the best option as Advanced Gasification. Figure 13 and the IRM Task Force's review both point toward Advanced Gasification as a suitable technology.

4.1.4 Gasification System

In selecting technologies for municipal systems, a common approach is to exclude from consideration any technology unless there are multiple existing operating examples identical to that proposed – essentially a "proxy approach." In Esquimalt's case however few or no examples are likely to be processing the exact wastes and volumes at the required size, scalability and flexibility, or with the current or future mix of feedstocks, feedstock fluctuation and phasing in Esquimalt. The "proxy approach" is a leap of faith that an example in one location means it will work elsewhere, and not a guarantee that it will work in Esquimalt.

Instead of a proxy approach, we focus on risk management and proving a system will work. This uses a sequenced protocol where: (1) Esquimalt's actual wastes are tested in an existing system to prove the system will work with Esquimalt's actual proposed wastes; and, (2) based on physical and laboratory tests, the manufacturer then guarantees the system will achieve the yields, which are then used in the business case. Because this tests actual wastes and physically proves operation before taxpayer commitment, and links payment to performance, it is a faster and cheaper way to confirm that systems will work, and is more directed while reducing taxpayer risk before proceeding. More information is included in section 4.4 *Feedstock Process* on page 35, and we note that not all systems manufacturers are willing to consider this risk management approach.

A wide variety of gasification systems exist but several factors are key in determining the optimum gasification solution:

- Increasing investment is being made to maximize yield from gasifiers such as plasma arc systems. While these claim high energy yields they are generally less proven with high consumables, low up-time and can be susceptible to feedstock fluctuations;
- Some gasification systems are ultimately less viable due to high consumables and related operating and maintenance costs;
- Some systems do not scale well for the sizes needed for Esquimalt;
- Some systems have low up-time operation, e.g. some plasma arc systems;
- Systems such as fluidized bed designs while high yielding and stable, are better suited to RNG production and not well proven with variable waste feedstocks of the type proposed in Esquimalt, so again are less suitable for the current purposes;
- Unmodified updraft/downdraft gasification systems while generally proven, are better suited to predictable feedstocks with little variation, as they can otherwise suffer from aspects such as bridging, ash volatilisation and other factors that trigger reduced efficiency with periodic possible system shutdown, reducing viability and reliability.

Working in conjunction with experts operating existing plants and academics at three universities in Europe and the US, we reviewed over 90 gasification systems to assess we identify as best suited to Esquimalt's needs, summarized in Figure 14.

#	Technology	Units	MSW	Capex/tonne	Opex/tonne	RNG	Biochar	Scalable	Feedstock flexibility	mwT/tonne	Uptime	Economic
1	RotoGasifier	<10	Yes	Low	Low	Low	Yes	Yes	V. high	V. good	80-90%	Good
2	Circle Draft	<10	Yes	Low	Low	Low	Yes	Limited	Moderate	Good	50-75%	Moderate
3	Plasma	10-50	Yes	V. high	High	High	No	No	V. high	Excellent	25-50%	Poor
4	Fluidized Bed	50+	Probable	High	High	High	No	Limited	Limited	Excellent	75-90%	Marginal
5	Up/downdraft	50+	Probable	Moderate	Moderate	Low	Yes	Yes	Moderate	Good	50-75%	Moderate
6	Pyrolysis	50+	Yes	Moderate	Moderate	Low	Yes	Yes	High	V. good	75-90%	Poor

Figure 14: Gasifier Technology Summary

Note that a basic explanation of the main different types of gasification is provided in the *Glossary* on page 73, with Figure 14 explained as follows:

- The number of operating units is summarized by technology and includes variants. This is an estimate because typically more systems are operating than are documented.

- As the Township is expressly interested in MSW capability, we have summarized each technology's ability to handle this. Typically all systems have tested or run with MSW, so "probable" refers to the long term operating potential.

- Capex/tonne provides an indication of the total capital cost in relation to the number of tonnes processed. This is relevant because technologies such as plasma arc gasification have high capital cost but many systems have as low as 25-50% uptime, which raises the cost per tonne.

- Opex/tonne, similarly to capex/tonne, provides an index of the overall operating costs for each tonne processed. Pyrolysis systems for example have a low opex, but as they often struggle with MSW, the operating costs rise in relationship to the tonnes processed.

- RNG is a comment on whether the systems can produce Renewable Natural Gas, i.e. methane (chemical symbol CH_4). Syngas from fluidized bed systems for example have a good carbon-to-hydrogen ratio, so the potential RNG yield is high, whereas pyrolysis systems and RotoGasifiers usually have poor carbon-to-hydrogen ratios, so the methane (RNG or CH_4) yield is low. Note that just because plants can produce RNG does not mean that it is viable to do so, which depends on feed-in-tariff and other factors.

- The ability to produce biochar is inherent in most systems but the yield varies widely, mostly being dependent on the feedstock. Some systems produce no biochar (dual internally circulating fluidized bed for example) as the biochar is recirculated internally to fuel operations, which improves the energy yield but at the expense of biochar production. Because biochar is a valuable product, internal reuse can thus lower the overall viability, net of increased energy yield.

- Scalability is a key consideration for Esquimalt due to community growth and phasing requirements. Some systems' lack of ability to be phased or plants to be increased (or if need be, reduced) in size makes them unsuitable candidates given Esquimalt's comparatively small waste volumes. Plasma arc and Dual fluidized bed systems likely fall under this category.

- Feedstock flexibility is important and will stress a system's robustness. Because Esquimalt's wastes can change and are not well defined, the flexibility to handle future changes in feedstock are extremely important. Fluidized bed and up/downdraft systems tend to be impacted by such variations. This would not necessarily rule them out, but means that spare units would be needed to handle issues when individual units fail when the feedstock changes. Where systems have both low scalability and difficulty with feedstock variations, they should be considered secondary options.

- The megawatt energy yield per tonne is a comparative indicator of the thermal output, which can be used for heating, cooling or electricity generation. This needs to be considered in tandem with the revenues from energy yield and other factors, e.g. while plasma arc systems are the highest yield, their lower uptime and higher capex and opex mean that the higher yield per tonne processed is more than offset by other factors. Note that energy costs in BC are in general fairly low, so the revenues from a high mw/tonne are at best an incomplete indicator of viability.

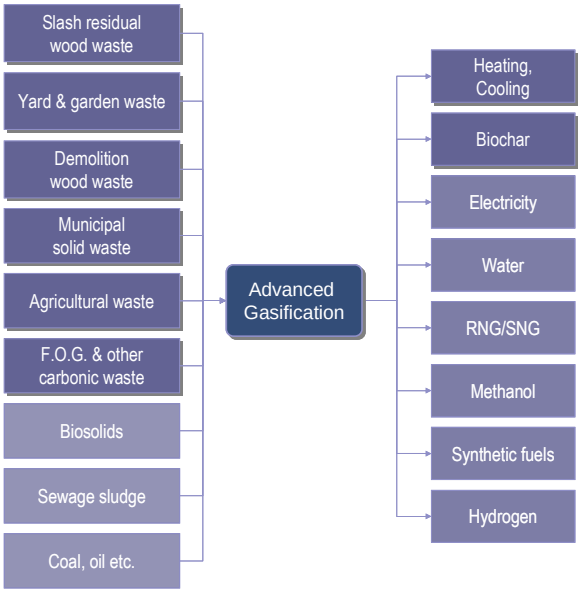

Figure 15: Feedstock & Resource Recovery Options

- Uptime is a critical factor. All systems will have maintenance downtime, but downtime due to difficulties processing MSW mean that, in combination with high consumables (i.e. high opex), some systems' economics are poor. Uptime can be solved however if the systems are highly scalable with low capex, by adding a comparatively inexpensive spare unit to offset unexpected downtime. Thus, plasma arc systems low uptime is difficult to offset as they are not highly scalable; which is offset by their relatively high flexibility and robustness in being able to handle MSW.

- The "Economic" column is a summary assessment of the linked factors of energy and biochar yield, the value of these products, capex, opex, uptime, robustness and scalability over a system's life cycle. Note that this is our assessment given the specific factors affecting the Township of Esquimalt and would likely differ elsewhere, if factors such as feedstock, growth, variability, flexibility, funding, markets etc. change. In reading this column for example: while pyrolysis systems have potential to be candidates for Esquimalt, they are less robust in handling MSW, leading to questionable uptime reliability, so their overall economic ranking is likely to be poor.

We have detail for each of these technologies but it is not the main function of this report to provide this detail. Also, it exceeds the scope and budget of this study to evaluate examples of each of the better options. We will be pleased to provide further detail on gasifiers reviewed if needed.

From our review, the RotoGasifier is the most suitable option for Esquimalt. The RotoGasifier's low number of plants is not a dissuading factor given that (a) it has been

tested and proven to work with local wastes (Figure 27); and, (b) has had a long development cycle with proven plants and can be guaranteed. Up/downdraft and Circle Draft systems while potentially less expensive, have greater constraints with uptime and flexibility, so their overall economics and suitability for Esquimalt are lower. While there are a number of high-yielding plasma arc systems worldwide processing MSW, these are not scalable to Esquimalt's size and usually have high downtime, making them less viable despite a superior potential energy yield per tonne. The RotoGasifier's developmental track record since the 1990's, superior feedstock flexibility and robustness, scalability and overall net viability are notable and while its energy yield may not be the best, it is superior to almost all other systems and technologies, which helps maximize GHG reduction and carbon sequestration, which are key community commitments.

The RotoGasifier is an Advanced Gasification system, so our conclusion is similar to Advanced Gasification being recommended by CRD's IRM Task Force. Because of the variation in system outputs and given the conclusions summarised in Figure 14, we worked with TSI, the RotoGasifier system manufacturer, on budgets etc. As a final safeguard, we have then outlined a best practice implementation approach used by the World Bank and others to provide taxpayer assurance that the RotoGasifier is the best option.

The Advanced RotoGasification system developed from rotary dryers and pyrolysis units, modified to provide gasification while rotating the feedstock. This improves resilience with varying feedstocks and can be scaled to meet the sizes required for Esquimalt, handling wastes and generating products shown in Figure 15. There are a considerable number of plants in existence so the system has an extended development and performance history. While no plants are currently operating with Esquimalt's exact proposed waste mix, plants are operating with similar feedstocks and both laboratory and physical demonstration tests with local MSW and sewage sludge waste (shown in Figure 27) have shown suitability, supplemented with the manufacturer being potentially able to guarantee performance. More information on the system is included in *Appendix 2:Advanced Gasification* on page 76.

A key aspect of the RotoGasifier is that multiple revenue streams are possible from the system's outputs. Not all gasifiers have this multiple revenue streams or adaptability to vary them, with some plants having few revenue streams and little flexibility. Some are purely operated as cost centres. Figure 15 shows the possible feedstock inputs and resulting resource recovery options, with less-preferred options greyed out. While some technologies pursue notionally higher value outputs such as biofuels, this is less proven and less robust. Additional reasons to select the RotoGasifier is therefore that the yields are compatible with the wastes available and basic energy and other outputs, which support viability, making the RotoGasifier simpler to implement while managing risk.

4.2 Demographics

When community services requiring significant capital investment are planned, they have to consider how demand for services will change in the future, so the plant and services can be sized to meet future needs. We thus reviewed demographics and waste volumes under varying scenarios.

Firstly, a concern with major infrastructure is that sizing can be highly reliant on projections that don't happen. We thus analysed statistics from CRD, BC Stats and Stats Canada and while the year-on-year percentage population growth is somewhat erratic, illustrated in Figure 16, long term growth has been reasonably stable (if low) since 2000.

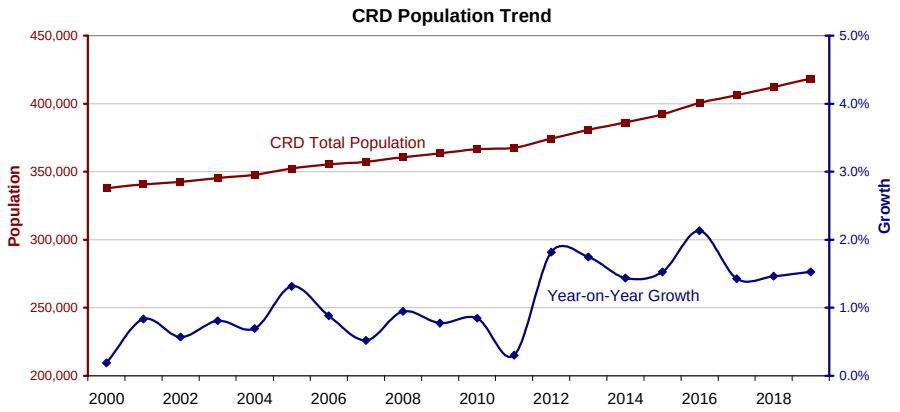

Figure 16: Overall CRD Population Trend

There are appreciable regional population growth disparities, shown in Figure 17 and Figure 18, with come communities exhibiting low growth while others have grown rapidly. This appears to be partly a function of having land suitable for development, and differing degrees to which communities embrace expansion. While Figure 17 shows the overall total growth by community within CRD, the issue becomes clearer when the annual percentage growth is viewed over time, shown in Figure 18.

	Population					
Community	1991	1996	2001	2006	2011	2016
Central Saanich	13,684	14,611	15,348	15,745	15,936	16,814
Colwood	13,468	13,848	13,745	14,687	16,093	16,859
CRD	299,550	317,989	325,754	345,164	359,991	383,360
CRD Core (CALWMP)	239,138	250,487	256,227	271,654	283,977	303,542
Esquimalt	16,192	16,151	16,127	16,840	16,209	17,655
Highlands	1,094	1,423	1,674	1,903	2,120	2,225
Indian reserves	3,214	3,806	4,667	4,670	5,282	5,244
Langford	15,642	17,484	18,840	22,459	29,228	35,342
Metchosin	4,232	4,709	4,857	4,795	4,803	4,708
North Saanich	9,645	10,411	10,436	10,823	11,089	11,249
Oak Bay	17,815	17,865	17,798	17,908	18,015	18,094
Saanich	95,583	101,388	103,654	108,265	109,752	114,148
Sidney	10,082	10,701	10,929	11,315	11,178	11,672
Sooke			8,735	9,704	11,435	13,001
Victoria	71,228	73,504	74,125	78,057	80,017	85,792
View Royal	5,996	6,441	7,271	8,768	9,381	10,408

Source: CRD &Statistics Canada

Figure 17: CRD Demographics, 1991-2016

Esquimalt's population[25] rose from 16,192 in 1991 to 17,655 in 2016, the latest year with available formal census data. Figure 18 shows this is an increase of 1,463 or 0.3% per annum over 25 years, i.e. the long term average growth rate. In the last five years however, Esquimalt's growth has risen to 1.7% per annum. This happened during a sustained peak in the economy, coinciding with increased activity in Esquimalt naval construction.

The 10 year growth rate (0.5% per annum between 2006 and 2016) is likely to be more representative as it spans most of a full economic cycle, however it includes a time when

[25] Source: CRD and Stats Canada.

Esquimalt was less conducive to growth and omits expansion of maritime activity. As such, we feel 0.5% likely understates the stable moderate growth rate, which is more likely to be in the ±1% range, i.e. similar to the regional average.

	Fm: 1991 To: 2016	*25 yrs to 2016*		Fm: 2006 To: 2016	*10 yrs to 2016*		Fm: 2011 To: 2016	*5 yrs to 2016*	
Community	**Increase**		**%pa**	**Increase**		**%pa**	**Increase**		**%pa**
Central Saanich	+3,130	+23%	+0.8%	+1,069	+7%	+0.7%	+878	+6%	+1.1%
Colwood	+3,391	+25%	+0.9%	+2,172	+15%	+1.4%	+766	+5%	+0.9%
CRD	+83,810	+28%	+1.0%	+38,196	+11%	+1.1%	+23,369	+6%	+1.3%
CRD Core (CALWMP)	+64,404	+27%	+1.0%	+31,888	+12%	+1.1%	+19,565	+7%	+1.3%
Esquimalt	+1,463	+9%	+0.3%	+815	+5%	+0.5%	+1,446	+9%	+1.7%
Highlands	+1,131	+103%	+2.9%	+322	+17%	+1.6%	+105	+5%	+1.0%
Indian reserves	+2,030	+63%	+2.0%	+574	+12%	+1.2%	-38	-1%	-0.1%
Langford	+19,700	+126%	+3.3%	+12,883	+57%	+4.6%	+6,114	+21%	+3.9%
Metchosin	+476	+11%	+0.4%	-87	-2%	-0.2%	-95	-2%	-0.4%
North Saanich	+1,604	+17%	+0.6%	+426	+4%	+0.4%	+160	+1%	+0.3%
Oak Bay	+279	+2%	+0.1%	+186	+1%	+0.1%	+79	+0%	+0.1%
Saanich	+18,565	+19%	+0.7%	+5,883	+5%	+0.5%	+4,396	+4%	+0.8%
Sidney	+1,590	+16%	+0.6%	+357	+3%	+0.3%	+494	+4%	+0.9%
Sooke				+3,297	+34%	+3.0%	+1,566	+14%	+2.6%
Victoria	+14,564	+20%	+0.7%	+7,735	+10%	+0.9%	+5,775	+7%	+1.4%
View Royal	+4,412	+74%	+2.2%	+1,640	+19%	+1.7%	+1,027	+11%	+2.1%

Source: CRD &Statistics Canada. Analysis: Pivotal

Figure 18: CRD Community Growth Trends, 1991-2016

In summary Esquimalt's population growth has been somewhat erratic historically, but has recently consolidated at rates at or above the regional average, ranging from a minimum of ≈0.3% per annum to a high of ≈1.7% per annum. We conclude that in the longe term, a moderate sustainable rate is likely to be closer to ≈1% per annum.

Following discussion with Township staff we note their expectation that Esquimalt's population is likely to level off at a maximum ≈25,000 some time over the next twenty years. This is based on current planning, service capacities, growth and development assumptions, but is in great part a reflection of the community not now having appreciable spare developable density. We discuss this later as part of our analysis and projections.

Population projections in the region are notoriously difficult due to fluctuating local and international economics and especially, local political constraints or enablement of growth. Because growth has historically fluctuated, planning any plant size based on growth projections is inherently risky but avoidable by using alternate strategies.

We thus conclude that any IRM solution needs to be flexible and adaptable to demographics, i.e. able to adjust to population growth and resulting waste services as and when it occurs. Any plan should not be dependent on achieving a specific growth projection that might well never be achieved, or changes overnight due to unpredictable regulatory or policy changes that render prior projections inapplicable, stranding assets, viability and environmental results.

4.3 Waste Analysis

Two types of waste were flagged for resource recovery consideration: liquid and solid wastes. Within these, two main factors need to be considered: the volume and nature of the waste (usually termed "composition"); and how this will change over time. At the same time,

consideration must also be given as to whether it's (a) possible and (b) worthwhile, to recover the resources.

4.3.1 LIQUID WASTE

We recommended deferring consideration of liquid waste resource recovery, which we were asked to explain.

There are three main types of resources that can potentially be recovered from sewage: (a) energy from solids; (b) heat; and (c) water.

In implementing its liquid waste plan, CRD will process the region's liquid wastes at a new plant at McLoughlin Point in Esquimalt. From there, extracted solids will be pumped in a slurry to an anaerobic digester located at Hartland Landfill in Saanich, ≈18km from McLoughlin. This means that extracting energy from sewage solids will be unavailable in Esquimalt, unless it is later reconsidered. For current purposes this recovery option has thus been discounted.

Turning to the potential to extract heat energy from sewage, KWL's 2013 study (section 3.3.1 on page 7) assumed rising sewage flows but data kindly supplied by CRD (Figure 19) shows, conversely, that flows have been falling, with opportunity to fall further as communities repair existing pipes. Reducing flows means the heat energy available for recovery is uncertain. Sewage flows appear to have stabilized at 70-72 ML/Day from a peak of 100ML/Day in 2006, a fall of ≈28%, whereas the model used for sewage flow projections[26] anticipated that sewage flows would increase by ≈12% over this period. Flow increases were assumed in KWL's resource recovery study for Esquimalt, which means the study's underlying assumptions have not been experienced in practice, making the study's conclusions risky to rely on without updating. While the McLaughlin plant capacity is sized at ≈50% above recent flows, which allows for aspects such as storm events, the divergence of projections from actual flows makes it uncertain whether resource recovery from sewage is worthwhile and whether the projection models can be relied on for energy planning of this type.

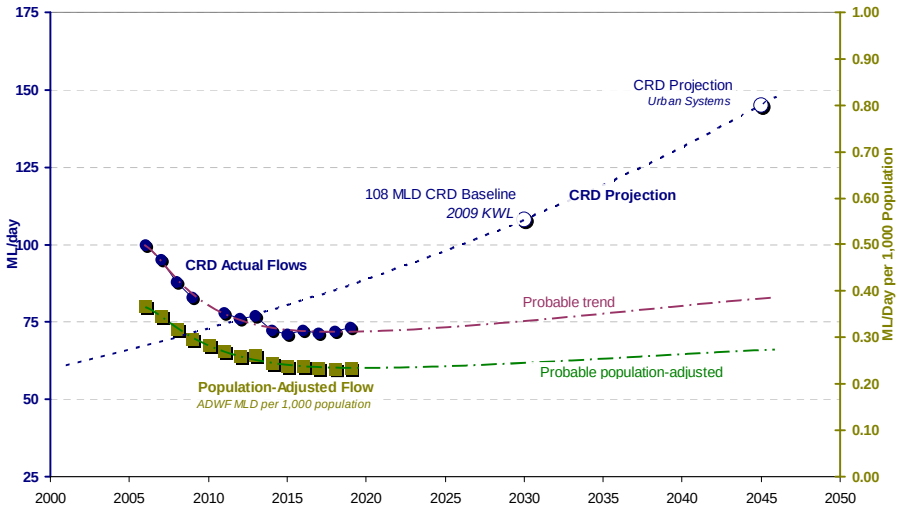

Figure 19: CRD Core Liquid Waste Volumes

[26] KWL originally developed the sewage flow projection model for CRD in 2000.

KWL's 2013 study concluded energy recovery from liquid waste flows was marginal. Given reduced flows shown in Figure 19, we expect viability would be lower and extraction of energy from sewage would probably be unviable. Given the difficulty experienced in predicting flow volumes, we recommended waiting until there is greater certainty, after McLoughlin opens and actual flows/temperatures are measurable, rather than relying on estimates based on projection models, with associated risks. We also recommended not considered water recovery from sewage because as discussed later, substantial volumes of water can be recovered from solid waste if desired, but the economics of doing so are currently unviable. The deferral of this aspect was thus agreed with staff, but can be revisited as desirable.

4.3.2 Solid Waste Composition

Municipal Solid Waste is typically a mixture of different material types that require technologies able to handle them. Esquimalt does not have an assessment of waste composition, but a summary of CRD's 2016 composition assessment for Hartland Landfill is summarized in Figure 20 with detail provided for both 2010 and 2016 composition studies shown in Figure 21.

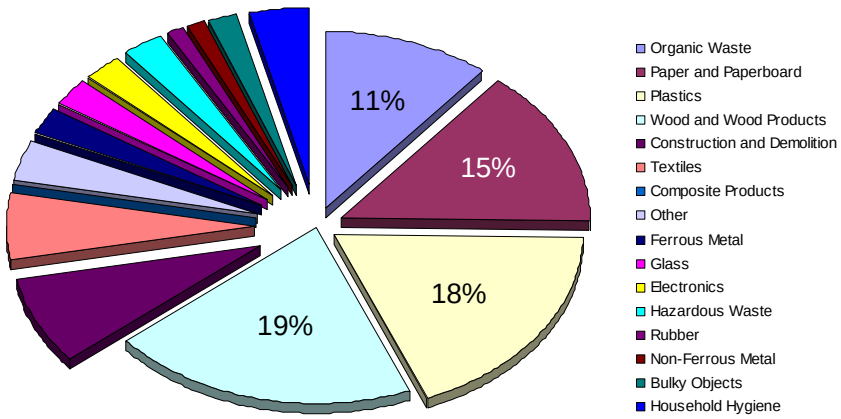

Figure 20: CRD 2016 Solid Wastes by Dry Weight

CRD periodically commission solid waste composition studies (most recently in 2009-2010 and 2016)[27] and we understand an update is being considered. Until Esquimalt's wastes are tested, CRD's analyses are the closest assistance available in assessing Esquimalt's waste composition.

- Organic waste has been a focus for diversion by CRD as this is a major source of GHGs. We calculate that organic waste received at the landfill fell between 2009/2010 and 2016 by ≈ 18,121 tonnes or ≈9.4% per annum, which is a ≈39% overall diversion rate over ≈6 years, i.e. assuming the review is correct, ≈61% of the organic volume was still reaching the landfill in 2016.

- Between 2009/10 and 2016 CRD's population rose from ≈360,000 to 383,000 and through increased organics diversion and other strategies, meant the waste per capita received at the landfill fell from 426kg/person on average to 352kg/person.

- CRD's composition studies track waste received at Hartland landfill but other wastes are known to exist, for example some are already being trucked and incinerated at a mid-

[27] See CRD Solid Waste document hub, 2010 and 2016 studies.

Island pulp mill and some communities (e.g. Saanich) have signed contracts to handle their organics independently of CRD.

- CRD's current approach with solid wastes varies, for example:

  a. Plastics and Styrofoam, amongst other recyclables, are now also being considered for alternate approaches as recycling has been called into question as China, the Philippines and Malaysia now reject Canadian materials;

  b. Biosolids will be trucked/barged and incinerated in Lower Mainland cement plants, although other options have not been ruled out;

  c. Kitchen scraps and yard and garden wastes are being considered for in vessel composting or anaerobic digestion at Hartland but are mostly currently being sent to the Lower Mainland.

Capital Regional District, Hartland Landfill Composition Studies											
	Study: 2009-2010				Study: 2016						Analysis
Category	**Tonnes**	**Wet %**	**Dry %**	**kg/person**	**Tonnes**	**Wet %**	**Dry %**	**kg/person**	**↑/↓**	**%pa**	**Diversion**
Organic Waste	46,606 t	30%	16%	129	28,485 t	21%	11%	74	-18,121t	-9.4%	39%
Paper and Paperboard	25,362 t	17%	16%	70	20,790 t	15%	15%	54	-4,572t	-3.9%	18%
Plastics	20,059 t	13%	18%	56	19,305 t	14%	19%	50	-754t	-0.8%	4%
Wood and Wood Products	15,225 t	10%	12%	42	22,950 t	17%	20%	60	7,725t	+8.6%	-51%
Construction and Demolition	9,385 t	6%	8%	26	9,045 t	7%	8%	24	-340t	-0.7%	4%
Textiles	8,441 t	6%	6%	23	7,965 t	6%	6%	21	-476t	-1.2%	6%
Composite Products	7,931 t	5%	6%	22					-7,931t	N/A	
Other	7,468 t	5%	7%	21	3,645 t	3%	4%	10	-3,823t	-13.4%	51%
Ferrous Metal	3,638 t	2%	4%	10	2,430 t	2%	3%	6	-1,208t	-7.8%	33%
Glass	2,974 t	2%	3%	8	2,295 t	2%	2%	6	-679t	-5.1%	23%
Electronics	2,928 t	2%	3%	8	2,430 t	2%	3%	6	-498t	-3.7%	17%
Hazardous Waste	1,179 t	1%	1%	3	2,430 t	2%	3%	6	1,251t	+15.6%	-106%
Rubber	1,083 t	1%	1%	3	1,080 t	1%	1%	3	-3t	-0.1%	0%
Non-Ferrous Metal	982 t	1%	1%	3	945 t	1%	1%	2	-37t	-0.8%	4%
Bulky Objects					1,755 t	1%	2%	5	1,755t	N/A	
Household Hygiene					9,315 t	7%	4%	24	9,315t	N/A	
Total	**153,261 t**	100%	100%	426 kg	**135,000 t**	100%	100%	352 kg			

Population	359,991	383,360		+1.3%pa
Kg per capita per annum	426 kg	352 kg	*Approx avg.*	-3.1%pa

Figure 21: Hartland Waste Composition Analysis[28]

While some wastes included in the 2009-2010 composition study have been diverted, their volume didn't disappear, but have been diverted and are no longer being handled at Hartland Landfill.[29] This means that current landfill rates could rebound, which an IRM approach may help to address.

The waste industry usually assesses solid waste using "wet" weights and with their high GHG potential and percentage of the wet volume at landfills, organic wastes have been a focus. However moisture is the largest single component in municipal solid waste – but is rarely counted. Since *dry* material is a potential energy resource, Figure 21 applies our assessment of average moisture content (based on tests in CRD and elsewhere), showing that organics are ≈21% of the wet volume but only ≈11% of the dry volume. This fundamentally affects

[28] Figure 21's calculations are consistent with CRD's 2018/1019 Hartland Landfill Gas Monitoring Report, page 8, that "*A conservative estimate of 20,000 tonnes has been [diverted] ... through 2018.*"

[29] For example, organic wastes did not drop from 46,606 to 28,485 tonnes per annum, the wastes were redirected to other locations such as composting operations on the Saanich Peninsula, the Cowichan Valley and Lower Mainland.

decisions and approaches, since moisture can be easily removed by waste heat from gasification while maximizing energy recovery. It shifts the primary focus from organics to having a more complete plan that maximizes reuse, recycling, resource recovery and landfill diversion, i.e. consistent with MoE's 5Rs policy.

4.3.3 Solid Waste Volume

Figure 22 shows that in 2019/2020 the Township collected 3,398 tonnes waste, largely from single-family residences, and provides the 2020 budget costs which include wages, new bin purchases, bin advertising stickers and vehicle depreciation (the "Tipping Fees" column, also shown as a $/tonne). For contrast we included CRD's Hartland tipping fees, to cover landfill costs. Note that the Township's costs are higher because they also cover haulage, systems and staffing. We are aware of costs in other communities, some of which exceed $400/tonne including haulage, i.e. the Townships costs appear to be within the range experienced elsewhere. The estimated moisture content of the wastes is shown with the resulting estimated dry annual tonnage. The latter is the most pertinent, as explained later.

Township of Esquimalt, 2019/2020						
	Tipping fee	Tonnage	$/tonne	Moisture	Dry	Hartland
Yard & Garden	$202,182	1,778 27%	$113.71	40%	1,067	$59.00
Food waste	$157,147	566 9%	$277.50	60%	227	$120.00
Subtotal	$359,329	2,344 36%			1,293	
			$153.28	45%		
MSW	$292,480	1,054 16%	$277.50	25%	790	$110.00
Total	$651,809	3,398 52%	$191.81	39%	2,084	
Plus: private hauled wastes		3,100 48%		25%	2,325	
Total current estimated volume		6,498 100%			4,409	
		Total current estimated volume, dry tonnes per day, public only			5.7dtpd	
		Total current estimated volume, dry tonnes per day, combined			12.1dtpd	
			Unsorted MSW moisture content		37%	

Figure 22: Esquimalt Waste Summary

The Township collects wastes from only a portion of the community, mostly comprising single family homes and small apartments, whereas private haulers mostly collect waste from larger multifamily buildings and businesses. We thus canvassed private haulers known to be active in the community who state that in 2019 they collected ≈3,100 tonnes of MSW in Esquimalt, which is added into Figure 22's totals. The haulers believe this contains only a small amount of non-Esquimalt wastes. The total of ≈6,498 tonnes is close to the provincial estimate for

Esquimalt of 6,223 tonnes in 2017 and is thus considered credible, so private haulage comprises ≈48% of the waste volume with the Township collecting ≈52% of the volume.

Notably, the combined volume of public and private wastes calculates as ≈347 kg/person (including yard & garden waste, which is not in the provincial guideline). The provincial guideline is for communities to reduce waste through the first 3R's, down to 350kg/person/year, so the total known waste in Esquimalt is below this provincial threshold guideline. Under MoE guidelines Esquimalt can thus consider energy recovery from waste.

The Township's data on waste volumes fluctuate during the year as shown in Figure 24 for 2018, the most recent year for which a full range of data is available, with an appreciable variance between food and MSW, compared to yard and garden wastes. This is likely due to

seasonal factors, which highlights the complexity of addressing waste volumes and sizing plant appropriately. Other years vary from these flows and while not all data is available for each waste stream by month from 2011-2019, we were able to interpolate and estimate volumes where the data appears anomalous or was not collected.

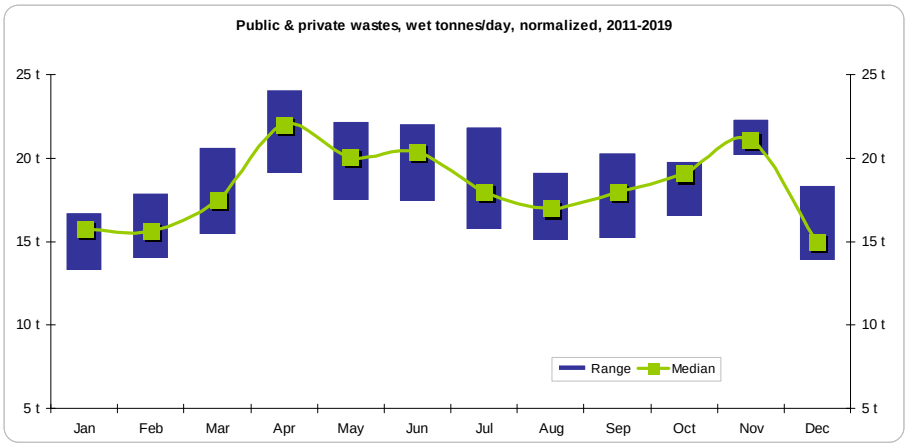

Figure 23: All Wastes, Wet Tonnes/Day

Figure 23 shows the total known Esquimalt wastes as (a) a range of volumes in wet tonnes per day, by month, between 2011 and 2019 (i.e. the way the wastes are received); and (b) the median volumes. This confirms an appreciable range of volumes over the year and thus, the need for any plant to be able to handle fluctuating waste volumes. Figure 25 shows the same data but adjusted to cover the underlying dry tonnage, which is key to determining energy yield and plant size.

Figure 23 is useful to scope receiving volumes and related aspects such as receiving bins, dryer capacity and tipping fees, whereas Figure 25 is more useful to estimate gasifier processing capacity, dried feedstock storage bin size, conveyor hoppers etc. Figure 25 suggests that *current* waste volumes are likely to be mostly addressed by three 5-tonne gasifiers, supplemented by either a balancing strategy to cover excess flows, or preferably a fourth unit to address extra volumes and plant rotation for emergency, downtime and maintenance purposes. As growth occurs or if sporadic volumes become more frequent, a fifth unit could be added; or the unit capacities adjusted if this proves to optimize operations (e.g. by purchasing 7-tonne units, not 5-tonne).

Figure 23 and Figure 25 assess the current total waste volume in Esquimalt but a smaller plant would be possible addressing purely the Township's own wastes. Other options have not been explored in detail pending a decision to pursue an IRM plan

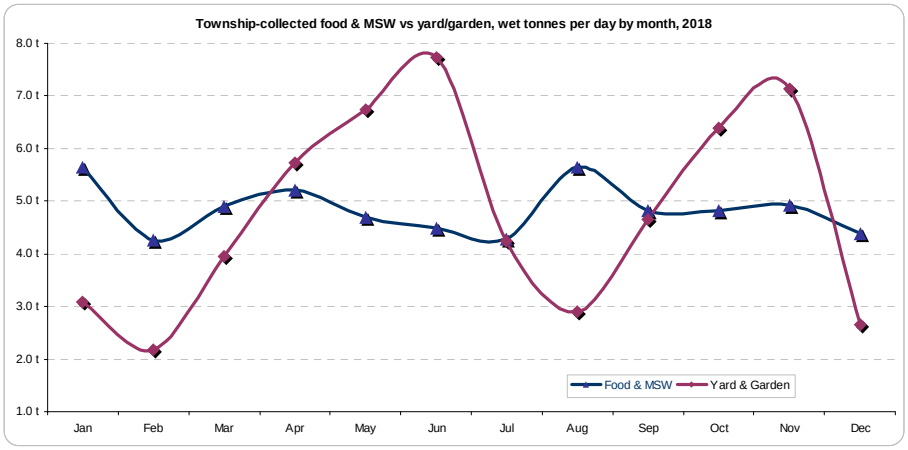

Figure 24: Esquimalt monthly waste flow comparison

further, but scenarios were developed comparing the Township's waste alone, compared to the entire waste stream. Should the decision be made to proceed further, additional review of underlying waste volumes will benefit, to improve accuracy and costing, and help address peak volumes while minimizing and phasing plant.

Addressing Esquimalt's private wastes would require the cooperation of haulers, so we contacted selected haulers[30] who expressed interest and support for supplying material to an IRM plant, once the concept was explained. The main concern was cost impact, which we anticipate would be minimal or an overall reduction and benefit to haulers, since it would reduce trucking and related costs.

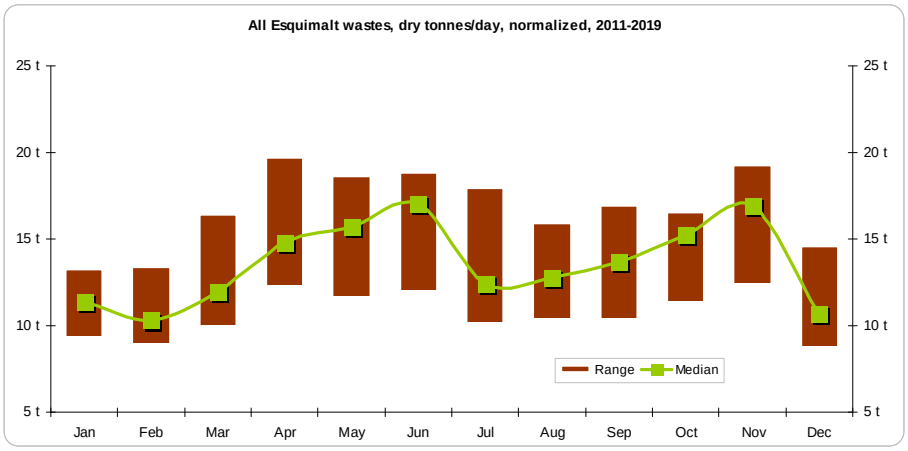

Figure 25: All Wastes, Dry Tonnes/Day

While haulers' interest is subject to further discussion once Council determines direction, their waste volume has been considered for scenario planning purposes and would be formally confirmed should Esquimalt proceed. We conclude that an IRM plant would benefit both haulers and taxpayers through reduced trucking, GHGs and cost-effectiveness, as well as improving resource recovery. Haulers are generally supportive and live in the communities they serve, so we do not feel that securing their waste will be a barrier.

4.3.4 Solid Waste Volume Projection

In planning major systems, a key consideration is how demand will grow over time. For current purposes we have adopted a 30 year projection "life cycle", although the equipment itself will have a 50 year design life with appropriate operating and maintenance costs (which has been included in life cycle projections). Since this is an extended duration and financing would likely be over a shorter duration, we chose to assess the first 30 years of the life cycle for projection purposes. The main question is how the volume of waste might grow over this term, which is primarily affected by:

- Increasing efforts to minimize waste and improve diversion, offset by increasing population. Other external factors such as senior government regulation and packaging changes will also change the nature of the waste, not just the volume;
- Waste volumes per person have fluctuated over time with CRD data likely embedding a higher portion of urban densification. CRD reports indicate 2018 Hartland waste volume

[30] Personal conversation between G Bethell and haulers, March and April, 2020.

at ≈388kg/person[31] up from 2016's 352kg/person but down from 426 kg/person in 2009 (Figure 21);

- Figure 18 shows that population growth has varied appreciably in Esquimalt, with higher rates of growth more recently. This wide range illustrates that projecting potential growth factors creates challenges (and impacts allowances needed for plant size).

We understand that the community is currently expected to reach a buildout at some point over the next ten to fifteen years, with an initial estimate of ≈25,000. While this will tend to limit potential growth in waste volume, aspects such as densification and/or increased home occupancy ratios might also cause maximum buildout projections to be exceeded. Conversely, recessionary factors or slow-down in naval base operations would extend the duration to achieve buildout or reduce growth. We thus ran scenarios independently of the buildout threshold, so the impact on plant sizing can be assessed.

Figure 18 shows a range of growth scenarios based on recent trends (0.3% to 1.7% per annum), estimated to 2053.[32] As it cannot be assumed that the waste per capita will remain fixed, several scenarios have been considered: (a) The Township's current collection volume excluding other sources; (b) the Township's waste plus collaborating known private sources; (c) CRD's 2009-2010 waste per capita and (c) CRD's 2016 waste per capita. A range of possible flows has to be taken into account in projecting plant size, shown in Figure 26.

Waste volume projections						30+3 yr projection
			Wet tonnes per annum		Dry tonnes per day	
			182kg/head	347kg/head		
Scenario	Growth	Popn	a) Township	b) Combined	a) Township	b) Combined
Current	0.0%/yr	18,716	3,398 t	6,498 t	5.7 t	12.1 t
1: Minimum	0.3%/yr	20,600	3,700 t	7,200 t	6.3 t	13.3 t
2: Moderate	1.0%/yr	25,700	4,700 t	8,800 t	7.8 t	16.6 t
3: High	1.7%/yr	32,100	5,800 t	11,100 t	9.8 t	20.7 t

Figure 26: Wet/Dry Volume Estimates[33]

Figure 26 estimates waste volumes with varying population growth scenarios[34] based on either (a) the Township's current waste collections; or (b) combined Township and privately hauled Esquimalt wastes. It indicates a minimum plant size using Esquimalt's *current* municipally-collected waste (estimated at ≈52% of the waste volume) at ≈3,400 wet tonnes per annum. Once private wastes are included and a minimum growth scenario calculated, scenarios range from a low of ≈7,200 tonnes/year to a high of ≈11,100 tonnes, albeit the more likely scenario is ≈8,800 tonnes per annum at the end of 30 years. Inclusion of private wastes while voluntary can be handled by contract and is a more complete solution, addressing the community's wastes, i.e. the most consistent in waste planning, climate change GHG reduction and landfill diversion.

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[31] 159,942 tonnes waste per Hartland 2018 landfill gas report (page 7); 412,220 population per CRD statistics.

[32] Allows for two year's preparation, one year's construction, 30 year life cycle.

[33] Projections are rounded. Detailed calculations were used by waste stream and may vary from the rounded totals.

[34] Figure 26 uses straight line compound growth projections, which in practice is unlikely to occur, but assists in developing a range of scenarios to understand the impact of varting growth rates.

An important aspect of Figure 26 is that growth happens slowly, so the initial plant size is likely to be manageable for some years before the plant's capacity has to be expanded. This affects budgeting and phasing as well as initial costs and risk, considered below.

Given the variability of waste volumes shown in Figure 24 through Figure 25, Figure 26 still represents an appreciable range, which increases risk because of uncertainties about population growth and waste reduction. However this risk can be almost entirely addressed using a risk-managed "just in time" approach:

- Gasifiers are scalable and units can be added relatively quickly (within 6-8 months, plus commissioning). This means that if, as and when the volume of waste grows, and/or as waste characteristics change, suitably configured gasifiers can be added and the plant adjusted or expanded.

- This "just in time" approach: (a) allows for technology adaptation and improvement; (b) avoids the need to pay a higher cost today, which would increase cost to current residents for a future need that is uncertain; (c) limits initial taxpayer investment and risk; (d) reduces resulting debt and operating costs until the need to spend more is proven; and, (e) allows system design to match waste characteristics available in the future, not the ones guessed today to potentially occur in the future.

Figure 27: Demonstration Test of Local Waste

In short a just-in-time approach allows for the plant to be sized as initially needed, then expanded as/when the need is proven and avoids building a plant for a volume that may not materialize. We have thus considered a phased just-in-time approach with allowance for future expansion and adaptability, discussed in section 5.

4.4 Feedstock Process

It is important to understand the gasification process as it impacts location, site use etc.

Waste streams available within the Township include: MSW; food scraps and source separated organics; yard and garden waste; and wood waste, including Construction & Demolition [C&D] materials. Recyclable materials, including metals, glass, plastics, paper/card board and related materials are separated into the Blue Box program and reused/recycled accordingly. Electronic wastes are also separately recycled along with white goods and appliances. Figure 15 illustrates gasifier potential feedstock and resource recovery options, but note that while some aspects are possible, they are not recommended. Advanced Gasification is able to handle a range of carbonic materials and Figure 15 shows the range of acceptable wastes and principal resource recovery options in bold. Figure 28 shows the general process for handling these waste feedstocks.

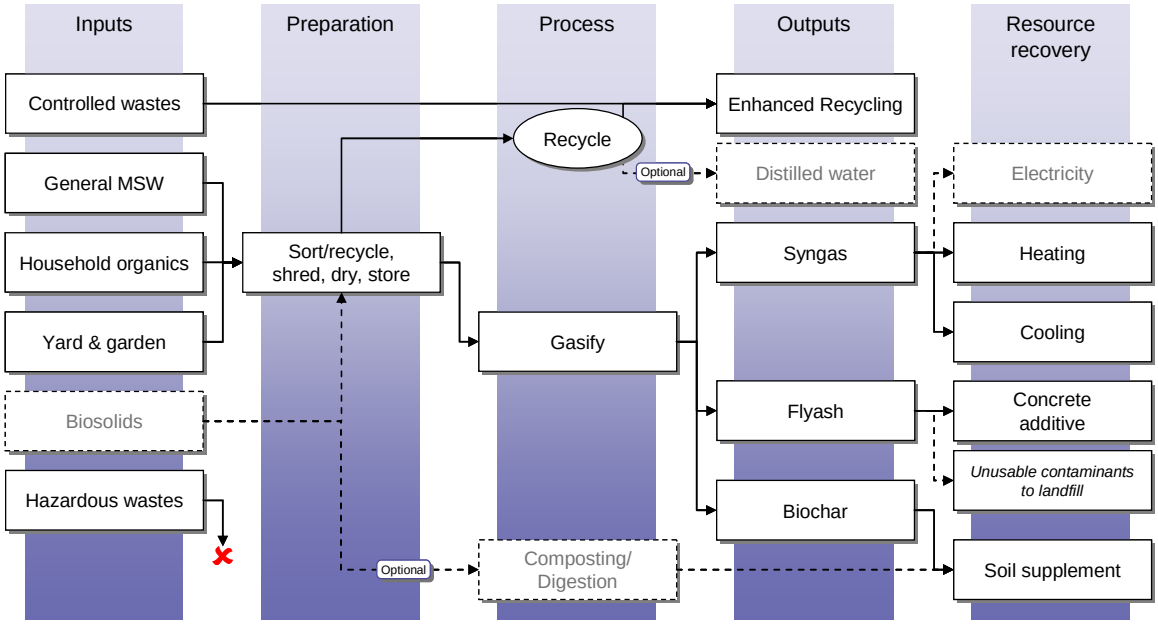

Figure 28: Gasification General Process

Laboratory testing has been previously undertaken of selected waste samples from Langford and Sooke, which is believed to be close to but not the same mixture as Esquimalt. An initial physical demonstration test has also been undertaken and independently observed as being satisfactory (Figure 27), i.e. the gasifier successfully processed the local MSW and biosolids. We recommend undertaking formal structured laboratory and physical tests however, as the fastest and least expensive way to confirm Esquimalt's proposed wastes will work. Formal tests are a minimum pre-requisite for a potential manufacturer's system guarantee and would be needed to confirm aspects such as biochar quality and potential – which would help resolve risk relating to one of the larger revenue sources.

It is helpful to explain how a guarantee would likely work. Firstly the manufacturer would contract with Esquimalt to deliver an agreed system design and energy yield, on which the business case is predicated. This would be determined by testing actual samples of the proposed wastes, both in a laboratory and in an existing gasifier. Funds would be bonded and held in trust and only released when the expected performance is achieved. In this way, Esquimalt taxpayers would be buffered from the risk of non-performance or under-performance. Certain advance funds – testing, design etc. would have to be expended but these are small relative to the cost of the system, covered by the guarantee. While the manufacturer would charge for this guarantee, the cost would likely be comparatively acceptable. Because testing includes samples of the actual proposed feedstocks, this sequenced approach provides physical recorded proof that the system works, before proceeding. This will quickly and very visually help address taxpayer and risk concerns.

The test shown in Figure 27 used locally-obtained MSW. It shows the gasifier can handle waste and modelling shows it can be viable and feasible. We note that on reviewing data provided for this study, we have not found issues that would cause a system not to operate successfully. Testing is thus a desirable and recommended next step. Base tests are likely to cost ≈$20-30,000, which secures proof of operation with actual waste, within weeks, at a fraction of the cost of a full system. Note that the cost and tests have to be confirmed depending on components required to reduce risk.

Recent international media coverage[35] of recyclables in the Philippines and Malaysia revealed that recycling was not happening as expected. For example as a result of this and given concerns over ocean plastics, CRD revisited the potential for plastics and Styrofoam to be handled locally. The RotoGasifier can handle these products, including compound materials where separation and recycling is not possible (either technically, practically or economically). The remaining household garbage consists primarily of dirty paper/cardboard, hard and film plastic, food and other organic material, leather, fabrics, shoes and other textiles, and related discarded materials. This general municipal refuse may contain small residual amounts of metal, glass and other inert materials which should ideally be removed for added recycling before the material is shredded, dried and placed into storage for processing through the gasifier.

Inert wastes that are missed during sorting and recycling will not affect the gasifier, as the materials will be expelled with the biochar. It is however better to sort and extract these items where feasible, to improve energy yield and increase recycling. Notably, this approach and the technology itself are resilient to improperly sorted wastes.

The Advanced Gasifier's rotating design helps eliminate the potential for ash fusion, which was a contributory reason to select the RotoGasifier as the best available technology. Ash fusion can lead to downtime while maintenance is undertaken. No other issues were found in the samples that would impact maximizing uptime through ongoing management and operating procedures will monitor feedstock in the event unexpected materials are included in the waste or other issues arise.[36]

Waste Type	Moisture content	Mineral ash content	Fusion Issues	Contaminants
MSW	25% - 35%	20% - 30%	No	Possible
Food scraps	60% - 80%	20% - 30%	No	No
Yard/Garden	50%	5% - 30%	No	No
Wood (C&D)	5% - 20%	5% - 7%	No	No

Figure 29: Composition Summary

Figure 29 summarizes the typical main composition of MSW, which can include chlorine and sulphur, which can form acid and sulphur dioxide (and ammonia if biosolids are gasified). This is managed with off-the-shelf standard in-line cleaning equipment, the need for which will be confirmed once testing and analysis has been completed. Besides the use of scrubbers, selective catalytic reduction systems and standard air emissions control equipment will be installed to remove particulates using an electrostatic precipitator (ESP) or coated bag filter system. Both have proven satisfactory on plants in Victoria and Europe for example.

Food scraps typically also contain napkins and other paper, cloth towels, plastic bags etc., and have a high water content and will likely require shredding and drying prior to gasification. Alternatively, there may be situations where they may only need to be mixed to be at or near the desired level of moisture content, or dried using heat from the oxidation heater. These adjustments are part of normal operating procedures.

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[35] See for example an overview video, a ≈20 minute CBC documentary video exposing this issue, or videos #1 or #2, showing repatriation of recyclables for incineration in Burnaby. Atlantic province clients report similar issues.

[36] In the event wastes exceed standards, yield would be reduced and not result in system failure.

Yard and garden waste primarily consists of pruned branches under 3 inch, shrubs, weeds, leaves and grass clippings (woody branches, weeds and shrubs will need to be chipped/shredded for gasification). Optionally this could be expanded to accept all woody material including tree trunks and large branches, which are suitable for the gasifier. The shredder/chipper can handle C&D waste wood which would be selectively sorted and processed in the IRM facility, i.e. the design can be adapted to allow for increased range and volume of wastes with little effort or cost, thus aiding increased diversion.

A key aspect of Yard & Garden waste is the highly cyclical nature of the wastes and volumes received in Spring and Fall, shown in Figure 24. Initial data did not show this but later data revealed fundamental differences in flow rates, causing the entire plant size, unit sizes, pricing and phasing to be recalculated. This item needs more review should IRM progress, but adequate assumptions have been possible for the current analysis to proceed.

A concern in terms of energy yield is moisture content. Typical moisture content of green wood is 40% - 45%, C&D wood 5% - 15% and the mineral ash content 5% - 7% and possible syngas contaminants from this are typically low. Pivotal staff managed the Dockside Green gasifier where particulate emissions were consistently below MoE permit requirements and we would expect a plant in Esquimalt to be similar. The plant will use energy recirculation and compatible dryers (used in drying sewage sludge and food scraps), specifically designed for energy recirculation and passing dryer air to the oxidation systems where volatile organics are mixed with syngas to improve energy yield and address odour.

In summary although more detailed assessment will be needed should IRM proceed further, we have not identified anything in the possible feedstock that is likely to cause significant issues for an Advanced Gasifier, or jeopardise achieving compliance with applicable regulations, or failing to meet the goals and expectations of the community financially or environmentally. Testing of the actual proposed wastes will be needed to confirm this but existing tests (Figure 27) have demonstrated successful operation.

5 IRM Assessment

This section outlines the IRM Options; assesses potential plant locations; proximity to possible consumers of recovered resources; the capital and operating costs including the viability of options; procurement models; and a possible implementation schedule. These factors were entered into a life cycle business case model that calculates the life cycle for 30 years [plus preparation and construction] for financial aspects and 150 years for GHGs. Inflation is also considered since this can have an appreciable impact. The general process used as a guide to assess IRM for Esquimalt is illustrated in Figure 2 on page 6.

Pivotal's IRM model is a "highest and best use and value" cash flow investment model, consistent with financial standards but adapted to use the same standards and approaches to address environmental and resource aspects.[37] The models allow for interactive assessment of options so financial, resource recovery and environmental impacts and cost/benefit can be compared and the best options chosen to maximize value over their life cycle. The assessment of resource recovery is thus dynamic and adjusted to address varying waste volumes, thus allowing the impact on Esquimalt residents to be assessed as assumptions are adjusted. Scenarios were then run to assess phasing and cost, and reduce risk. The following describes the inputs, assumptions, process and conclusions.

5.1 Main Scenarios

Based on the evaluation of population demographics and waste stream volumes and after discussion with staff, we assessed the following scenarios:

Scenario	Growth	a) Township	b) Combined
Current		3,398 t	6,498 t
1: Minimum	0.3%/yr	3,700 t	7,200 t
2: Moderate	1.0%/yr	4,700 t	8,800 t
3: High	1.7%/yr	5,800 t	11,100 t

Figure 30: Scenario Summary

Figure 30 summarizes a range of growth scenarios (1-3) in combination with either Township-only wastes (a) or combined Township and privately-hauled wastes (b). Further detail is provided on flow variations and scenarios in 6 *Findings*, starting on page 59. Given these potential flows, plant size was estimated, initial needs and expansion potential taken into account, with the following consideration of sites, phasing potential and budgets.

[37] The IRM model and approach is proprietary to Pivotal but has been independently reviewed and approved by multiple climate change, financial and accounting experts, including academics.

5.2 Location Options

Over the past few years, the primary site owned by the Township and suggested for consideration is the Public Works Yard at the northeast intersection of Canteen and Esquimalt Roads. An alternate site was also suggested in the lands adjacent to Archie Browning Sports Centre. Although other site options exist, these are the main current options, considered as follows:

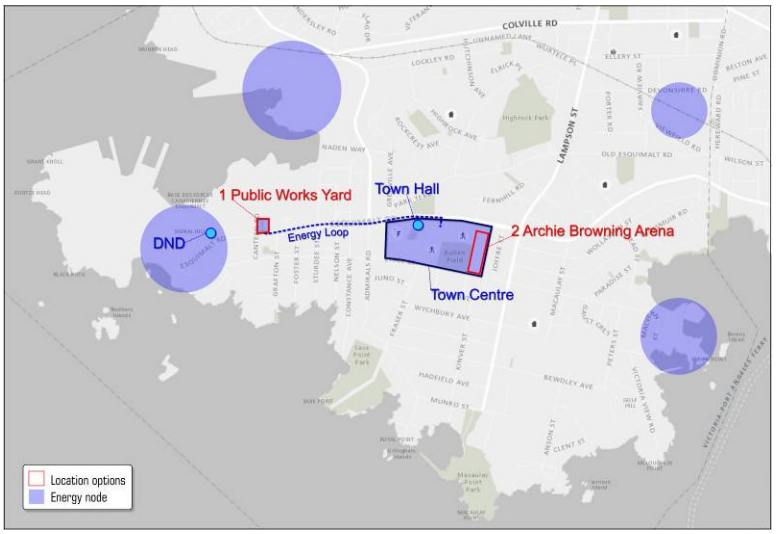


Figure 31: Possible Locations & DES

1. **Public Works Yard** – this small site on Canteen Road is already well used, but there should be sufficient space to accommodate a plant, with expansion potential and without requiring existing activities to be relocated, if planned carefully. Staff expressed concern about phasing on this site so an initial discussion of options is provided in section 5.2.1 *Phasing on page 41*. Subject to decisions over plant size, we are satisfied a plant can be suitably phased using the western portion of this site, with minimal impact to the main (upper) part of the site.

   The site is already zoned for similar use, but would need to be approved for a variation in zoning to permit energy generation. The location has reasonable proximity to users able to take advantage of the plant's recovered energy (for example Figure 31 illustrates a District Energy System alignment to serve the municipal centre). Given the gradual densification of the corridor between Canteen Road and the town centre, this is a suitable location with a loop commencing at the Public Works Yard, extending initially to the municipal centre and Archie Browning, then expanding as demand permits.

   The Township owns and controls the site and it already has a somewhat similar industrial use, so it is considered a potentially suitable option. The Public Works Yard activities do not need the energy an IRM plant would produce, so the energy will have to be delivered to nearby consumers using an energy loop.

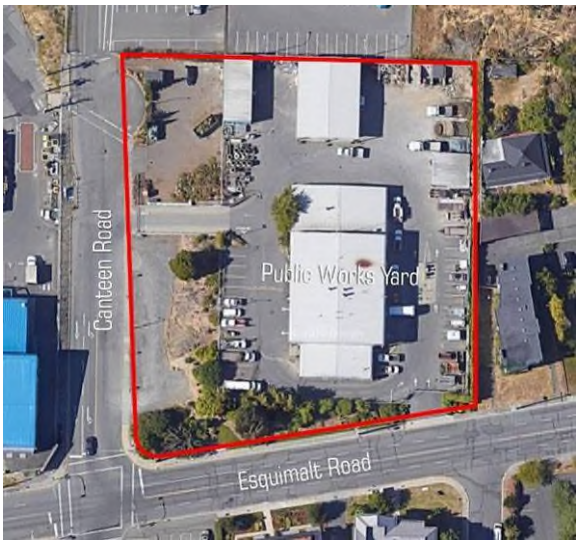


Figure 32: Public Works Yard[38]

2. **Archie Browning Sports Centre** – this is a potential energy consumer due to the

[38] Courtesy Google Maps.

Centre's high energy needs. It has potential land if much of the plant can be located underground, thus avoiding any reduction in the land use. The location could also serve the nearby municipal building, Esquimalt Recreation and Village Centres. The location marked "A" on Figure 33 is one alternative, as this could be completely shrouded from adjacent buildings, but some other locations and orientations are possible on this site too.

Some challenges exist however. Archie Browning Sports Centre is nearing the end of its life cycle and it is assumed will be redeveloped at some point, which due to phasing may see it relocated on the site. Since this has not commenced it cannot yet be determined how the gasifier could work with the Sport Centre or integration as part of the Recreation Centre. Access thus cannot yet be determined but would logically be from either Esquimalt, Fraser or Lyall Streets, however locating the plant and access, would likely be delayed until the broader planning is completed. This would make an IRM plant on this site dependent on planning for this centre, thus delaying implementation. Locating an IRM plant at this site would also likely be part-underground and/or with parking above, both raising costs and increasing servicing complexities and costs.

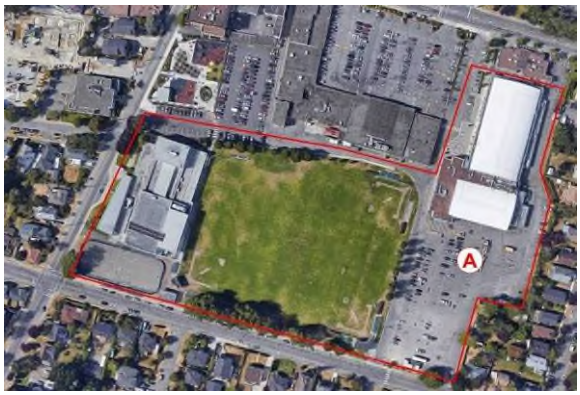


Figure 33: Archie Browning Site

5.2.1 Phasing, Access & Traffic

As the Public Works Yard might initially appear to be too small a site, it helps to show an existing plant located in White Castle, Georgia (Figure 48 on page 77), which has more than double the capacity estimated to be needed for Esquimalt, but on a similar footprint to that at the Public Works site, which should thus be suitable provided if it can be integrated with the Yard operations to accommodate truck unloading and turning manoeuvres.

Figure 34 illustrates some options using the Public Works Yard Canteen Road frontage to develop the IRM plant. Having the site on two levels creates both a difficulty and a possible advantage: the ramp needed to service the upper part of the site can be relocated or if required, retained. While design will be needed to confirm necessary detail, one option is to receive feedstocks from the upper level, which might mean allowing 2-3 trucks per day into this area. Alternatively it may be possible to receive trucks from Canteen Road, but this would likely increase costs. As illustrated in Figure 34, the "B" part of the site for example might contain the gasifier(s) and related energy systems, with the gasifiers on sleds, thus being removable directly onto Canteen Road for off-site maintenance or replacement.

As an alternative, Figure 35 shows moving buildings 1-3 to site 4, to create a single area for an IRM plant at the rear of the site which while not as large, is usable. Relocation of existing buildings would add cost – but may be desirable if this also improves the Public Works Yard's utility. In both options the systems would likely be at sub-grade level to mitigate appearance and access, allowing for decking overhead and two levels of operation. Existing staff parking can be located on parking structures built over the IRM plant – which would increase cost but may be expedient.

In summary there are several options for how the Canteen Road site might be utilised, subject to more detailed review and discussion. We note that the site has a significant rock outcrop, which will increase site preparation costs, but will be offset by reducing foundation costs to carry the main plant. An estimated allowance for this has been included in budgets.

Figure 25 is helpful in showing that current Township waste volumes could be addressed by two five tonne per day units, with a third for high waste volumes and as a backup or maintenance unit. Within a few years and as/when waste volumes grow, other units would be added. Figure 34 illustrates the approximate size estimated for multiple gasifiers on site "B" with associated service access. The 'sled' or container size that would likely be used similar to the gasifier shown in Figure 38 (or the central unit in Figure 47). This provides some sense of the comparatively small size of the units, their suitability and that it would be reasonably simple to add further units as and when needed.

In the long term future should waste volumes become excessive, site modifications prove impossible or excessively expensive, the Public Works site may become unsuitable. In that event it may be necessary to open a second site, or intensify use of the Public Works site, or relocate. Using gasifiers on removable sleds supports this flexibility and importantly, is consistent with a just-in-time service adaptation strategy, which lowers risk and initial cost.

In short, options exist to accommodate growth if and as required without the need to plan, build or budget for this from inception, in contrast to solutions such as anaerobic digestion, which requires major investment and reliance on projections that may never happen.

Traffic is a concern for all projects in Esquimalt and warrants consideration. In that regard and assuming the plant takes both Township and private wastes, the volume at the start of the project is estimated at ≈18 tonnes per day, which is currently collected by trucks already operating in the community (estimated at ≈2-3 truck visits to the IRM facility per day). This is anticipated to rise to

Figure 34: Public Works Yard Layout 1

Figure 35: Public Works Yard Layout 2

a maximum of ≈25 tonnes which will likely be supplied by the same ≈2-3 trucks per day at peak (they will have slightly bigger loads). *It is important to note that we do not currently expect this to increase truck traffic in Esquimalt*. These trucks are already collecting waste in the community but instead of going to Hartland Landfill, will make a much shorter trip to Canteen Road, thus reducing overall disturbance and GHGs by unloading at Canteen Road. At any given point near the site we anticipate that at maximum, residents might see trucks going to the plant for perhaps three 30 second intervals in total each way (arriving and departing), but spread over the entire day. Additional employee traffic is anticipated to be a maximum of perhaps 3-5 additional cars or bicycles over the span of the entire day, as existing Township employees would likely transfer to the IRM plant. While the final traffic impact will need review once plant capacity, private waste suppliers and staffing are confirmed, we currently expect no significant noticeable impact to surrounding buildings.

5.2.2 Site Conclusions

In conclusion, Archie Browning and Esquimalt Recreation Centre can be serviced from the Public Works site and while this would require a District Energy Loop, the Canteen Road site is simpler to service, more appropriately zoned and allows for phasing in other DES users, as and when opportunity permits. It is also simpler to expand and phase appropriately. We thus conclude Archie Browning is a secondary option but the preferred site and assumed herein for modelling purposes, is the Public Works Site. Other options exist if their consideration proves necessary however, and were discussed with staff, but these are not as controllable, are less accessible, have higher costs to make workable (and with greater difficulty) but importantly, would increase cost to deploy recovered resources. This does not necessarily rule them out as being viable or usable, but they are not as good as the above two options.

The Public Works Yard site on Canteen Road is owned and controlled by the community and is in a location with compatible uses, but it is also likely to be the most acceptable from a traffic and servicing perspective. Although there is residential property adjacent to the east, these are unlikely to see, hear or smell the plant as they will be buffered by the existing buildings (and the gasifier would not create odour, noise or emissions).

The Canteen Road site suitability will require confirmation following preliminary plant layout and design stage and as planning progresses through detailed assessment, public engagement, regulatory approvals, financing and Council's decision. As the site is owned by the Township, we have excluded land cost. Should either of these sites not be acceptable, we conclude that other sites are likely to be possible, but would need additional work to confirm. Non-owned sites will increase plant costs.

5.3 Costs

Capital costs

Capital costs have been assessed for plant development with budgets obtained from suppliers for major plant and equipment components. This includes costs for items such as shipping, staffing, supplies, insurance etc. Basic allowances were included for enclosures, which should be reviewed once the plant size and location have been determined, but we anticipate savings may be possible through co-location at the Public Works Site. These will be offset to some extent by additional site preparation costs (rock

removal and stabilisation, parking accommodation etc.).

Most of the main plant can be fabricated locally to address possible issues with exchange and import duty, which are currently somewhat in flux. We have previously met with qualified BC fabricators for the gasifier – whose bids have been competitive for other plant fabrication – to confirm quality and timeliness of delivery, as this is the largest single component. Other fabricators exist experienced making TSI's plants in Alberta and Quebec. Budgets were developed for this project based on the main plant scenarios.

Because feedstock laboratory and physical testing has not yet been undertaken, some uncertainty exists about the equipment needed to prepare the feedstock, storage, emissions control, chemicals management etc. Standard assumptions have been included in the capital and operating budgets. We do not currently expect any extraordinary costs but the budget should be reviewed once plant size is confirmed, testing has been completed and the system design confirmed, as this would alter overall system pricing.

Soft costs and fees

The initial capital cost mainly relates to preparation, impact assessments, permits, design and implementation planning, regulatory and other aspects. Regulatory agencies were approached to confirm process which for the most part relates to emissions monitoring. Costs and timing for these aspects were included in the model, for municipal processes, licensing and associated fees.

Contingency & inflation

Contingencies were set at 20% for the planning and preparation period as this is where extra time and cost typically occurs. Following discussion with major suppliers, a 15% contingency has been used for construction and associated soft costs. We assumed the highest additional margin indicated to us (cost plus 15% on all capital costs) rather than quoting costs as "cost ±15%" which is a common practice. This is conservative and means that (in Scenario 2b for example) the budget total is under $19m ±15%, but $21.3m has been used to test viability.

BC's long term inflation rate was used for inflation-adjusted models and run in parallel to current cost models so the impact of inflation could be assessed. Inflation can have an appreciable impact on life cycle value. Values quoted are thus the amounts that would be expected to be received, adjusted for inflation.

Finance

The interest rate applicable to debt depends greatly on the procurement approach. The lowest rate can be obtained by the Township owning and operating the plant, but this can add risk if not carefully managed. The highest cost of debt is likely to be for a private provider absorbing the risk with minimal taxpayer-backed guarantees. We assessed the cost of finance under varying scenarios and included this in the model. The implications are considered in the *Risk & Procurement* section.

We model IRM using both cash flow and DCF models to allow comparison. As the debt finance rate is a reflection of the risk of a project, and the cash flows include it, risk is included in the finance rate. DCF calculations

exclude debt, so the discount rate reflects risk in DCFs. An alternative cost of money approach was used in selecting the discount rate, assuming that the community has taken reasonable steps to reduce risk whether the project is community-owned or implemented with alternate procurement.

Operating & maintenance costs

Experience with staffing for gasifiers in Victoria, the USA and Europe were used to develop basic staffing models. Private haulers have been canvassed and provided comment on staffing and waste processing requirements. Operating and maintenance costs were projected based on industry standards for a project of this type and projected for the life cycle. Note that existing staff may choose to transfer and potentially upgrade skills, which in combination with other possible savings (such as GHG reduction costs, GHG taxes, etc.), we estimate should reduce Township budgets by ≈$4-500,000 annually but has not been taken assumed in the models, i.e. we expect there will be further savings. O&M budgets vary depending on the scenario used and are included as line 02 in Figure 30.

5.4 Revenues

IRM systems have multiple potential outputs which are saleable and the revenues are used to partially or fully offset system costs. The main revenues include:

- **Electricity**. Currently, BC Hydro is not actively pursuing new sustainable energy contracts because the province is a net exporter of electricity, but electricity generation can be added later, should circumstances change and BC Hydro express interest in supporting sustainable local power generation. Note that we have modelled electricity viability and conclude it is a marginal financial and environmental benefit, largely due to high costs of compliance with BC Hydro requirements, extended process and contract, increased risk and a low feed-in tariff. This may change if local generation rises in priority, for example to avoid expenses in funding additional transmission lines.

  Since BC's electrical generation is dominantly hydro-electric, the potential CO_2e reduction from sustainable electrical energy is not high, except in displacing air conditioning, which can also be achieved with a DEL. We have thus excluded electricity from the planned model at this point.

	Heat	Power
Thermal	3.23mw/tonne	—-
Thermal & electrical	2.26mw/tonne	0.73mw/tonne

Figure 36: Yield Per Dry Tonne of Waste

- **Heating and cooling**. Gasification generates substantial amounts of heat and by using absorption chiller systems can produce cooling, which means that gasification can displace both natural gas and electricity. On average, Canada uses fossil fuels for an appreciable portion of its thermal needs and the lifecycle GHG intensity of natural gas is 0.252tCO_2e /MWht whereas electricity's lifecycle GHG intensity is 0.071tCO_2e /MWht.[39]

  Natural gas typically costs in the range of $2-2.50/GJ (adjusted for efficiency to $3/GJ), but government is pressing suppliers to achieve increasing percentages of "Renewable

[39] GHGenius model v4.03 and Government of Canada 2018 National GHG Inventory.

Natural Gas" (RNG) to displace fossil-based methane. The syngas produced by RotoGasification is not directly usable as natural gas and so has historically not qualified as being renewable, however this appears to now be changing where syngas displaces natural gas. In the case of the proposed Esquimalt plant, syngas would displace natural gas for heating.

While confirmation will be required from the BC Utilities Commission (BCUC), we have discussed with Fortis and other utilities the potential for output to in effect, qualify as RNG, which is achieving prices of $20-30/GJ, so we have thus adopted a value of $20/GJ in modelling and assessed the implications in initial sensitivity models. Cooling is priced equivalent to the cost of electricity so for modelling purposes we have adopted $0.11/kwh. The ≈1km DES cost has been estimated and included as part of the system capex and the IRM model includes adjustment for conversion losses etc.

- **Water**. The largest single element of solid waste is in fact water but this is almost never reported. Kitchen scraps, yard and garden waste can contain as much as 70% moisture, i.e. only 30% is the dry component that creates energy. This is why incineration of waste is expensive, since combustion of waste requires it to be as dry as possible. By contrast Advanced Gasifiers work best with a moisture content of 20-25%, but can tolerate up to 50% moisture content, making them ideal for managing both liquid waste residuals and solid waste. In addition water (H_2O) when gasified, separates into hydrogen and oxygen, which the gasifier turns into hydrogen and carbon monoxide, the main components of syngas. Recycled heat is used to dry waste to the requisite level, with the water condensed as a bi-product, which has the potential to be filtered and reused as distilled water. In the IRM models we ran, we calculate up to 3.2 million litres of water may be generated and potentially reused annually as distilled water.

  Capital Regional District has an efficient potable water system with ample clean water supply at extremely low cost. Filtering water recovered from gasification for possible use and sale would thus add cost and not be competitive, net of revenues from sales. Therefore while the option exists to add filtration and bottle the water as distilled water, it would currently increase taxpayer cost to recover and sell water. We have thus assumed this will not currently be pursued, but can be explored and added in subsequent years if circumstances change and there is viable demand. The distilled water from gasification will be cleaned and discharged to storm sewers, or possibly to the main sewer. This decision can only be made once the volume is determined and wastes tested.

- **Carbon Credits**. Gasification of municipal waste has the potential to significantly reduce carbon emissions and is a verifiable offset able to be sold on carbon markets. Federal government has been pushing for a move towards carbon tax of $50/t$CO_2$e, by 2022 but this is not the level of revenues that might be achieved from sale of credits. The question thus arises as to the level that credits might achieve in the long term. If sale of heating is confirmed under BCUC regulations, the CO_2e benefit would not be available, which has been assessed as part of modelling.

  In emerging markets, long term values are difficult to predict and because carbon credits sell essentially to brokers, an allowance has to be made for profit margin. For modelling purposes we estimated half the expected value of carbon tax, then canvassed opinions from carbon sector professionals. They confirmed this as being reasonable. A rate of $25/t$CO_2$e has thus been applied which in reality, is likely to prove conservative as climate action strengthens.

- **Tipping fees**. Esquimalt collects waste from dominantly single family homes and charges based on cost recovery for this service. We calculate (Figure 22) the Township's total costs including haulage and disposal total on average approximately $191.81/tonne, although components are up to $277.50/tonne. As noted in s.4.3.2 (page 29), staff confirm that the Township does not collect all waste in Esquimalt and our research identified an additional 3,100 tonnes, which implies the total waste generated in Esquimalt may be in the order of 6,498 wet tonnes in 2019.

  There are thus two main initial plant options: a first that addresses solely the volume collected by the Township; and a larger volume that includes other Esquimalt waste volumes. Both would need Council and community support but the larger plant would be consistent with the need to plan for all the community's wastes. Both smaller and larger plant capacity options have been assessed.

  Regarding collection costs and to provide context, tipping fees at Hartland are currently $120/tonne for food waste, $59/tonne for yard waste, and $110/tonne for mixed MSW, which excludes the cost of collection and haulage. We used $75/tonne as a volume-adjusted average for food, yard and garden waste and $110/tonne for sorted MSW in modelling. This excludes haulage costs since these are needed to support collection and delivery of wastes to the plant, but which should be able to drop slightly, given that a local IRM plant should reduce or avoid trips to Hartland.

  While total revenues vary depending on plant size, it helps to provide context to this item. Tipping fees have historically risen roughly in line with inflation so this revenue is considered to have low risk. Tipping fee revenues are important in that where the plant is sized to cope with the full community waste, the tipping fees approach the cost of financing the plant. Since ≈52% of the tipping fees is controlled by the Township and ≈48% can be pre-contracted, this risk can be reduced before the project is committed.

Figure 37: Biochar Output & Testing

- **Biochar**. Biochar represents an appreciable portion of the potential revenues from gasification and as it may be unfamiliar, greater detail is provided on this aspect.

  Most people will be familiar with biochar as charcoal for barbecues, which is usually wood, heated so the volatile organic compounds turn into gas and the residual is a crystalline carbon char, usually black and in lumps or powdery and containing minerals. Biochar is where the source is biogenic in nature and since waste is

mostly biogenic (typically >88%), gasification of waste can create a biochar. It can be used as a sterile soil amendment for rehabilitation or stabilisation, or as a soil supplement. At the higher end, biochar may also be familiar as "activated charcoal filters", used for air filtration in the medical, laboratory and other sectors. Lower quality filters also use it, for example in pool and aquarium installations. Figure 50 provides a list of biochar uses, which are increasing because the carbon lattice structure retains organics, fertilizer, water and minerals, which are beneficial for restoring soils, improved plant growth etc.

Because it is sterile and retains minerals, biochar can essentially act as a fertilizer and subject to testing, should be able to exceed requirements for local land application, if this is desired. Figure 37 shows biochar output with weather testing. It can also be fabricated as a briquette (Figure 52), but an important benefit is its ability to maintain its structure and retain water, microbes and fertilizers.

Values for biochar have generally risen, linked to the biochar market and quality. Pivotal's research of retail biochar prices from late 2019 shows a range of retail prices, with the highest quality activated carbon filtration as high as US$48,000 per tonne.

Without testing and certification, values of biochar from waste are difficult to predict and likely to achieve lower levels of value. West Biofuels currently sell untested bulk biochar from RotoGasifier tests in California to a local municipal parks department, for use as a soil amendment, at US$750/tonne. Biochar used as a soil supplement is typically in the range of US$4,000 and higher retail. Following consultation with industry advisers in the US, we used US$2,000/tonne in modelling to test the sensitivity of the financial model.

Biochar has an element that commentators believe is increasingly likely to raise biochar's profile and value in the future. Independent studies have concluded that biochar sequesters carbon when used as a soil additive and the tCO_2e of biochar is 2.9336 times the weight. This means that with for food scraps for example, 100 "wet" tonnes would generate about 12 dry tonnes of biochar, which has a carbon sequestration potential of ≈35 tonnes CO_2e. While the amount sequestered varies depending on the nature of the waste, sequestration is gaining attention as a way to reduce atmospheric carbon but is not fully reflected in carbon credits or other revenues, which is currently the only financial value attached to sequestration. The intangible value of sequestration is increasingly substantial.

Because biochar is one of the more important contributors to the business case, and the exact amount of biochar can only be determined by testing and certification, we have recommended early testing so the value and sequestration potential are confirmed and pre-contracted before proceeding much further. Assessment of test results from biochar experts has been engaged but more will be required and as testing opens the potential for a system and yield guarantee, it is a recommended, fast and simple risk mitigation step.

5.5 Intangible Benefits

Over and above the tangible benefits of developing an IRM gasification system in Esquimalt there are numerous potential intangible benefits that will stimulate economic development and

prove to have benefits over and above the economics. The following list outlines some of the potential benefits likely to be achieved by the Township:

- The evidence of similar examples in Europe is that projects of this nature produce attention nationally and internationally, due to the linkage of financial and environmental leadership. An EU example resulted in demand for education and training, tourism, and partnerships from like minded business leaders, new commercial locations and hotels. We thus expect a multiplier effect where other business is generated because of the commitment to sustainability an IRM plant demonstrates. An example in Austria generated a 35% boost to a small rural community over a 5-10 year period after years of the community declining in commerce and size.

- We expect there to a local re-spending effect, where investment in local infrastructure and employment reduces payments to outside communities, and is replaced by retaining expenditures within the community. Examples of these include cessation of landfill spending, cessation of energy payments (heating, cooling) to external companies, and improved revenues from sale of biochar reducing taxpayer costs, allowing taxpayers to spend the financial benefit locally.

- External direct full-time jobs will likely be created in addition to the employees currently with the Township. Some employment will be technical but others will be more unskilled, thus providing broader employment opportunities. We also anticipate indirect service and support employment, the extent of which is difficult to quantify but unlikely to be large.

- There is an advantage for other BC and Canadian communities to understand how Esquimalt achieved and exceeded carbon neutrality on operations at negligible difference in cost, including sequestering carbon. In Europe this has generated eco-tourism and eco-training opportunities, increasing media coverage of the community. This creates media and recognition benefits without media expenditures and a positive association of the community with sustainable direction. As sequestration is a key international goal, this aspect is likely to gain the Township considerable and broad media coverage, with positive connotations.

- As noted previously, emissions from gasification are expected to be equivalent to a natural gas flue and are ≈88% atmospheric, i.e. not from fossil sources.

- A final relevant benefit for the region relates to Hartland Landfill. Assuming the recommended option is implemented in Esquimalt and then adopted across the region, there would be appreciable landfill diversion, which is projected to hit capacity by 2045. An Esquimalt IRM plant would only extend this life by approximately two years but if IRM is broadly adopted, the landfill's utility would be extended until at least 2186. We have not priced this benefit in financial or environmental terms, but it would be very considerable indeed.

5.5.1 Broader Carbon & Energy Reduction

IRM was in part conceived to reduce GHGs, which is a community objective. Should the decision be made to implement IRM, the plant will use an energy loop to distribute recovered energy to consumers, most likely in the vicinity of the municipal core and recreation centre – originally assessed by KWL. In that event, planning should include a review of facilities to

assess how to reduce their energy needs, which would permit the recovered sustainable energy to supply more buildings, thereby further reducing those buildings' carbon footprint and their energy costs. This is how IRM has been implemented in Sweden for example.

Our energy engineering advisor's review of the potential concluded that Esquimalt will benefit from a strategic Net Zero assessment to understand how to both reduce energy costs and carbon costs and also, how to phase in a District Energy Loop as part of a DES. This will benefit even if IRM is not pursued, because it is expected to support carbon reduction and reduce energy costs. Without this assessment, the DES will be planned based on existing energy demand, which will miss the potential to maximize both carbon and cost reduction. Most of this benefit will accrue to the Township, but we expect would also benefit other buildings and owners, and is thus recommended.

5.6 Risk & Procurement

Simple changes to how IRM might be procured could almost eliminate the cost, and/or near-eliminate the risk. Risk and Procurement are thus extremely important issues.

Many communities have common approaches to service delivery and use basic ways to obtain services. While self-supply and taxpayer funding of services may often be preferred, it has implications that should be carefully compared with other options. An introductory discussion of risk and procurement follows but a follow-up workshop is highly recommended.

5.6.1 Risk

We were asked to provide a preliminary comment on the main risks. While not a full risk assessment, it is intended to provide a preliminary grasp of the main aspects, their probability, impact potential and resolution options. There are a number of risks specific to projects of this nature worthy of note.

Item	Comment
Technology & operating risk	Almost all systems used in the waste sector have some form of technology risk, some being more widely known than others. The question is whether the risk/benefit ratio of pursuing an IRM direction makes the systems worthwhile; what alternatives exist; and whether the risks of the technologies are reasonable and can be managed. IRM uses more advanced technologies with fewer existing precedents in the way that Esquimalt intends to operate. This represents potential risk. However as shown by the technology review, other options to address waste have proven either incomplete, expensive, or fail to achieve environmental or resource recovery objectives and many have their own significant risks. While IRM has technology risk, the waste sector has few simple solutions, which is why innovation is needed with direct effort required to manage them. The issue for Esquimalt is therefore whether the risk represented by gasification is acceptable, given the alternatives and options for managing the risk.

Item	Comment

Firstly some studies suggest there are no gasifiers operating with MSW, which is incorrect. Internationally there are a significant number of gasifiers handling municipal wastes, with considerable operating track record. We have reviewed information on over 90 gasification plants operating in Europe and Asia processing MSW, scraps and biosolids with an equivalent total of more than 1,000 years' operation and more certainly exist operating successfully, processing MSW or MSW components. This is because gasifiers work with any carbonic material and do not treat MSW's carbonic feedstock differently.

Secondly, the risk can be managed either through running physical samples of the waste through a test unit in California, or by purchasing a small mobile unit (similar to that shown in Figure 38) for extended on-site tests.

Thirdly, the risk can be managed through guarantees. These would ensure handover and payment only occurs when the systems are achieving stable yields equal to those in the business case. Long term operating risk is partly a function of technology, but mostly down to the operator. This risk can also be offset through offsite monitoring. Combined, these insulate taxpayers from technical risk.

Lastly initial demonstration tests have been successful using local wastes and prove the systems work (Figure 27). The tests were independently observed and separate laboratory tests also confirmed suitability.

Figure 38: Mobile RotoGasifier Unit

The main technology selected is Advanced Rotary Gasification (RotoGasifier) manufactured by TSI Inc. of Washington State. The company was established in the 1990's with a long track record of successful operations and plants at multiple scales, including the world's largest gasifier pellet plant (Figure 47). Construction companies and operators with balance sheets exceeding C$20bn are prepared to underwrite the system and provide a full wrap (i.e. a guarantee). The fact that large companies with substantial funds are prepared to underwrite the gasifier provides assurance that the system works.

Should there be any concern about the technology after formal laboratory and physical tests, it may be possible to test the recommended system with an initial 5 tonne removable sled unit (similar to Figure 38). This should provide comfort with the system's capability and resolve any remaining questions about technology risk.

Item	Comment
	In summary while the probability of technology risk is high with all systems – not just Advanced Gasification - the impact is considered low/minimal (i.e. underperformance until corrected) and the ability to mitigate is high. Technology risk should not be a reason to reject the approach.
Feedstock risk	Esquimalt's feedstock characteristics have varied over the past ten years and can be expected to continue to vary. Any approach to managing waste must thus be adaptable to changes and resilient to feedstock fluctuations. Even though the plant is a multi-fuel system, this can be a challenge because waste quality will be managed by operators, not system manufacturers, making it difficult for them to guarantee systems. The community will want to dispose of waste but often lacks the diligence to separate wastes correctly, which places higher emphasis on ongoing management. Feedstock risk thus needs careful consideration. Historically landfills have been used and easily handle waste fluctuations, but these result in leachate, odour and rising GHGs, and fail to capture energy except at high additional cost and have significant residual post-closure costs and environmental challenges, which are rarely included in the cost during their operating life cycle. New technologies based on biological systems do a better job of capturing energy and avoiding environmental risk, but are susceptible to fluctuation (e.g. anaerobic digestion is sensitive) and have a high life cycle cost and thus, risk. Biological systems also have a limited band of wastes they can manage and are a less complete solution than gasification (noted in Figure 7). Feedstock variation is a less important risk for the Advanced RotoGasifier, which is a thermochemical and physical process. This provides a greater degree of control and certainty and the systems can be adjusted to manage changes in feedstock within broad operating limits. While the above should be sufficient to address technology risk, all technologies are susceptible to changes in feedstock, which is outside the technology supplier's control. A sample of waste from Langford, similar to Esquimalt's waste, has been tested by TSI and confirmed suitable for gasification. A demonstration test was also run (Figure 27), but has not yet been run for an extended duration, i.e. the system is expected to work, and has physically worked with similar wastes, but further testing is desirable. The system will be designed to handle a specific type of waste, with pre-specified tolerance. Ongoing effort will be needed to ensure the waste falls within the specifications, so this is considered a manageable risk but not without cost and process. Much of this can be addressed prior to substantial investment and commitment through testing.
Contract risk	There are multiple types of contract risk, the following considers some of the more distinctive risks only. Construction risks are common for capital projects with known mitigation strategies (insurance, bonding etc.) and

Item	Comment
	should be considered separately. The Township has some control of current waste collection services but this is not mandated by law and cessation is a potential risk. While the Environmental Management Act provides for the Minister to direct waste in a jurisdiction to be processed in a specific way, this has been declined for other communities such as Metro Vancouver, the issue being that doing so essentially expropriates a personal chattel. Private haulers expressed interest entering into long term contracts to deliver the waste. These contracts may also be at risk. This is managed by the system being sufficiently competitive to ensure that it can retain contracted haulers or if these fail, their replacements. This will be more challenging initially so care has been taken to assess the initial financial performance. While the taxpayer may be the 'underwriter of last resort' to the risk, most scenarios show that revenues should generate sufficient margin to avoid requiring subsidy. Other unique contract risks likely relate to long term systems maintenance, which has been raised with suppliers and can be managed through intellectual rights/permits, plans and licences in the event of supplier failure. Standard contract risks (such as construction) are typical for projects of this type and can be managed through appointing a General Contractor. Three qualified contractors are interested in taking this risk as a full wrap with this specific technology, two locally and one nationally, although more are likely to exist. This is positive as one in particular is familiar with the systems and suppliers and will guarantee them, with >C$10bn book value, i.e. substantial capability.
Cost/revenue risk	Revenue risks exist and are potentially significant, but most are considered low probability and manageable as they can be largely pre-contracted. Tipping fee risk can be contracted with haulers or is controlled by the Township. Biochar risk is the single largest risk so extra information on this component has been provided. Discussions with sector experts and gasifier experience is that this risk can be mitigated by testing samples and pre-contracting (see *Revenues* on page 45 and *Appendix 3:Biochar* on page 78 for more information). In terms of pricing, we re-checked with sector advisors to confirm potential and selected a sale price in the mid- to upper-end of the range for low grade soil supplements, knowing it should be feasible to exceed this price with good management, i.e. this risk is moderate as the price chosen is conservative. The volume output is also comparatively small, making it less risky to address. Biochar is an emerging market and currently prices are rising, but the long term growth risk of this revenue is not known. We tested the sensitivity of the IRM model to changes in biochar

Item	Comment
	revenues and mitigated this risk by ignoring growth potential for this item, beyond normal inflation. Revenues from heating and cooling can be contracted with community assets but recently, Fortis has indicated that it considers syngas to be equivalent to Renewable Natural Gas, making it eligible for RNG tariffs. We have a general LOI with Fortis for RNG production and have confirmed pricing potential with a major utility that has committed above the rates used. This price will require BC Utilities Commission ratification, but is logically being treated as RNG given that it replaces the need for natural gas and is from sustainable sources considered to be atmospheric carbon, and already complies with the sustainable electrical generation requirements. The value used in models represents a one third reduction from the maximum RNG rate indicated to us, i.e. is considered conservative, to manage risk. The risk of tipping fees and energy price reducing over time is considered low. This is as distinct from feedstock risk, discussed above. Cost risk was managed by obtaining budgets from providers and added appropriate contingencies however, until testing is undertaken and the feedstock and plant size confirmed, budgets should be regarded as preliminary but reasonable for current purposes. Enquiries were made to confirm debt and refinance rates under a range of possible procurement scenarios but the probability and impact of these is low. In summary revenue risk probability is initially high but addressed through pre-contracting, i.e., making it manageable. In the long term, contracts will require management and renewal, so this risk is considered low/moderate but manageable. Impact of both is likely to be limited to short term financial underperformance that is manageable. Initial cost risk is considered low in probability and impact given allowances in the model and will be addressed through underwritten performance-oriented fixed contracts. Long term cost risk exists and has been allowed for in modelling; impact is likely reduced financial performance.
Regulatory risk	While enquiries with the Ministry of the Environment indicate the Township should have authority to implement a system and the process to comply with environmental regulations is considered feasible, this requires confirming. As it should be feasible to mitigate this risk at low cost, but the risk is a pass/fail impediment, we recommend resolution of the ability to proceed first. Compliance is then a stringent but normal and manageable process. Environmental and other regulations could change, which is a concern for any private sector company or investor contemplating a project of this type. This affects emissions, aspects such as mandated recycling processes, and more. Typically existing permitted systems are either grandfathered or additional equipment added to provide compliance. RotoGasifier air emissions are

Item	Comment
	similar to that of high efficiency natural gas boilers, and particulates are handled through the Best Available Control Technology (BACT), so these risks can be pre-managed prior to commitment and managed continually. The risk is considered to have low long term impact and to be manageable. Community permitting is known to the Township and in its control. Planning and zoning risk require community participation but prior efforts (West Shore Innovation Days etc.) all indicate support. This risk is considered manageable. Over time community support could change, in which case the plant could be dismantled and moved, but this risk is considered low and manageable with reasonable cost to mitigate if it occurs. Regulatory risk may exist with BCUC approval for RNG, but would also occur if the plant moved into electrical generation. As this is a normal and understood process and associated risk, it exists but is considered low. While the probability of regulatory risk is considered low/moderate, it is manageable through grandfathering so the overall impact is considered low.

In summary, risks exist and in projects of this type are to be expected. The largest risk – technology performance matching the business case – can be offset using suitable procurement management. Most other risks can be mitigated before making final commitment to proceed. We do not consider any risks identified to date to be insuperable.

5.6.2 Procurement Through Delegated Management

One option for Esquimalt is that waste management is delegated to CRD. The advantage to this is that it would reduce complexity for Esquimalt, albeit with the associated risks and costs. Esquimalt would be reliant on CRD's planning and management and their solution, which Esquimalt taxpayers would pay for, but have less control of. Staff thus asked us to comment on this aspect.

The first consideration is how CRD plan to proceed with managing waste. In 2018 CRD issued an expression of interest for respondents to provide proposals to handle organics and residuals, but to date this call has not proceeded. As it was an expression of interest the responses were not firm proposals, so the cost is unknown and timescale uncertain. We have been advised that CRD are now considering using anaerobic digestion, which would cope with Esquimalt's organics but not other wastes. As noted earlier, digestion would leave ≈63.5% of Esquimalt's solid waste stream unaddressed whereas gasification should cope with all solid wastes. To fully compare the cost to Esquimalt taxpayers of using CRD's digestion approach with gasification, we would need to add CRD's cost of addressing the remaining ≈63.5% of Esquimalt's waste stream (per Figure 7), which raises the question of the planned other solutions to waste management.

CRD commenced public engagement to prepare a new solid waste management plan in 2019, which can typically take several years to complete and approve, so it does not currently have a plan or budget for the remaining 63.5% of solid wastes. This prevents us estimating the cost, timescale or environmental benefit of CRD's direction with an IRM plan for Esquimalt,

however digestion requires lifetime taxpayer financial support, which gasification avoids, so on this item alone, CRD's direction is expected to be more expensive.

This report concludes that appreciable GHG reductions are possible from gasification and an IRM approach – significantly exceeding the Township's corporate emissions and making an appreciable contribution to overall community GHG reduction. For the aspects of CRD's direction confirmed to date, we could not find an assessment of the GHG potential of anaerobic digestion (from when the CRD Liquid Waste Management project's business case was approved). While we cannot calculate this impact, the reduced energy capture of digestion compared to gasification means there is reduced ability to offset fossil fuels, and Hartland's location makes it difficult to deploy these benefits, so we expect at least on this aspect, that the environmental benefits of the known direction will be less than an IRM approach with a gasifier in Esquimalt. Should CRD maximize GHG reduction, this would be shared with other communities and the proportion shared with Esquimalt is not known.

It will be operationally simpler for Esquimalt to assign responsibility to CRD and it would reduce direct risk, but not avoid it. This risk would be handled by CRD and proportionately charged to Esquimalt taxpayers. Since this study concludes that implementing an IRM solution in Esquimalt could yield a financial and environmental dividend, devolving responsibility to CRD would probably reduce these potential dividends and benefits accruing solely to Esquimalt taxpayers – assuming CRD adopted them, which as noted above with CRD declining to pursue IRM (or the provincial direction, IRR), currently appears unlikely.

CRD's current known direction thus suggests it may be more expensive and less environmentally positive to delegate waste management to CRD than to have an IRM plant in Esquimalt. CRD could nevertheless revert to an IRM approach, in which case this aspect can be reviewed once CRD's plans and costs are firmer.

The main issue the Township will wish to consider is whether in overall terms, the potential financial and environmental benefits of an IRM approach are outweighed by the cost, risk and responsibility of setting up an IRM plant, and whether IRM is within Esquimalt's capacity and capability. While CRD is one way of addressing these issues, another is whether the costs and risks could be addressed by outsource contracting to companies with the technical and financial capacity to handle them. Initial enquiries (and the financial analysis) confirmed the potential for outsourcing with qualified companies, discussed below.

5.6.3 Alternate Procurement

In 1998 the NDP government at that time committed to using Public-Private Partnerships (P3's) with the objective of reducing capital debt, risk and costs, shifting procurement to a governance position where the direction, quality and performance criteria under which a service is delivered, whether by contract (with government ownership – the traditional mechanism) or some form of outsourcing. There are many variants to how such contracts can be structured and services delivered.

Two specific factors cause problems with standard procurement for IRM: (a) a lack of expertise in the consulting sector knowledgeable, experienced, qualified and competent with gasification; and, (b) very few technologies qualified and able to meet Esquimalt's needs, with typically few or no prior evidence of the exact wastes Esquimalt needs to process. This means quality advisory support for Advanced Gasification and IRM is low, making proposal

calls difficult to draft, review, rate and rank; and the technologies wanted are difficult to attract. Private sector providers are in consequence hesitant to bid – they lose confidence in the process – and rarely take risks they cannot control (e.g. emissions, regulatory etc.). These combine to make traditional procurement and contracting ineffective.

It is not the primary function of this report to provide recommendations on procurement but it would be remiss to omit it, because it can completely change the costs for taxpayers. For example one approach could eliminate the entire cost and substantially reduce or eliminate risk. Procurement is thus a critical aspect to consider.

Should Council decide to consider IRM further, we strongly recommend holding a procurement workshop because traditional procurement of IRM has repeatedly proven not to work and using it yet again will in our view be guaranteed to fail. This does not mean that IRM cannot be implemented however, as there are internationally adopted approaches[40] using benchmarks to protect taxpayer value, which are better suited and will in our view be necessary.

5.7 Implementation

In the event the Township considers proceeding further, it helps to have some basic understanding of what the next steps might be, because this illustrates how risk is managed. Foremost, we recommend taking a measured approach to mitigate risks as this will safeguard both project and taxpayer value. Aspects include, in no special order:

- Confirm IRM can meet MoE requirements and that CRD will amend the Solid Waste Management Plan accordingly. Confirm regulatory and development process;
- Undertake Detailed Development and Implementation Feasibility Assessment and develop an Implementation Plan;
- Undertake laboratory and physical tests for physical, chemical and energy suitability; model potential air emissions for the preferred option;
- Hold a workshop to more fully understand some of the key implications and options such as procurement, risk management, contracting etc;
- Confirm design and layout, costs and schedule; revise potential expansion and associated implementation plan, phasing and pricing;
- Undertake energy demand assessment for Esquimalt's core, map against plant outputs; prepare detailed DES plan including contract assessment; obtain pre-contractual commitments;
- Secure agreements with private haulers to confirm availability of waste supplies for an IRM facility through Letters of Intent with conditional contracts;

[40] See Wikipedia article and international legal expert summary.

- Prepare scope and cost for project management of IRM Plan implementation including bid process and selection of Prime Contractor, construction, testing, commissioning and certificate of performance and formal hand-over.
- Secure a suitable performance guarantee with gasifier manufacturer, and subsequently confirm a full engineering wrap from a qualified company/consortium with fixed cost contract and energy guarantee;
- Update capital and operating cost projections; update business case; and,
- Consider establishing an advisory committee with experienced appointees from disciplines able to provide advice and an element of oversight.

These steps and more should be structured following consultation with staff. Figure 39 illustrates phasing for an initial plant.

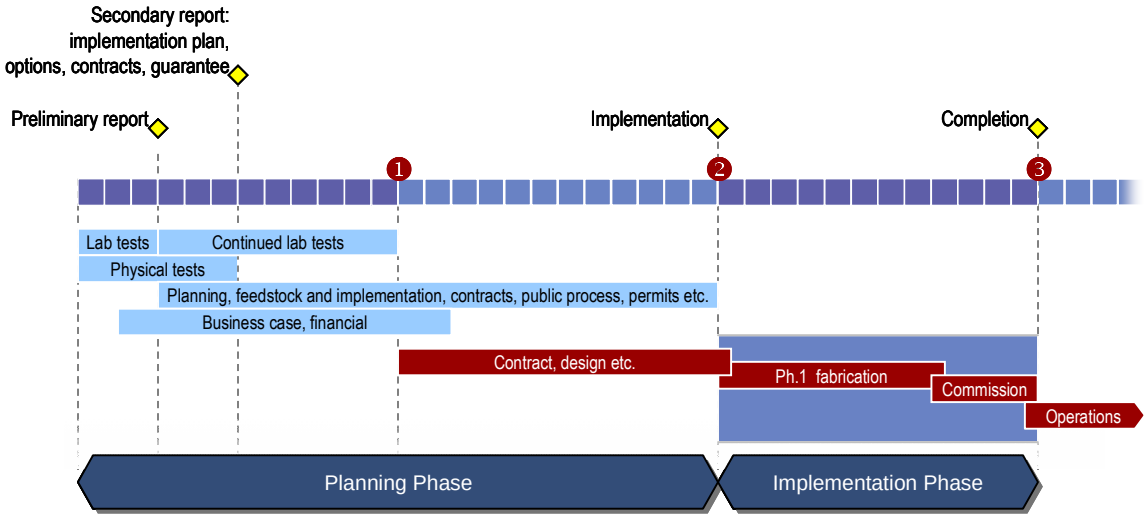


Figure 39: Implementation Outline

MoE and community confirmation, procurement approach and funding availability, testing and business case refinement are initially the most important. Testing is required to confirm a guarantee. Should any step raise concerns, the project would be suspended to allow for correction or the project cancellation, up to decision point 2. Up to that point costs will rise but will be comparatively low. We have not included phasing in Figure 39 (beyond a first phase) as this will depend on Council decisions. Most scenarios have the potential for a viable initial plant to be initially smaller but expand as demand and waste volumes rise.

6 Findings

6.1 Introduction

This section reviews modelling and findings from six scenarios developed with varying waste volumes and community growth potentials. The model combines financial and non-financial aspects, as described previously. Each scenario is a result of iterative assessment to attempt to optimize each scenario, to reduce costs, improve revenues and maximize resources and environmental results. This means additional research was undertaken to clarify wastes and obtain improved costs, but as the scope of the study is limited, further refinement of the preferred scenario is recommended, assuming the decision is taken to proceed further. The iterative optimization process is illustrated in Figure 2, *IRM Process Overview* on page 6.

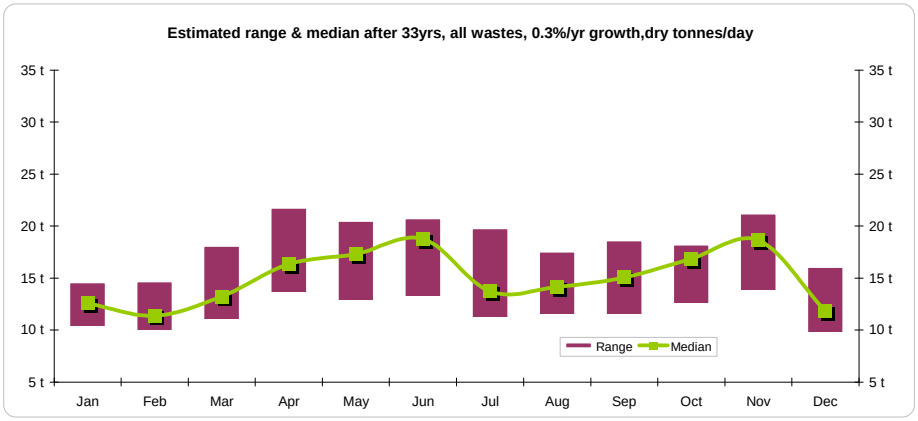


Figure 40: Scenario 2a – Minimum Growth

Reporting is summarized by major heading, since detailed modelling comprises full life cycle projections for 30 years plus residuals/reversion, adjusted for tiered equity and debt financing. Environmental models include full life cycle projection for GHG emissions (up to 150 years), since

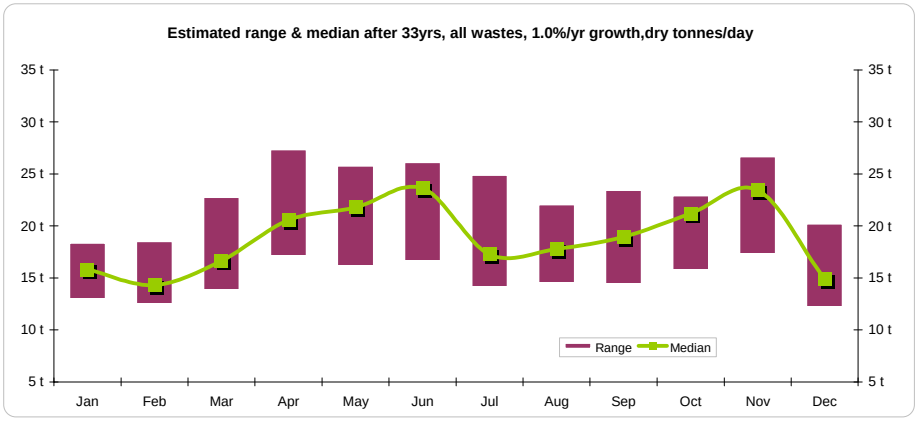


Figure 41: Scenario 2b - Moderate Growth

emissions have long life cycle. The environmental model was developed for Pivotal by Michael Wolinetz of Navius Research Inc., using international standards (government of Canada, EPA etc.) and includes life cycle projection by GHG emission gas and type so GHG reduction can be optimized. Should the project proceed, Navius should be contracted to undertake a more detailed assessment of the GHG and sequestration values.

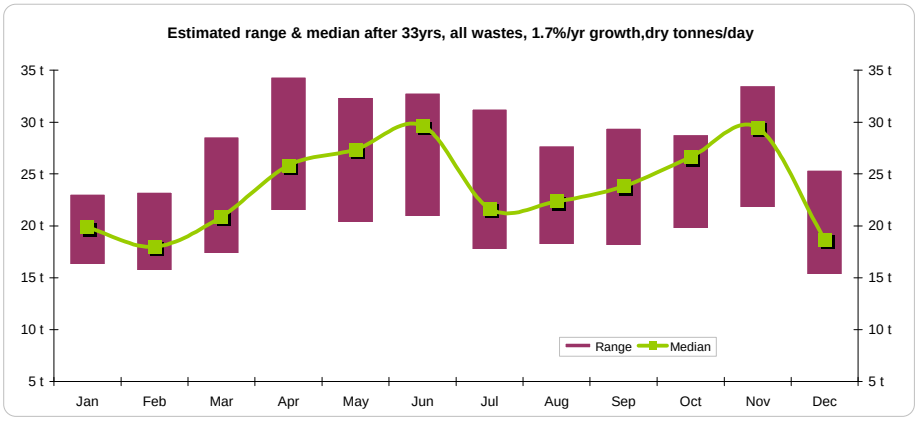


Figure 42: Scenario 2c - High Growth

Figure 30 summarized six main scenarios for assessment, however significant feedstock fluctuations mean that plant scale, unit sizes and the ability to adjust systems to meet changing volumes will be essential. Within the six scenarios, we thus looked at the implications of feedstock fluctuation, assessing both the median and range of possible flows, based on evidence of monthly data from 2011-2019. This was then applied individually to the Township's collections of MSW, yard and garden waste and food scraps, and interpolated to apply to private haulage volumes. While Figure 40, Figure 41 and Figure 42 look at combined wastes under low, moderate and high growth scenarios respectively, we assessed the implications for Township-only wastes and concluded that Figure 41 provides an understanding for plant and equipment sizing and planning.

6.2 IRM Results

Value is internationally defined as a financial sum that something can be sold, between a willing buyer and seller, acting at arm's length and without undue influence. This relies on something having a 'market' value, but government infrastructure often has little in the way of market equivalent or value, so the more applicable main metrics relate to the "worth" of a project. This allows for a broader assessment of environmental and resource benefits than purely their 'value in exchange', as in this case. An example of worth is that the community might think it is 'worth' undertaking something for the environmental and other benefits it creates, even if the cost exceeded revenues. In other words it is 'worth' implementing even though it couldn't be sold since it had negative 'value' on the open market. Worth can thus include the more intangible aspects of a project.

IRM models use financial metrics but also include non-financial metrics such as resource recovery and measurable environmental results. This moves towards a "Triple Bottom Line" assessment of worth. In this report the social dimension is not assessed, since this will be determined by Council and the community, who will have their own opinions of the project's overall "worth." The metrics in this assessment thus provide a range of indicators, so the community can reach its own conclusions of the project's "worth."

6.2.1 METRICS

The following explains the main indicators used in Figure 43 *Scenario Summary* on page 65. These metrics are intended to be used in combination, for example GHG reduction or landfill diversion indicators can be used with financial indicators, so the GHG results can be compared with the costs/revenues it took to produce them. Inflation is applied throughout the cash flow projection at BC's long term inflation rate of ≈2%.

One aspect we recommend strongly against is relying on discounted cash flow (DCF) metrics such as NPV and IRR. While useful in a market context, they fundamentally distort long term government project performance. While relevant should Esquimalt decide to partner with a private sector provider, they can be misleading and result in poor decisions if incorrectly interpreted. We will be pleased to explain this further if desirable.

A) Main indicators

The main project components for basic comparison of different options & scenarios		
01	Total capex	The total estimated cost of the plant in 2020 dollars, undiscounted.
02	Annual O&M	The annual operating and maintenance costs in 2020 dollars as at the plant's opening.
03	Waste volume	The total waste volume capacity of the plant, in original "wet" tonnes, as received. Plant operations (receiving, holding, metering, gasifier, dryer etc.) are adjusted to handle volumes and moisture content, by scenario.
04	Est. unit size/capacity	Volume processed by the gasifier in dry tonnes per day. This refers to gasifier capacity, which is adapted for each scenario to attempt to optimize overall net financial yields.

B1) Public Financial

Provides financial indicators for public delivery assuming 100% debt.		
05, 06	IRR, NPV	Internal Rate of Return and Net Present Value are discounted cash flow indicators used by the private sector to estimate the value of a project and are market indicators with limitations for public projects. The IRR is the percentage return over the project's life cycle from investing the project cost today, intended to be comparable with other investments where the project cost are invested initially. Few government infrastructure projects are undertaken in the way an IRR calculates. A common private sector threshold for an IRR in a 100% debt model might be 15%, but lower if there is a government covenant (say ≈11%). A lower yield may be perfectly acceptable for government undertaking a public project, especially if there are few alternatives.

		Governments often accept the IRR without appreciable challenge if it exceeds the cost of borrowing. The NPV is the "present value" of the project today, net of all future costs and revenues, over the project's life cycle, using a discount rate based (here) on the "cost of money." The discount rate emphasizes early costs and reduces longer term revenues, leading to distortion. For example $100 from sale of heating, in 30 years, becomes an NPV of $22.59. Since in practice costs of heating go up not down, discounting distorts long term project revenues. A positive NPV means the cost is exceeded by revenues and a higher value indicates lower likelihood of taxpayer support. A negative NPV may also be acceptable for a public project provided debt is included, which it is in our models.
07	ROI	The ROI is the ratio between the value of the project (i.e. its expected returns) as a ratio of the initial capital investment. The higher the ROI the better. Some analysts use different ways of calculating ROI but in this instance the ROI uses the net returns expected over the project's life (revenues minus costs, including the costs of capital). Generally, a positive ROI is good but a negative ROI may also be acceptable in a government context. The more the ROI exceeds the cost of capital the better it is viewed.
08	Life cycle profit/loss	The total net profit or loss from the project over its life cycle, undiscounted, inflation-adjusted. Similar to ROI, but provides an indication of the net profitability of the project over the projection period (here, 30 years). In a public context a positive net life cycle value indicates a dividend or profit and the higher the better, but a loss may also be acceptable (but suggests taxpayer support may be required). Note that this can disguise periodic negative cash flows where subsidy is required. #08 is not discounted and thus is not adjusted for time or risk, as compared with #06, which is discounted for time and risk. Metric #08 is distorted less by risk and time adjustments, since the cost of capital is included as a project cost, so it is closer to the net amount the taxpayer can expect over the life of the project.
09	EBITDA	Earnings before interest, taxes and depreciation. A standard financial indicator but has limitations for long term sustainable projects where debt etc. can be leveraged to improve viability. Largely an indicator used by the accounting professions, it helps to understand the overall revenue potential, undistorted by other factors.
10	Simple payback	Approximate number of years before the initial capital investment is repaid, net of costs. Less used by the public sector as it relates mostly to the point at which breakeven is achieved, which is of lesser concern in the public sector.

11 & 18	Taxpayer dividend/subsidy/yr, avg	The average dividend or subsidy required from taxpayers over the first ten years of operations. Adjusted and net of all costs and revenues, but assuming current tipping fees. Divided by the number of homes from Stats Canada 2016 totals, i.e. providing an estimate of the approximate dividend or subsidy for each home.

B2) Private Financial

Estimates the probable position of a private sector partner, financier and/or operator, for the project. Assumes 30% equity 70% debt, with refinancing.		
12, 13	IRR, NPV	See B1)05, B1)06. Private sector hurdle rates will vary depending on whether guarantees are available for aspects such as feedstock, but will typically be a minimum 15% at 100% debt and seeking 25-30% leveraged IRR on equity. NPV is typically compared to equity invested and usually required to at least exceed equity investment for the project to be of interest. The discount rate is usually set at the cost of capital or higher if the project is risky.
14	ROI	See B1)07. Private sector ROI is a less important metric for projects of this type but typically exceeding 15% ROI on 100% debt is a minimum requirement, with ROI >25% leveraged desirable.
15	Life cycle profit/loss	See B1)08. Private partners will require an appreciable return and will be interested to confirm a healthy long term cash flow, since #15 can tend disguise periodic dips in viability.
16	EBITDA	See B1)09. Private investors require a healthy EBITDA to sustain projects in the event viability changes over the project's life cycle. Threshold target requirements vary.
17	Simple payback	See B1)17. This is a basic indicator usually used in the private sector to estimate breakeven. Private sector interest is best with payback of ≈3-5 years or less. Beyond ≈7-10 years private interest in projects can be limited without underwriting or similar support.
18	Equity invested	Estimated total assuming 70/30 debt/equity on the initial capital investment. Depending on procurement structure and potential for public guarantees, lenders may require a higher equity ratio, reducing the potential leverage. 70/30 split is based on discussions with funds and an assumption of limited recourse but that Esquimalt will provide a long term contract for waste and associated fees.

C) Resource recovery

Physical resources recovered from waste, or resulting from conversion of waste, capable of beneficial utilisation.		
19	Face yield, mwt	Hourly gross thermal yield in megawatts. Measured gross at the point of generation, which will be greater than actually delivered.

20, 21	Total mwt/yr & life cycle	Total gross thermal yield in megawatt hours annually and over the project's life cycle. Measured gross at the point of generation, which will be greater than actually delivered.
22, 23	Total GJ/yr & life cycle	Total gross thermal yield in gigajoules annually and over the project's life cycle. Measured gross at the point of generation, which will be greater than actually delivered.
24, 25	Total biochar tonnes/yr & life cycle	Total projected maximum tonnage of biochar annually and over the project's life cycle, gross FOB plant. Note that this is not the same as the tonnes of CO_2e in #32 and #33, since the sequestered potential value is ≈3 times the weight of the biochar.
26, 27	Water potential, litres/yr & life cycle	Potential maximum water recoverable annually and over the project's life cycle. Note that this is initially expected to be filtered and discharged, as it is unviable to reuse at current CRD water rates.

D) Environmental

28, 29	tCO2e/yr && life cycle, redn/increase	Metric tonnes of carbon dioxide equivalent either reduced (in black) or red (a net increase) from the proposed project compared to the current management of waste (mostly landfilling). This is the projected GHG reduction/increase either annually (#28) or over the project's life cycle (#29). Note that this initial estimate compares between current waste processing and planned IRM system, net of emissions from each operation and assuming aspects such as unsold composting. The GHG reduction may increase once a detailed assessment is undertaken. Note also that the life cycle reduction is many times the annual tCO_2e reduction because emissions benefits have up to 150 years' life cycle.
30, 31	Vehicle equiv/yr & life cycle, less/more	The number of vehicles' emissions that the GHG reduction or increase is equal to, using standard government comparative indicators, either annually or over the project's life cycle.
32, 33	Sequestered carbon, tCO2e/yr & life cycle	The number of metric tonnes (GHG carbon dioxide equivalent) that biochar is potentially able to sequester. Note that tCO_2e is different to the total tonnage of biochar (#24 and #25 above) as biochar sequesters ≈2.9x the weight as tCO_2e. Further explanation including on sequestration is provided in *Appendix 3: Biochar* on page 78 and in section 5.4 starting on page 45.
34	Life cycle $/tCO2e profit/cost	The total project profit or cost, net, divided by the total life cycle tonnes carbon dioxide equivalent. This is useful for comparing GHG reduction options as it allows for net cost or profit comparison as a standalone GHG reduction strategy. Note that this includes any carbon taxes or credits, assuming these are paid/received. An amount greater than zero (i.e. a profit) indicates a net positive

		contributor financially, given the GHG increase or reduction noted by indicators 28 and 29.
35, 36	Tonnes/yr & life cycle landfill diversion	Total metric tonnes annually and over the project's life cycle, diverted by the proposed project. Useful for comparison of different potential waste diversion initiatives, in combination with other indicators (e.g. #'s 8 & 15), to determine whether diversion is achieved through increased taxpayer cost or conversely, profit.

6.2.2 MAIN FINDINGS

		Township waste collections only			Combined Township/Private Waste Collections		
	Scenario	1a	2a	3a	1b	2b	3b
	Population growth %	0.3%	1.0%	1.7%	0.3%	1.0%	1.7%
A) Main indicators							
01	Total capex	$16.4m	$17.3m	$17.8m	$21.3m	$21.3m	$25.3m
02	Annual O&M	-$1.5m	-$1.5m	-$1.6m	-$1.7m	-$1.7m	-$1.9m
03	Waste volume	3,740 t/yr	4,670 t/yr	5,830 t/yr	7,150 t/yr	8,930 t/yr	11,150 t/yr
04	Est. unit size/capacity	6 dtpd	8 dtpd	10 dtpd	13 dtpd	17 dtpd	21 dtpd
B1) Financial : Public delivery : Inflation-adjusted, 100% debt							
05	IRR	5%	9%	13%	16%	22%	24%
06	NPV	≈$1m	≈$11m	≈$24m	≈$46m	≈$71m	≈$93m
07	ROI (life cycle)	510%	660%	890%	1,040%	1,370%	1,470%
08	Life cycle profit/loss	$16m	$47m	$86m	$152m	$226m	$297m
09	EBITDA	$0.8m	$1.4m	$2.1m	$3.4m	$4.7m	$6.2m
10	Simple payback	≈21yrs	≈14yrs	≈10yrs	≈8yrs	≈6yrs	≈6yrs
11	Taxpayer dividend/subsidy/yr, 1st 10 yr avg	≈-$60/home	≈$0/home	≈$90/home	≈$200/home	≈$360/home	≈$480/home
C) Resource recovery							
19	Face yield, mwt	≈0.80 mw	≈0.90 mw	≈1.20 mw	≈1.60 mw	≈2.00 mw	≈2.50 mw
20	Total mwt/yr	6,700 mWht	8,300 mWht	10,400 mWht	14,100 mWht	17,600 mWht	22,000 mWht
21	Total mwt, life cycle	201,000 mWht	249,000 mWht	312,000 mWht	423,000 mWht	528,000 mWht	660,000 mWht
22	Total GJ/yr	23,960 GJ	29,930 GJ	37,340 GJ	50,740 GJ	63,390 GJ	79,070 GJ
23	Total GJ, life cycle	718,800 GJ	897,900 GJ	1,120,200 GJ	1,522,200 GJ	1,901,700 GJ	2,372,100 GJ
24	Total biochar tonnes/yr	460 t/yr	570 t/yr	710 t/yr	970 t/yr	1,210 t/yr	1,510 t/yr
25	Life cycle biochar, tonnes	13,800 t	17,100 t	21,300 t	29,100 t	36,300 t	45,300 t
26	Water potential, litres/yr	0.9 ml/yr	1.1 ml/yr	1.4 ml/yr	1.1 ml/yr	1.4 ml/yr	1.7 ml/yr
27	Life cycle water potential, litres	26.4 ml	32.9 ml	41.1 ml	32.8 ml	40.9 ml	51.1 ml
D) Environmental							
28	tCO2e/yr redn/increase	1,600 tCO2e/yr	2,000 tCO2e/yr	2,500 tCO2e/yr	3,600 tCO2e/yr	4,500 tCO2e/yr	5,600 tCO2e/yr
29	Life cycle tCO2e redn/increase	81,001 tCO2e	101,185 tCO2e	126,245 tCO2e	178,632 tCO2e	223,139 tCO2e	278,358 tCO2e
30	Vehicle equiv/yr less/more	350 cars/yr	440 cars/yr	550 cars/yr	780 cars/yr	970 cars/yr	1,210 cars/yr
31	Life cycle vehicles less/more	10,600 cars	13,200 cars	16,500 cars	23,300 cars	29,100 cars	36,300 cars
32	Sequestered carbon, tCO2e/yr	1,343 tCO2e/yr	1,678 tCO2e/yr	2,093 tCO2e/yr	2,844 tCO2e/yr	3,553 tCO2e/yr	4,432 tCO2e/yr
33	Life cycle sequestered carbon, tCO2e	40,290 tCO2e	50,330 tCO2e	62,795 tCO2e	85,333 tCO2e	106,594 tCO2e	132,972 tCO2e
34	Life cycle $/tCO2e profit/cost	$190/tCO2e	$470/tCO2e	$680/tCO2e	$850/tCO2e	$1,010/tCO2e	$1,070/tCO2e
35	Tonnes/yr landfill diversion	3,740 t/yr	4,670 t/yr	5,830 t/yr	7,150 t/yr	8,930 t/yr	11,150 t/yr
36	Life cycle landfill diversion, tonnes	112,200 t	140,100 t	174,900 t	214,500 t	267,900 t	334,500 t

Figure 43: Scenario Summary – Public Option

Figure 43 shows the results for each main scenario tested using the metrics in section 6.2.1 based on the plant being publicly financed and operated, with the recommended option highlighted in light green. In summary, we comment as follows:

- The scenarios are tabled in ascending order of waste volume from left to right (shown in lines 03, the wet waste volume and 04, the average dry tonnage processed daily). From a taxpayer perspective, viability is also arranged in ascending order from left to right with the least viable on the left and most viable on the right (note lines 05, 08 and especially line 11, which estimates the approximate taxpayer dividend or cost per door).

- The three scenarios with Township wastes (1a, 2a and 3a) are the most marginal and two may well require some taxpayer support (1a and 2a), with 3a viable, i.e. if community

and/or waste growth exceeds projections – and the likely maximum buildout – a plant would be viable with the Township's waste alone. It would nevertheless be possible to proceed only processing the Township's collected wastes, assuming careful management to avoid fiscal impact, but this would only address ≈52% of the community's waste.

- The extent of possible taxpayer support is not substantial in most scenarios, in part because we expect growth to exceed the minimum (≈0.3%) threshold. There will also be external savings not accounted for in this analysis (e.g. meeting corporate emissions targets without further cost, landfill diversion benefits, under-valued benefits from resource recovery price stability, sequestration etc.). The three Township-only waste scenarios are thus possible with minimal potential taxpayer exposure, but are more likely to result in taxpayer support at some stage, especially in the early years.

- All the scenarios with combined public and private wastes are expected to be profitable, with superior resource recovery and GHG/CO_2e reductions. Of these three scenarios, Scenario 1b uses the least growth experienced in 25 years and in our view could lead to under-assessing the capacity of waste going to an IRM plant. By contrast Scenario 3b assumes continued growth at one of the highest rates in recent years and probably over-estimates future waste growth. Note that the approach used allows for phasing to suit a variety of growth scenarios, allowing for phased expansion as growth occurs.

- The population and waste growth assumptions driving scenario 2b are considered the most realistic, not least because this assumes population growth roughly equal to the Township's current buildout projection estimates, and is in line with the regional trend. 2b is viable and is our recommended planning model should IRM proceed further. Note however that Scenario 1b shows that even in a worst case scenario with combined wastes, an IRM plant should exceed breakeven. These projections should be reviewed following receipt of better detail if the project proceeds.

- All scenarios are expected to be able to eliminate the Township's corporate GHG emissions. Scenario 2b should yield GHG reductions of ≈4½ times the corporate emissions profile and represents GHG reductions equivalent to ≈12% of the entire community's waste – roughly equal to taking 970 cars off the road or over 29,000 cars over the 30 year projection. This is a significant contributor to the Township's declaration in 2019 of a Climate Emergency and target of carbon neutrality by 2050. We are not aware of similar progress by other Canadian communities, except at appreciable cost or other impact, whereas this has the potential to generate a dividend.

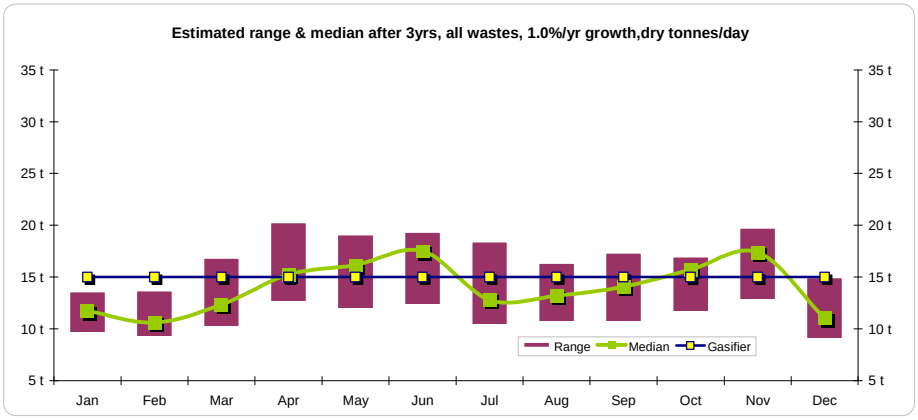
- Option 2b is expected to generate an additional sequestration potential in the range of ≈3,600 tCO_2e annually or ≈107,000 tCO_2e over the 30-year projection period. While the carbon credit value is included in the model (at \$25/tCO_2e), sequestration is more significant than accounted for by carbon credits, as it takes carbon out of the atmosphere. This is one of thee few mechanisms able to achieve this.

- In all scenarios the major resources recovered are heating, cooling and biochar with primary revenues from biochar, tipping fees and energy sales. The main costs are the gasifier and related plant and equipment. Most of the key costs can be controlled from an early stage through fixed price contracts, guarantees and bonding, including guarantees on system yield (on which the business case relies). This will limit cost impacts. Similarly, most of the main revenues can be managed through contracts signed prior to

proceeding, again stabilising the business case and managing risk. Phasing is discussed as part of the concluding comments in section 7 on page 71.

- Landfill diversion varies but is positive under all scenarios, with initial laboratory and demonstration tests running local wastes (Figure 27) confirm the systems can work with the proposed wastes. Under the recommended scenario (2b) diversion is estimated at ≈8,930 tonnes per year or almost ≈270,000 tonnes over the plant's initial projected life cycle. The review of technologies here and previously by CRD concluded there are few options as viable or as complete in handling wastes, which mirrors European and Asian experience.

- Waste volume fluctuations and population growth uncertainties affect viability. The scenarios were therefore mostly priced based on 5 tonne units, to allow for flexibility to increase capacity, as and when warranted. This allows for scaling to happen in pace with community changes, minimizing initial costs, but it increases smaller plant costs because 5 tonne units are more expensive than tailoring units to meet volume. Further review is expected to reduce costs further, which would improve viability and accuracy. In short Figure 43 and Figure 45 will tend to be somewhat conservative and should Council decide to progress further, further assessment and pricing should be beneficial.



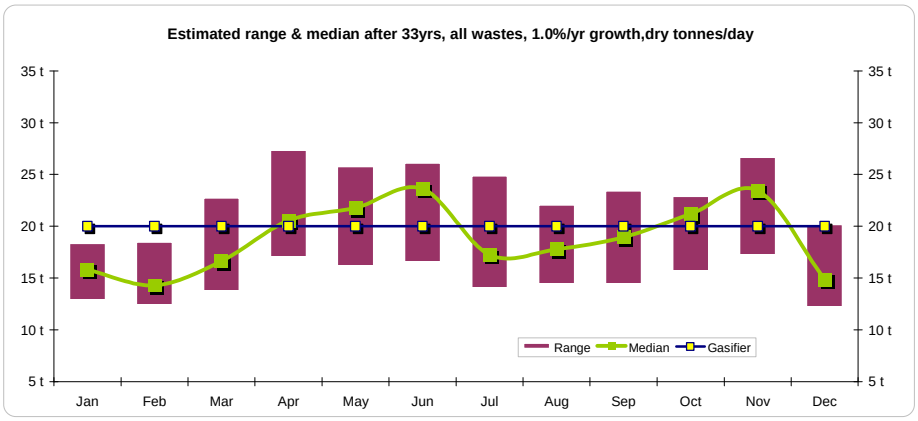


Figure 44: Phasing estimates, Scenario 2b

- Although Scenario 3b is designed to assess a high population growth scenario, it also assesses the impacts of having a larger plant. It suggests that working with neighbouring communities to accept their wastes would improve viability, resource recovery and environmental results, as would potential dividend and risk buffer. The difference might imply allowing up to two extra trucks per day, but be more economic and efficient. In the event that private sector engagement is pursued we expect this will be proposed.

- Figure 43 scenarios show a plant could be viably phased to minimize cost and risk. The initial plant would likely be based on Scenario 2a (Township waste), which would operate at breakeven. As private haulers confirm their wastes an extra unit would be added (Scenario 2b), which improves viability. This should be possible to conclude during the initial planning period. Depending on how growth proceeds, extra 5 tonne units can then be added as the community grows, so if growth exceeds expectations units can be added or if needed, resized and replaced. The potential maximum gasifier capacity on the site exceeds the Public Works site's ability to receive and process wastes without re-planning the site, so the constraints on waste handling and viability are more site-related, not technology- or viability-related. Note that should Council decide to proceed to a next stage of assessment, a more detailed review of wastes and phasing will be needed.

Figure 44 shows Scenario 2b initial volumes with three 5 tonne units (upper graph). A fourth unit can be added as required (lower graph). Projections indicate that if growth continues at the current high rate, extra units may be required within 5 years, but that extra units improve viability, environmental and resource recovery. Extra units can be added as needed in response to demand, peak flows or maintenance needs. Further assessment of this should be included in planning, assuming the decision is taken to proceed to the next steps.

6.2.3 Overall Viability

We also ran the same scenarios, adjusting the financials for possible private procurement, where the operator would also finance the project. This represents the viability as it might be assessed from a private sector perspective, summarized in Figure 45, with the recommended option highlighted in light green.

		Township waste collections only			Combined Township/Private Waste Collections		
Scenario		1a	2a	3a	1b	2b	3b
Growth %		0.3%	1.0%	1.7%	0.3%	1.0%	1.7%
B2) Financial : Private delivery : Inflation-adjusted, leveraged, 30% equity							
12	IRR	6%	13%	28%	40%	48%	49%
13	NPV	≈$0.7m	≈$11.0m	≈$28.8m	≈$51.7m	≈$70.8m	≈$94.0m
14	ROI (life cycle)	450%	1,020%	1,860%	2,620%	3,550%	3,950%
15	Life cycle profit/loss	$23m	$55m	$102m	$173m	$235m	$311m
16	EBITDA	$1.2m	$1.8m	$2.4m	$3.7m	$5.0m	$6.4m
17	Simple payback	≈28yrs	≈11yrs	≈5yrs	≈4yrs	≈3yrs	≈3yrs
18	Equity invested	≈$5.1m	≈$5.4m	≈$5.5m	≈$6.6m	≈$6.6m	≈$7.9m

Figure 45: Scenario Summary – Private Option

- Results from indicators 12-18 show that it should be possible to attract private sector participation if desired, but with caveats.

- Pursuing a plant that only processes the Township's wastes is likely to be more difficult as the financial metrics are generally below the level a private partner might want, without guarantees of some form. We expect private investors will typically wish to see leveraged returns in the order of 25% or better, subject to how risk is managed, so 1a, 2a and 3a are likely to require guarantees or other structures to help manage risk.

- Combined waste scenarios raise both issues and opportunities for the private sector:

  - All metrics for Scenarios 1b, 2b and 3b are positive for private involvement. Again, the Township is recommended to resolve issues it can control to reduce risk, maximize

the system and the opportunity. Full privatisation while possible, may reduce control and flexibility, not just taxpayer dividend. Metrics 12-18 generally show that Council has options, but we caution that standard procurement processes are problematic due to limited suppliers with few qualified and experienced advisors, as noted in section 5.6 *Risk & Procurement* on page 50.

- Leveraged returns are attractive with equity contributions of ≈$5-8m and total net life cycle returns (undiscounted, inflation-adjusted) of ≈$247m and net present value of ≈$77m for the recommended scenario. These are attractive numbers, however the project size is smaller than most suitable private partners would consider, thus potentially limiting the ability to attract a private partner unless a larger plant taking extra local wastes is considered acceptable.

- The private sector scenarios show that if higher waste volumes are acceptable, profitability improves, with similar environmental and resource recovery benefits. Should Council decide to engage the private sector in some form, there will likely be interest in taking more waste than purely Esquimalt's, to improve economies of scale. Should Council choose to limit this or other innovation, both interest and viability will be more difficult to attract.

In summary the higher waste volumes of combined Township and private waste scenarios are more likely to attract a private partner, if the Township considers this desirable to explore further. This is mostly because the improved viability with larger volumes helps with plant size in addressing fixed costs specific to this project (DES costs, rock, complex site etc.).

6.3 Initial Sensitivity Assessment

IRM models are generally less sensitive to assumptions than other infrastructure projects, largely because of the more varied range of possible revenues and ability to control costs through fixed price contracts, revenue- pre-contracting and technology guarantees. While reviewers may believe that specific assumptions have major impact on results, we generally find that the models are considerably less sensitive than first perceived. We have therefore run basic sensitivity analyses using the recommended scenario (Scenario 2b) as a basis, varying selected input assumptions by 20% in each case and measuring the impact on: (1) average net dividend per year over the first ten years; (b) total net profit over the life cycle; and, (3) the Internal Rate of Return. Comparisons used the public sector finance recommended model, debt financed.

Sensitivity to 20% change			
	Avg. profit/yr	Life cycle profit	IRR
Capex	-12%	-3%	-15%
O&M	-9%	-10%	-3%
Debt rate	-5%	-1%	0%
Tipping fees	-7%	-5%	-4%
Heating	-6%	-4%	-3%
Cooling	-7%	-5%	-4%
Biochar	-32%	-22%	-14%
Carbon credits	-1%	-1%	0%

Figure 46: Preliminary Sensitivity Analysis

Figure 46 shows the sensitivity of the items listed to a 20% "worst case" change (i.e. costs increased; revenues reduced). In Figure 46 a 20% increase in capex results in a 12% drop in average profit per year over the first ten years with only a 3% drop on overall net profits over the projection life (30 years) and a 15% drop in the IRR. Note however that this shows the

percentage drop, so while the capex changed by 20%, the original IRR fell from 22.3% to 19.0%, which is equal to the 15% drop in IRR shown in Figure 46.

While the "Average profit/.yr" column shows the change in average profit over the first ten years of operation, the "Life cycle profit" column shows the change over the entire projection (33 years). The IRR column is more helpful in understanding conventional market understanding of viability, which emphasizes early profits and is the reason we recommend relying on DCF indices for assessing long term infrastructure projects of this nature.

Biochar is the largest single revenue generator in the models and most sensitive aspect, and thus a key target for early risk reduction. Figure 46 shows that a 20% drop in biochar value results in up to a 32% drop in the average profit over the first ten years, with smaller but still appreciable impacts on the life cycle profit and IRR. It equates to a drop from $3.2m/year average profit down to $2.4m/year. It is thus important to confirm biochar revenues and mitigate this risk by pre-contracting revenues as soon as possible. It is also the reason we adopted low values for this item compared to market evidence noted in Figure 54 (we used US$2,000/tonne based on industry expert recommendations whereas retail is up to US$48,000/tonne). Thus while this is an important risk item to resolve early on, the potential exists for a plant to be more viable than assumed in all models. Elimination of any revenues whatsoever from biochar suggests a plant would be viable but marginal. No expert we consulted expects biochar to be unsalable.

Other items with sensitivity are the capital, operating and maintenance costs, which is to be expected. Strategies to deal with capital costs (and related performance and yield guarantees) have been explained. Operating costs will need continual diligence to maintain at manageable levels but are not a major item on their own. Maintenance will over time be important to maintain but again is manageable providing planned preventive maintenance is undertaken. A long term allowance for this has been made in the budget.

This is not intended to be an exhaustive assessment of the main sensitivities in the model, but is taken into account in the risk section (on page 50). The model and related recommended planning sequences are structured to try and mitigate risk, with implementation intended to address or quantify and mitigate the main risks before major financial commitment.

7 Conclusions & Recommendations

We conclude that IRM can be implemented in Esquimalt, with appropriate care and due diligence. The existing Public Works site appears to have sufficient space to be able to accommodate a plant of the scale needed to address the wastes currently in Esquimalt, and be able to cope with expansion of the plant to meet increased waste volumes, as the community grows and for the foreseeable future.

The Township collects ≈52% of the identified waste streams and while a plant could be implemented solely addressing this volume of waste, doing so is only anticipated to achieve breakeven and is likely to continue to be marginal. However discussions with haulers indicate they are willing to contribute their Esquimalt wastes under contract, which would raise both economies of scale and viability. We recommend pursuing this further as it helps pay for fixed costs such as site preparation, DES etc. while improving environmental results.

Uncertainties about waste volume, content and fluctuation in flow, as well as population growth, mean that a flexible implementation approach to IRM is important but achievable by phasing the plant. On this basis most scenarios are expected to be viable and could potentially yield a substantial dividend. A phased plant would likely start at ≈$15m but rising to ≈$21m as the waste volumes and community grows. This cost could be reduced or even eliminated, depending on: (a) procurement approach; and, (b) grants. Any financial shortfalls could be addressed by temporarily accepting waste from adjacent communities.

Under all scenarios the environmental benefits are potentially significant. The Township's declaration of a Climate Emergency and commitment to GHG reduction are reasons to consider IRM because the recommended scenario can yield GHG reductions of ≈12% of the entire community's GHG profile and ≈4½ times the Township's corporate GHG profile, i.e. ≈4,500 tCO_2e annually, ≈223,000 tCO_2e over the life cycle. It is also expected to sequester ≈40 tonnes (CO_2e) for every 100 tonnes of waste received, or ≈107,000 tCO_2e over the project's 30 year life cycle. This is a very significant advance in carbon reduction.

Ministry of the Environment guidelines revolve around the 5Rs process. The steps already taken by Esquimalt and reduced waste volumes already meet the guidelines, and technology reviews over the past decade, and this study, mean that Esquimalt is using best practices and technology. This means Esquimalt should be able to proceed to the next steps from a regulatory standpoint. MoE will have continued involvement through permitting, but gasification is a known item and permitted by them, so while there will be a rigorous permit and monitoring process, we do not expect this to be an overwhelming impediment.

In conclusion, a viable initial plant is likely to require a capital commitment in the order of ≈$15m (±15% on capital), but be expanded to ≈$19m (±15%) once other Esquimalt wastes are confirmed. Adding extra units to address larger waste volumes can be undertaken as and when required and while the initial plant is expected to only yield a small dividend, expansion

thereafter is expected to be increasingly viable, with commensurate improvements in environmental benefits.

In closing it is important to note that engagement was undertaken to confirm key aspects such as the potential to contract with haulers, manufacturer pricing and procurement options with alternate service delivery. Implementation is thus considered feasible and if undertaken appropriately, is expected to be both financially and environmentally beneficial for the Township and Esquimalt taxpayers.

Appendix 1: Glossary

5R's hierarchy	The 5 R's hierarchy is a pollution prevention principle to guide the recovery of wastes according to Reduce, Reuse, Recycle, Recover and Residuals Management
AD	Anaerobic digestion (see below)
Anaerobic digestion	A system where microbes are used to convert feedstock into gas, usually with a high methane content ("biomethane"), usable instead of natural gas. The digestion by the microbes happens in a sealed vessel where oxygen is minimized
Alternate Service Delivery	Different way of delivering services where a private company participates in the service delivery. Can range from full outsourcing through hybrid contracting and/or partnering, including funding variations
ASD	See Alternate Service Delivery above
Biochar	Biochar is charcoal like substance that is made by burning organic material in a controlled low or zero oxygen process and used as a soil amendment for both carbon sequestration and addition of minerals
Biogas	Product (usually but not exclusively) from an anaerobic digester. Typically contains contaminants (water, carbon dioxide etc.)
Biomethane	Methane generated from biogas after it has been 'cleaned' for use as natural gas
Biosolids	Solid portion of liquid waste
Carbon credits	A carbon credit is a tradable certificate that allows the company that holds it to emit a certain amount of greenhouse gases. One credit is equal to equivalent emission of one tonne of carbon dioxide (tCO_2e)
Carbon footprint	A carbon footprint is the amount of greenhouse gases, usually measured as an equivalent in terms of tonnes of carbon dioxide, released into the atmosphere by a particular human activity
Carbon neutral/negative	Reducing carbon footprint either to zero (i.e. Carbon Neutral) or where carbon is sequestered (carbon negative)
Capex	The capital costs

Circle Draft	Type of gasifier modified from normal up/downdraft systems where the syngas is recirculated to reduce tars and raise yields
DCF	See section 6.2.1 starting on page 61
DES	District energy system usually distributing heat in hot water pipes
DTPD	Dry tonnes per day
EBITDA	See section 6.2.1 starting on page 61
ESP	Electrostatic precipitator – used to remove particulate matter from air emissions
Feedstock	Feedstock is the processed waste stream material mixed for input into the dryer and gasifier systems. It may consist of municipal waste, food scraps, and yard and garden waste but can also include selected construction and demolition waste
Fluidized bed	A gasification system where a bubbling bed of sand or other similar material is heated to a high temperature and turns the feedstock into syngas
Gasification	Is a thermochemical and mechanical process where the feedstock is heated in a chamber with zero or minimal oxygen to produce a synthesis gas ("syngas")
GHG	Greenhouse Gas
GJ	Gigajoules, a unit of energy often applied to natural gas
Integrated Resource Management	Is an approach to water, energy and waste management that stops viewing them as wastes, and instead aims to maximise their use and value as resources, in ways that reduce costs to taxpayers (or even create profit) and reduce greenhouse gas emissions (GHGs) and pollution
IRM	See Integrated Resource Management above
IRR	See section 6.2.1 starting on page 61
MoE	Ministry of Environment and Climate Change Strategy
MSW	Municipal solid waste
MW	Megawatt, a unit of energy usually applied to electricity
Net Zero	Refers to buildings that generate 100% of their energy needs, either on- or off-site, from renewable energy sources. See World Green Building Council explanation. IRM generates renewable energy
NPV	See section 6.2.1 starting on page 61

OCP	Official Community Plan
Opex	The operating costs, usually including maintenance costs
Outsourcing	Arrangement with a private sector company where the private entity delivers some component a government need or service, either in whole or part. May or may not include finance, usually includes performance criteria
P3	See Public-Private Partnership below
Plasma & plasma arc	A system of gasification where the feedstock material is heated to a high temperature so that it creates a gaseous plasma. Typically high yielding but requiring high energy inputs to generate and sustain plasma generation
Public- Private Partnership	Contractual arrangement between government and a private sector company where services are delivered by the private party. Typically includes some form of private financing, either interim or long term
Renewable natural gas	Methane generated from processing a feedstock that is largely "atmospheric" in nature, i.e. is not extracted from mining or similar methods, and thus avoids being a "fossil fuel"
RNG	Renewable Natural Gas see above
ROI	See section 6.2.1 starting on page 61
SWMP	Solid Waste Management Plan
Syngas	A mixture of hydrogen, carbon monoxide and carbon dioxide plus small amounts of methane, butane, propane and pentane
Swiss Challenge	Procurement approach where government works with an identified proponent, then seeks bids based on the developed project to safeguard best value for the taxpayer
TPD	Tonnes per day
Tipping fees	Tipping fees are the charges applied by CRD for the disposal of waste types at Hartland landfill
Updraft	A gasification system where ≈10% air is introduced from the bottom and syngas comes of the top
Downdraft	A gasification system where ≈10% air is introduced from the top and syngas comes of the bottom

Appendix 2: Advanced Gasification

Gasification is a process that converts carbon-based materials into a mixture of carbon monoxide, hydrogen and carbon dioxide gases. Gasification is achieved by reacting the feedstock material at high temperature (above 500 degrees Celsius) with a controlled low amount of oxygen and/or steam. The molecules separate from the carbon containing material and form a gas mixture called synthesis (syngas) gas or producer gas which is itself a fuel. The energy or power derived from gasification and combustion of the syngas is considered to be a source of renewable energy if the gasified compounds were obtained from biogenic material like wood, food scraps, yard waste, biosolids etc.

During gasification the carbon containing material goes through two stages to efficiently extract its energy. In the first step, called pyrolysis, the material is heated to around 250 ˚C to produce volatile hydrocarbon gases and biochar. Then as the temperature increases the hydrocarbons and biochar with the proper mixture of oxygen or high temperature steam, produces syngas and crystalline biochar.

The advantage of gasification is that using syngas is potentially more efficient than direct combustion of the original fuel because it can be combusted at higher temperature where the upper limit of the thermodynamic efficiency is higher. Syngas can also be converted into hydrogen, methane and other fuels and chemicals via various additional processes.

We selected the Advanced RotoGasifier developed by TSI (Figure 47) as the technology the Township would use. The RotoGasifier is an improvement to up/down draft gasifiers and used in TSI's existing torrefaction systems[41] systems where the pyrolysis process is controlled to maximize biochar production. The first was built in 2010 in Everett, Washington to demonstrate operations and test feedstocks, with systems based on similar design in successful operation in the forest and agriculture industry across the USA, in Canada and internationally.

Figure 47: Plants in Georgia, California & Louisiana

[41] Torrefaction uses only the pyrolysis stage of gasification where the process is controlled to maximize biochar production.

Figure 47 includes (middle picture) a mobile demonstration unit with a capacity of 240kg/day (dry weight), with the largest current plant in Waycross Georgia (1,860 tonnes/day, 680,000 tonnes/year – pictured on the left). More typical systems will have multiple units to support maintenance to allow for peak volumes and 24/7/365 operations (e.g. the 44 tonne/day plant in Louisiana, right).

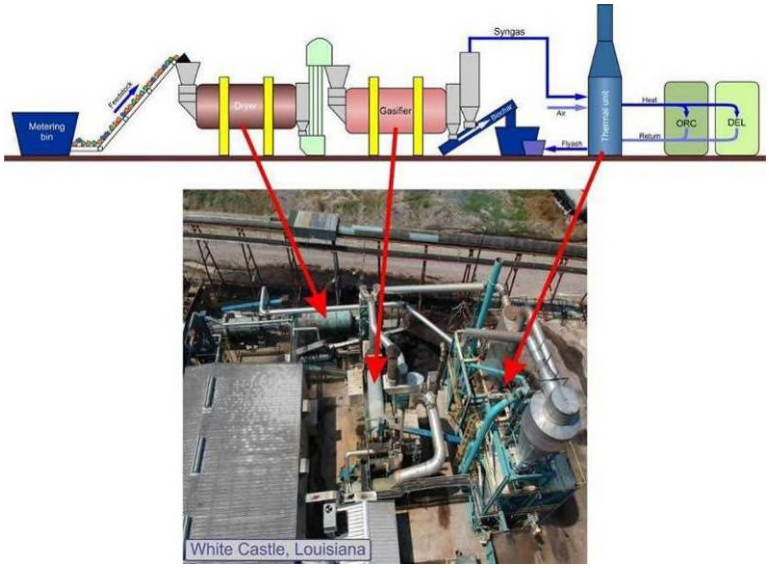


Figure 48: Schematic Overlay of White Castle Plant

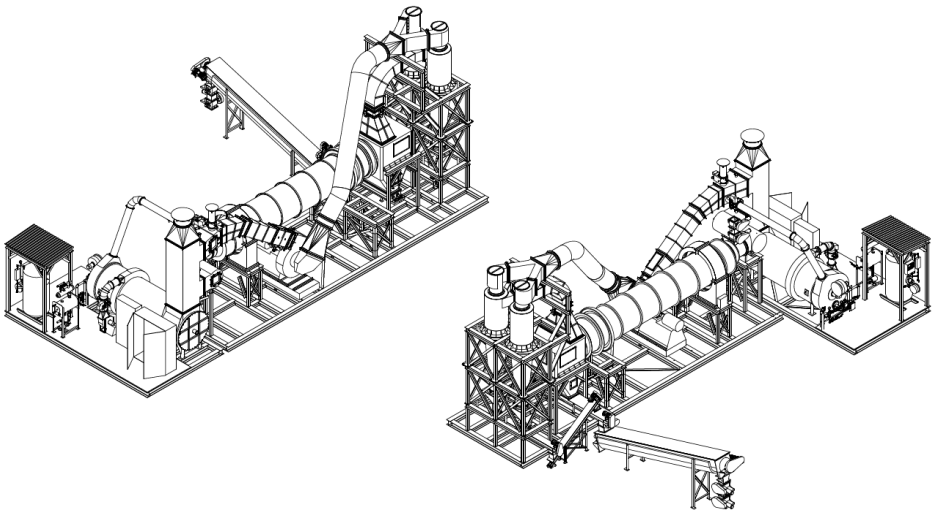


Figure 49: Gasifier Schematic

The horizontal rotating design addresses vertical processing issues by eliminating channelling and bridging, which can require shutdown to clear, thus improving operational efficiency. The RotoGasifier's horizontal rotating chamber improves flexibility in feedstock types and with its double airlock feed system, results in improved gas quality, better performance and overall improved efficiency, with its reduced downtime. The plant can be scaled to feedstock availability, implemented in stages to meet growing demand, is simple to operate and has a high level of automation.

Appendix 3: Biochar

An initial introduction to biochar is provided on page 79, with the following providing additional detail.

Background & Uses

Biochar is created by heating organic materials to produce something similar to barbecue wood charcoal. It has multiple uses and more are being identified, so both demand and value are increasing. Gasification is able to produce a quality biochar since it heats the feedstock without oxygen, thus avoiding combustion and producing biochar's crystalline carbon structure with other minerals.[42] While the quality, size, nature and granularity of biochar depends on the products it is created from, the main uses include:

A. Use as an energy storage material. Because carbonic material is combustible, biochar is a relatively high density means of storing energy;

B. Use as a filtration medium. At its most pure, "activated charcoal" or "activated carbon" but also used for lower-purity filtration. Uses include the medical, scientific, industrial and commercial sectors for odour management, particulate containment, but also water filtration and applications that don't require high purity, e.g. liquid waste etc.;

C. Use as a soil amendment to rehabilitate soils lacking structure or requiring improved water and nutrient retention, including use as a natural, organic fertilizer. Biochar's moisture retention capabilities supports communities with water scarcity or where nutrients are being washed out of the soils;[43]

D. Use as a mechanism to sequester carbon. It is one of the few viable and proven ways to be carbon negative, especially for Municipal Solid Waste, which is mostly atmospheric carbon. For every 100 tonnes of sorted MSW or food scraps for example, biochar can

[42] Char or charring refers to the darkening of a surface from combustion. It may be a charring of non-organic matter whereas biochar relates specifically to organic matter as described above. Some consider biochar as designating its use for organic purposes.

[43] An Overview of the Current Biochar and Activated Carbon Markets (Hugh McLaughlin, PhD, PE — Lee Enterprise Consulting, Inc. BioFuels Digest October 11, 2016).

sequester up to ≈35 tonnes CO_2e, which is a substantial potential contributor to GHG reduction commitments given this can be achieved incidentally to processing municipal biosolids or solid wastes.

While biochar's use can be traced back over 2,500 years, its wider utility has only recently been understood as a way to reduce Green House Gases.[44] Unlike many other approaches to GHG reduction through sequestration – which incur costs – biochar is a saleable, organic commodity, which reduces sequestration costs. It is also less energy-intensive to produce and qualifies as a "green energy" source, with lower GHGs.

Advanced Gasification biochar will vary depending on the source material, so the feedstock has to be assessed and tested to determine the most suitable market and process. Based on tests, sales can then be pre-contracted to reduce risk in the business case.

Primary uses for char & biochar

1. Animal farming – ≈90% of the market in Europe
   - Litter, silage and slurry agent/treatment
   - Feed additive / supplement
   - Manure composting agent
   - Water treatment in fish farming
2. Soil conditioner
   - Fertilizer, compost additive or substitute
   - Plant protection
   - Trace element substitute/rehabilitation
3. Building sector
   - Insulation material & humidity control
   - Air and sub-soil decontamination
   - Electromagnetic radiation barrier
4. Decontamination
   - Soil remediation (mine-works, military bases, landfill etc.)
   - Soil and wastewater filtration
   - Pesticide barrier
   - Pond and lake water aeration & filtration
5. Anaerobic digestion & biogas production
   - Biomass additive in anaerobic digesters
   - Biosolids and digestate treatment/filtration
6. Water & wastewater
   - Active carbon filter for wastewater treatment
   - Pre-rinsing additive for wastewater treatment
   - Soil substrate for organic plant bed wastewater treatment
   - Composting toilet wastewater treatment
   - Micro- and macro-filters for potable water
7. General commercial & industrial
   - Exhaust filters for emissions and intake
   - Industrial material – carbon fibres, plastics etc.
   - Electronics – semiconductors, batteries etc.
   - Metallurgy and metal reduction*
   - Cosmetics – soap, skin-cream, bath additives etc.
   - Paints and coloring, e.g. colorants, industrial paints
   - Energy storage/production* – pellets, lignite substitute
8. Medical - Detoxification, pharmaceutical carrier, topical etc.
9. Fabric additive – underwear, insulation, deodorant etc.
10. Wellness
    - Mattress/pillow filling to address odour, toxins etc.
    - Electromagnetic radiation shield – microwave ovens etc.
    - Food Conservation

*All uses are considered to sequester carbon except as noted by **

Figure 50: Biochar Uses

Market

The biochar market is expanding as new uses are identified and while supply is also increasing, demand is currently outstripping supply, resulting in rising prices. The following comments on the nature of the market as at late 2019.

The price of biochar varies depending on its characteristics and by market. There have been several qualified assessments of biochar markets, mostly focussed on activated carbon (i.e. the filtration market) because this is better developed with known retailers.

The "Global Activated Charcoal Market" report[45] assessed revenues and volumes from 2013 with projections through 2025. It concludes the activated carbon market was estimated at

[44] See the International Biochar Initiative (IBI) and the United States Biochar Initiative (USBI).

[45] Global Activated Charcoal Market (Androit Market Research, 2019).

US$4.72 billion in 2018 and is likely to exceed US$6.60 billion by 2025 with a broad array of sector demand for activated carbon, shown in Figure 51.[46]

A 2013 survey conducted by the International Biochar Initiative ("IBI") indicated prices between US$73/tonne and US$12,267/tonne, but did not distinguish biochar quality or whether the product is wholesale or retail. A 2014 IBI study found the mean price to be US$2,286/tonne[47] and by 2016, as demand and supply expanded in lower value ranges, that the mean price dipped to US$1,820/tonne.[48]

Roskill Market Reports[49] noted that internationally, the average value of shipments from the USA increased from US$2,700/tonne in 2012 to US$3,822/tonne in 2016. They expect international demand will raise US prices for speciality biochar grades, pressured by this international demand.

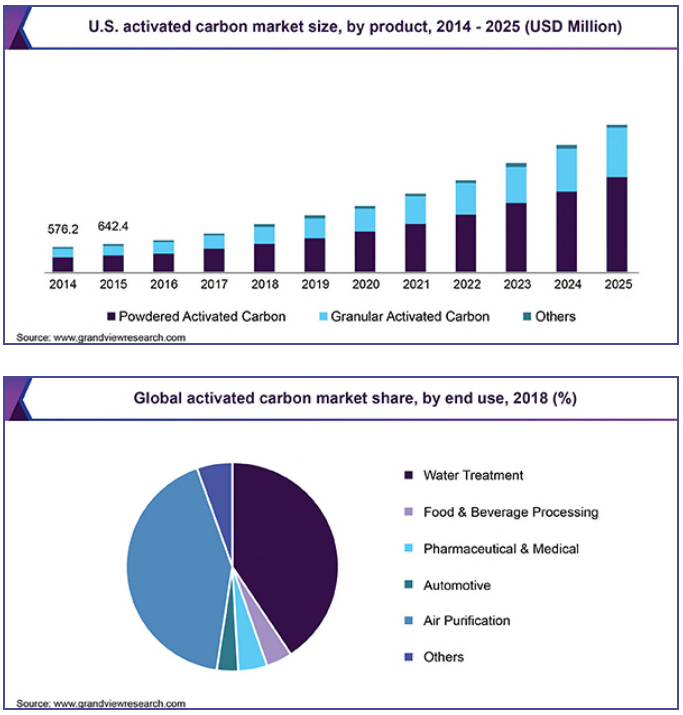


Figure 51: Activated Carbon Value & Demand

A 2018 US Forest Service analysis,[50] reported prices paid for biochar upward from US$660/tonne with an average price was US$1,134/tonne, but with US$1,758/tonne the most often cited price. This mostly considered soil amendment biochar however, which typically achieves lower values than filtration biochar. The report expects demand to continue to rise, outstripping supply, so prices are expected to rise despite expanding supply.

In summary, recent studies have shown an increasing demand and price for qualified biochar with the most recent studies showing it at a minimum US$2,000/tonne for soil amendment and lower quality biochars, with higher values paid for filtration medium. Wholesale prices are typically 25-50% of retail, subject to certification, and demand and prices are expected to rise for the foreseeable future.

In November 2019 we reviewed online biochar sales, mainly in the US. Listings are mainly for small retail packages of char sold as an amendment or for filtration, shown in Figure 54. Listings averaged ≈US$15,000/tonne for filters, ≈US$7,550/tonne for

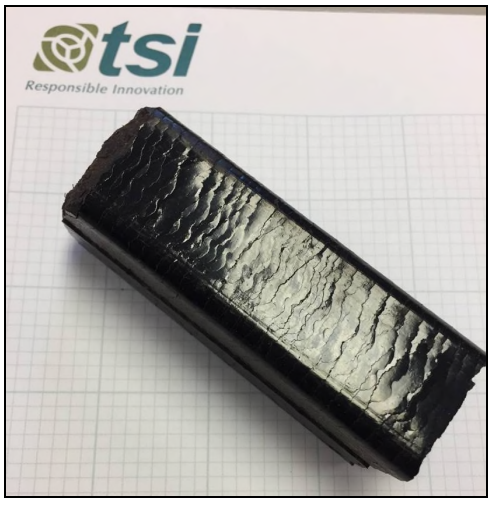
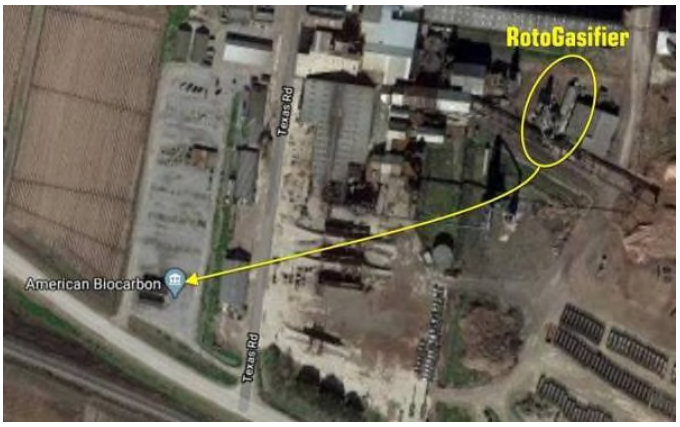


Figure 52: Rotogasifier Biochar

[46] Grand View Market Research study summary.
[47] Applied Energy study, (Campbella, Anderson, Daugaard & Naughton, 2
[48] Biochar vs Activated Carbon (Finger Lakes Biochar, 2016).
[49] Roskill Market Reports (2017 activated carbon forecasts to 2025).
[50] Survey and Analysis of the US Biochar Industry (Preliminary Report, 2

soil amendments and the overall median is ≈US$10,000/tonne. 78% of list prices exceed US$5,000/tonne.

Generally, the higher quality biochar requires certification and attracts a higher price as filters than as a soil amendment. Note also that gasifiers can recycle filters and resell or improve energy yield, increasing productivity and value.



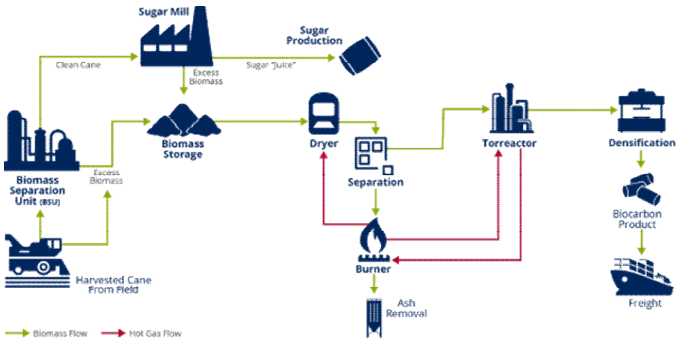


Figure 53: American Biocarbon Process, Louisiana

Sale price differences are mainly influenced by: (a) impact of product branding, marketing and market dominance of specific brands; (b) size of the individual package being sold – with smaller packages commanding a higher price per metric tonne; (c) the quality and certification, with filtration typically using a higher quality, more expensive biochar. Where used as an energy fuel the price is expected to relate to the price of electricity. The White Castle, Louisiana RotoGasifier plant produces biochar able to be used either for generation or other highest and best uses, making it a flexible product saleable into multiple markets (Figure 53[51]).

A characteristic of biochar is that it sequesters carbon when used as a soil supplement or 'buried'. Since municipal waste (liquid and solid) are largely atmospheric carbon in nature, biochar can sequester approximately 2.9336x its tonnage as tCO_2e (per academic assessments). This not only applies to soil supplements, so only energy use of biochar would fail to sequester carbon. The market benefit of sequestration is currently not being fully reflected in either market demand or pricing.

Quality

Currently, most biochar is sold without compliance with standards, which are increasingly developed around the International Biochar Initiative (IBI). This covers aspects such as chemical parameters, toxic elements, origin, feedstock, composition, metal and other properties (such as, moisture, organic carbon, C:H ratio, ash, nitrogen, pH, electrical conductivity, lime content and particle size distribution). Certification carries the "IBI Certified™" seal. Going forward we expect certification will be more important for uses that require quality control, e.g. laboratory or medical uses, than other uses.

With variable feedstocks, biochar is tested regularly to asses whether its properties create challenges with the intended use. Advanced Gasifiers can be adjusted to improve biochar

[51] See also American Biocarbon web site. Process diagram courtesy of American Biocarbon.

quality and volume, or to reduce aspects such as volatile organics. Organic feedstocks (wood, kitchen scraps and other organics) may mean adjusting separation to meet the quality required for specific markets. This means that the biochar's value can vary but is controlled through ongoing testing and specific application.

Advanced Gasification biochar (from wood chips) has been tested against IBI Standards and while they did not seek certification, the biochar is sold to the City of Woodland, CA for US$750 per ton. TSI tested organic-based biochar with electron microscopy and confirmed the high quality lattice required for quality biochar. Pivotal also supplied samples to University of Calgary researchers who considered it would be suitable as a soil amendment, with final confirmation being project- and feedstock-specific.

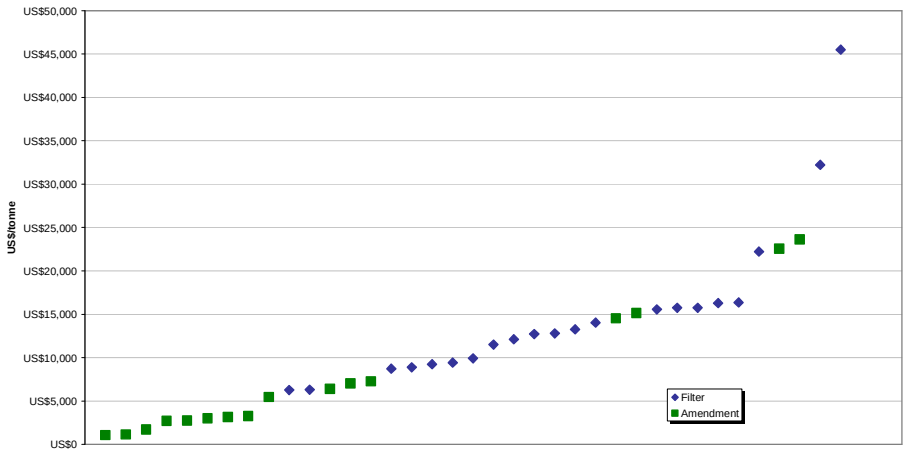


Figure 54: Retail Biochar Prices, 2019

Conclusion

Biochar is a product and market that is gradually maturing. A range of values are proving feasible, with increasing demand, linked to biochar quality and volume, which varies by feedstock and yield, so biochar futures are currently limited. Advanced Gasification biochar can improve revenues while potentially sequestering carbon, making it an area of rising interest. Because biochar value can affect Advanced Gasification project viability, biochar potential should be assessed through testing and using Pivotal's IRM model, so the project, feedstock, operations and contracts can be aligned to optimize potential.

Appendix 4: Grants

FEDERAL

1. Federal Infrastructure Fund – started in 2016 with $518m, and now has committed $9.2 bn for green infrastructure and clean technology projects that stimulate the economy with a focus on GHG emission's reduction and economic development at the community level, and includes solid waste management projects. The fund is open for applications. The IRM project would qualify for this funding.

    a. Green Infrastructure Fund – The current Phase II round of funding has been allocated, however, there are likely to be follow-on programs for renewable energy from solid waste management, GHG reduction and community climate action programs. The IRM project would be a suitable project for this funding.

    b. Municipal Climate Innovation Program is delivered by FCM and extends through 2022. It is designed to assist communities to adapt to the impacts of climate change and assist with GHG emissions reduction. The IRM project would qualify for funding under this program.

    c. Gas Tax Fund focuses on core infrastructure needs but does not specifically mention solid waste management but it may be applicable for the Township's IRM program with its benefits in resource recovery from wastes, GHG emissions reduction and potential revenue streams.

    d. Natural Resource Canada – The Clean Growth Program has $155 million for investment in the demonstration of projects in clean energy with an emphasis on GHG reduction. They are currently not accepting applications but are to in the future.

2. Western Economic Diversification program funds innovation initiatives for clean tech. The funding calls have very short application time frames. The IRM program would appear to qualify under the acceptance criteria for funding.

3. Green Municipal Funding Program has $120 million for feasibility studies, sustainability plans and waste management projects making it ideal for the IRM program. It is open for application.

New grants have been publicly mentioned, related to COVID-19 measures. These are changing rapidly so are not detailed here.

PROVINCIAL

1. Energy Mines AND Petroleum Resources – Community Energy Leadership Program provides funding for clean energy project owned (incl. partial ownership) by local Government or First Nations. Funding supports communities to reduce GHG emissions reduction, stimulate economic development and promote partnerships with industry to advance the clean energy sector. Going forward funding will be on a project by project basis. Previous funding ranged from $10,000 to $175,000 per project for construction costs. Contact is Nairn Albrecht, Ph: 1.778.698.7166; email is celp@gov.bc.ca.

2. Ministry of Environment and Climate Change Strategies and Municipal Affairs administer the CleanBC Communities Fund (CCF) which target capital infrastructure projects for public use and benefit to meet the following outcomes: increased capacity to manage renewable energy; access to clean transportation; energy efficiency of buildings and generation of clean energy. Calls for applications are not scheduled at this time. Available funds total $63 million. Contact: Municipal Affairs at 1.250.387.4060; email is infra@gov.bc.ca.

3. Municipal Affairs and Housing – Infrastructure Planning Grant Program offers funding to local government that supports energy and climate change action. Grants are provided for projects to study the feasibility costs and technology options. The funds are available to match funding up to $10,000. Contact: Municipal Affairs at 1.250.387.4060; email is infra@gov.bc.ca.

MUNICIPAL

1. Western Economic Diversification – Regional Inn ovation Ecosystems Program provides funding to municipalities for clean energy and added value agriculture projects. The IRM project would qualify for the clean energy and biochar production which could be used as an advanced soil supplement. Contact: Ph 1.604.666.6256.

2. Federation of Canadian Municipalities (FMC) – The Green Municipal Fund supports projects that reduce energy consumption (generating GHG reductions) and improve air, water and soil quality. Funds are available for planning, feasibility studies and pilot projects. Low interest loans and grants are available for capital projects. The IRM project would qualify for this funding program. Applications are open on a project by project basis.

3. Union of BC Municipalities (UBCM) provides funds for capital and planning projects for energy, sustainability planning, solid waste management, transit, water and wastewater. The IRM project would qualify for this funding. Contact: Ph. 1.250.356.5134; email ubcm@ubcm.ca.

4. Real Estate Foundation of BC provides matching funds for planning studies with single or multiple phases for renewable energy projects. Applications are due in February and August annually. The IRM project would qualify for this funding but call before submitting application. Contact: Ph. 1.866.912.6800; nick@refbc.com.

5. VanCity Credit Union – Community Partnership Program provides funding for planning and assessment of community based clean energy projects that address sustainability and climate change action. The IRM project meets those criteria. Funding maximum is $10,000. Applications are open.

6. Columbia Basin Trust provides funding for community based clean energy project development up to $50,000. The IRM project qualifies for this funding. Contact: Ulli Mueller; Ph. 1.800.505.8998; email umueller@ourtrust.org.

7. BC Bioenergy Network provides funding for municipal projects on a project by project basis including partnership funding. Funding is focused on technology feasibility, development engineering design, project management t, and capital costs. The IRM project would likely qualify for this funding. Contact: Scott Stanners; Ph. 1.604.889.4549; email scott.stanners@bcbionetwork.ca.

Appendix 5: Study Team

Person	Role & Qualification
Graeme Bethell	Graeme is a gasification specialist, President and co-founder of Pivotal IRM. He specializes in the integration of solid and liquid wastes and biomass to produce clean heat (cooling) and power (CHP); biochar markets; and district energy systems. As a Technical Specialist, he specializes in advanced gasification, sustainability and climate change, with a focus on community invigoration through job creation, integrated energy resources, carbon reduction, environmental sustainability and economic development.
Chris Corps	Chris is a Land Economist and is CEO and co-founder of Pivotal IRM. His experience has included feasibility and viability assessments for sustainable land development, economic development and energy projects. He specializes in complex business cases and has worked on some of the largest and most difficult projects in Europe and Canada. He has lead international projects and set financial standards in current use in 132 countries covering sustainability and valuation, and has been a leading member establishing government financial standards. Chris originally recommended BC government investigate IRM, which led to the Provincial Integrated Resource Management study, liaising with Treasury Board and Climate Action Secretariat staff. Chris advised multiple ministries and agencies on how to embed sustainability into capital planning and advised on sustainability revisions to the Capital Asset Management Framework, which is BC's procurement policy.
Dr. Matt Summers	Dr. Summers is a professional engineer with a background in both the liquid waste treatment and Advanced Gasification. He specializes in bio-energy system design and analysis and is a Specialist in kinetic and thermodynamic measurement and modeling; manufacturing systems design and analysis, and precision sensors and control systems. He is Chief Operations Officer, West Biofuels, LLC, with responsibilities for design, construction, and start-up of commercial biomass gasification systems, plus he supervises staff, contractors and project partners to coordinate projects and directs the research at their Research Center used for testing technology performance, controls and emissions.
James Pratt	James is a Registered Professional Planner, James brings 25 years of experience as an independent consultant serving governments, First Nations, non-profits, and network organizations. A specialist in

Person	Role & Qualification
	participatory engagement, he facilitates opportunities for meaningful involvement of residents and affected parties who can provide valuable feedback and input. He has provided consultation services as part of planning in local and regional governments, as well as First Nations and non-profit organizations. Based in Victoria since 1995, he has a reputation as a principled, dedicated professional.
Albert Bicol	Albert Bicol PEng LEED AP is internationally experienced in energy systems and sustainable energy master planning and development. Albert's background with Energy Net Zero master planning and development led him to conclude that Advanced Gasification is one of the only ways that buildings can be self-sustaining in term of energy, while reducing carbon. Albert has advised on Vancouver's False Creek development, Shangri-La Hotels in East Asia and is currently advising on projects including a major global airport, a 1m sq ft Vancouver development, a major multinational with 26 outlets in the Lower Mainland alone, and a 1m sq ft multiplex entertainment centre in Japan, all sole sourced and direct awarded and assessing Advanced Gasification. This includes Canadian federal agencies.
Michael Wolinetz	Michael is a Partner at Navius Research Inc., who helped develop the GHG automated calculations in Pivotal's IRM model. We expect to use this in developing GHG assessments relative to Esquimalt's 2030 and 2050 GHG reduction goals where Michael will help evaluate Pivotal's GHG modelling and will review the model's estimates. It is envisaged that this summary reporting will be sufficient at this stage, but Michael would then be able to provide more complete assessment as part of a separate study. Michael specializes in quantifying greenhouse gas emissions and their impacts from actions and policies undertaken by government. He specializes in CIMS energy-economy modelling, in designing and executing energy and air emissions forecasting analyses with this model.

Esquimalt IRM
Public Comments

Prepared for:
Township of Esquimalt
4 November 2020

Jeff Miller
Director of Engineering & Public Works
Township of Esquimalt
1229 Esquimalt Road
Esquimalt, BC,
V9A 3P1

4 November 2020

Dear Mr. Miller,

ESQUIMALT IRM - PUBLIC COMMENTS

During public engagement, respondents' comments were sought for each of the four questions as well as general comments. This document lists the responses received.

Yours truly,

Graeme Bethell
President
Pivotal IRM Inc.

Chris Corps
CEO
Pivotal IRM Inc.

cc

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Table of Contents

1 Preface

During public engagement, respondents' comments were sought for each of the four questions as well as general comments. This document lists the responses received. Not all the respondents answered every question, nor did they provide comments for every question.

All the comments received are reported herein, without exception or alteration, exactly as received. The survey system used by the Township reports individual IP (Internet Protocol) addresses for responses, so these are also reported. For privacy and confidentiality reasons, and to improve the impartiality of results, the actual identity of respondents was not tracked and is not known.

For further information on public engagement please refer to the Summary Report or contact Pivotal.

2 Q1: Overall Support

"What is your level of support for Esquimalt creating an integrated resource management facility?"

IP Address	Comment
24.69.193.39	Local processing to reduce transport
70.67.50.132	It is important to find alternative methods of using waste as a valuable commodity rather than as a nuisance taking up acres of landfill.
192.252.235.212	demonstrate leadership and actually make an impact on GHGs
154.20.45.178	Primarily for its environmental benefit of reducing GHG emissions and diverting waste from landfills. Secondly for its cost efficiency. Thirdly for its simplification of waste sorting at the household level.
207.6.183.225	It's climate change benefits and energy benefits for Esquimalt
24.69.200.159	The proposal sounds interesting, but at $21 million I need to know more about the long-term benefits and potential cost-savings that will be passed on to residents.
70.67.45.248	This is win-win based on the information presented. Lower GHG emissions, address Hartland landfill restrictions, and possibly even generate income.
70.66.172.244	environmental benefits and climate change goals can be helped
204.191.179.50	to tackle climate change by reducing greenhouse gases
70.66.169.93	This is something that should be done as a region and set up at Hartland. We need to deal with things collectively, having a population of 15,000 deal with garbage in isolation of a population of 450,000 is a waste of money
24.68.225.81	This is the most progressive and environmentally friendly way to deal with the waste our communities generate.
70.67.56.75	Cost in a time when money is tight for everyone. Impact to property taxes was not clear to me.

173.181.101.102	Esquimalt needs their own composting facility.
50.98.167.60	Appears to be an excellent way to meet our targets and provide enhanced services to the community.
209.52.88.94	It will create jobs and help the environment. If its anything like the famous facility in Europe, the town will be able to sell the byproduct and eventually be able to process some of the other greater Vic waste
24.68.8.51	Too expensive
24.69.205.114	It seems like it will benefit out air pollution
24.69.133.30	Interesting idea but concerned about risks
172.218.235.236	Gassification of materials is not recyling or diversion - there are much better higher value solutions such as composting, actual recyling into new products, and waste reduction efforts that make a better long term impact
24.69.201.188	It doesn't belong in a residential neighbourhood. Its not been done anywhere else before and this is an industrial application. Risks are too high compared to benefits.
162.156.84.63	Great opportunity for the township
24.84.145.46	Long term investment in our climate and also financially responsible.
207.194.133.9	After reading the FAQ, this seems like a no-brainer. Less cost plus less GHG emissions, plus useful byproduct, plus less landfill. Why would we not do this?
184.69.124.230	GHG reduction
173.183.120.47	it's the future for dealing with man's waste contaminants but needs to be science based
199.7.159.40	Good for environment & being a leader
70.66.169.19	We cannot keep dumping in the landfill. We must recycle or deal with our waste. IRM promises benefits, with possible revenue, over composting -- including dealing with a wider number of waste types. I think it's great that my community is looking at these alternatives.
70.66.164.224	Need more information
64.114.222.234	Landfills are not the answer. They will come back to haunt us.
70.67.44.126	Theoretically, it sounds wonderful. I just don't understand enough of the physics/etc. to give a 'strong in favour'

70.66.166.29	Sounds like a sound environmental decision
70.66.179.239	This is a similar concept that was proposed in 2009 when the sewage treatment discussion started, the residents wanted all the waste to be processed on site.
70.66.172.179	Although a great idea, it should be coordinated at the regional level.
173.183.122.88	It's an incinerator. A really expensive one at that.
209.205.88.238	Great idea, very progressive move for Esquimalt
70.66.167.192	it has a strong business case and I support the potential GHG reductions
70.67.50.169	It makes sense to reduce our emissions through this process
75.154.249.172	Good to see the Township playing a leadership role - should generate learning and demonstrate positive results (even if all does not go as planned)... learning along the way.
209.205.88.238	There seem to be many benefits to this program including environmental ones
154.20.47.89	We need to divert from Hartland landfill before it becomes too full. Reusing energy in our own community is a win win. We need to be more green and cut our carbon emissions.
216.13.208.106	It is a smart method that could likely be expanded to assist in other uses such as dealing with biosolids and other waste materials.
96.54.245.233	reduces greenhouse gases
96.54.233.169	landfills create methane which is worse than carbon pollution. We're in a climate crisis.
70.66.254.45	Need to switch to a circular economy with zero waste. One municipality in the CRD has to take the lead to entice the others.
70.66.254.45	zero waste ; need to shift to circular economy; risks can be managed; one municipality has to take the lead on innovation so the other CRD municipalities will follow.
70.66.185.29	The cost on the tax payer and uncertainty of who will operate it
24.68.98.230	recycle
75.157.24.144	Anything that reduces our footprint and saves us money is a good thing.
107.190.24.120	Environmental benefits, proactive plan to address diverting waste from Hartland before it closes

107.190.24.120	Better than a dump
24.69.196.61	The proposal presented is a good way to reduce landfill and repurpose waste in a positive way.
70.66.184.248	We should be taking care of our own waste!
70.66.188.88	Great to see esquimalt enter the 21 century
70.66.184.248	Better resource than sending our recyclables to who knows where, and keep it out of the landfill. Better for the planet.
70.67.60.64	Excellent use of resource money. In line wiht values and priorities
154.5.145.40	We can't continue to dispose of this to Hartland Landfall.In the long run this will save us money.
70.67.52.188	It works well in conjunction with the Blue Box program and the human waste treatment program
154.20.44.239	1. Major reduction of GHG 2. Potential for tax reduction 3. Make Esquimalt an enviromental leader. The recognition could lead to more businesses in the community and enhance civic pride.
172.218.235.236	Should be done regionally
24.69.208.85	We already have a garden/kitchen waste program in place. So why are we duplicating this? It seems to me to be more of a money grab for the municipality than anything else.
205.250.53.78	While I support any project that would reduce GHG and curb landfill waste, I need more convincing this will be an odour free facility.
173.183.123.52	need to see more info
70.67.56.99	Sounds like we'll be able to manage the waste from our municipality in an environmentally responsible way.
70.67.44.53	Innovative, generates energy and revenue, reduces traffic to landfill, GHG reduction
75.157.27.116	It makes financial and conservation sense to me.
72.143.239.77	It makes economic and environmental good sense.
154.20.45.179	It looks like a great way to generate long term income and reducing landfill waste
173.183.121.9	The way of the future. We have to deal with our own refuse and we can use the end results (bio char)

70.66.167.25	We need to make sure our waste does not go to a landfill.
70.66.167.104	Esquimalt being proactive
70.66.154.155	Unproven as of yet.
70.66.177.189	Climate change emergency
70.67.48.151	Everything should be done to reduce dependence on traditional landfills, because they are not satisfactory or sustainable.
70.67.50.8	Seems unproven, despite claims. At 9000 tons for 1.7M O&M that's almost $200 a ton to process, which is higher than hartland or transport to metro van facilities. Revenues seem to be a leap of faith and would require additional investment to get heat to the end user. Math is not adding up. Seems like a sales job. Let someone else in bc do it first, dont gamble our tax dollars.
70.67.56.73	reduce
107.190.20.30	It seems like an efficient green system that improves on the current one
173.183.120.227	Waste management is an issue in the region and this seems like a strong strategy from financial and environmental perspective
162.156.84.63	It is such an important environmental step towards becoming net zero emissions • GHG reduction • Heating & cooling, not electricity • Landfill diversion • Carbon sequestration
24.244.23.60	Sounds easier as far as sorting at home, and good for the environment
70.66.186.198	This is the future and the right thing to do financially and environmentally. A perfect plan as proposed and opportunity to showcase esquimalt as a true innovator.
154.20.47.249	Managing our municipal waste in a planful long term way is important. Possible cost recovery down the road.
70.66.172.177	The CRD voted against this option based upon poor financial outlook, Esquimalt doesn't need to be the front runner in our region for this technology.
24.69.193.180	I'd love to see us be a leader in green technologies
24.69.196.204	Need to know cost first
207.6.182.232	Waste should be managed at source.
70.66.177.234	its important to manage garbage and resources efficiently

70.67.52.53	Limited space , proximity to downtown (land value to great) uncertainty of the technology and risk of smell.
104.142.125.194	As long as it doesn't stink up my neighborhood or bring increased truck traffic.
154.20.45.35	All Island communities should be doing this. Esquimalt can show it’s possible!
70.67.62.111	Would be great having a place close by
70.67.50.37	I dont know enough about it.
70.67.60.39	Meet the needs of waste management with less transport of materials to landfill
70.67.50.83	I will always support more green initiatives, it's more than important right now
70.66.161.214	It's good for the environment
204.191.179.50	cost benifit
70.66.177.162	It helps in regard to global warming, and we really have to stop using so much land just for garbage
50.92.249.27	Recycle don't burn it
206.87.177.45	We need to find wasy to ambitiously reduce GHGs and deal with waste in a new, environmental way. YET
154.20.46.120	GHG mitigation and economic development
209.205.88.211	Costs feel underestimated and best case scenario
70.67.49.173	Potential to eliminate microplastics polluting our oceans.
24.69.200.68	Anything that cuts down on the waste that could filter into our oceans is a good thing.
70.66.170.178	Brilliant in every way!
70.67.61.73	This should be a CRD project. We have very limited funds in Esquimalt. Unless the business ase is less than 4 months, please shut this down and focus on higher priorities
173.183.123.56	seems like a very responsible thing to do in addressing climate change and waste management
173.183.122.41	Less traffic to hartland and effective disposal of waste material

70.66.165.204	This seems like a very viable alternative to landfill and has benefits directly to the township as well.
154.20.46.154	To help with climate change goals
70.67.52.16	Home grown climate action
70.67.53.200	better waste management, aid to meet climate change golas
172.103.218.169	It is incredibly important to generate and consume energy in a responsible, environmentally friendly, and cost-effective manner. That said, I am concerned about the cost of investment in this IRM facility, and the timeline for return on that investment.
70.66.170.26	Forward thinking - considering the capacity limitations at Hartland and GHG emissions
204.191.179.50	Report errors and creative use of statistics
192.99.110.132	We need to replace the present system before the landfill has to be replaced. Finding a new site will be a major challenge.
24.69.217.96	It appears to work successfully in European countries and helps us to the Esquimalt goals for waste reduction.
172.98.82.13	Managing our resources effectively is food stewardship, saves $ in the long run, sets a food, positive civic example of responsibility
209.52.88.19	Duplicates services
104.142.125.239	Landfill diversion
24.69.209.86	Sustainable approach to waste stream with benefit to environment and to taxpayers
173.183.120.210	Environmentally contentious change
70.66.160.111	reducing waste going to landfill, very efficient method of dealing with waste
70.66.165.204	Seems like an excellent way to protect our planet and reduce GHGs
70.66.174.4	Uncertain about the environmental impact of this technology.
209.52.88.26	Introducing an energy loop system had tremendous benefits to the community as does the reduction in GHG associated with transport of waste to Hartland.
70.66.166.29	Seems like a good step for the environment

173.181.100.67	Need to know more about it (short of watching a 90 minute video) but if it's reasonably cost-effective I strongly support it
173.183.122.1	Provided it lives up to expectations, it sounds very good
70.67.56.43	I've read the technical details and it looks like a cost-effective way to manage waste and sequester atmospheric carbon.
70.67.61.85	we need to reduce our waste
104.142.126.74	Environmentally and fiscally responsible.
184.70.226.222	anything to lessen emissions, reduce waste to Hartland, increase efficiencies, provide useful byproducts
70.66.169.165	To reduce waste and our carbon footprint
70.67.61.85	Handling wastes in a responsible manner is important.
24.69.221.82	Garden waste should be integrated into our green bins and utilized to make our community more self sustained.
70.66.176.146	This is a fantastic opportunity to reduce carbon emissions and create revenue.
24.69.196.61	Sounds like it might reduce landfill
216.180.65.21	The technology is very new and costly
64.180.144.106	Local leadership on environmental stewardship.
24.69.210.24	Responsible environmental stewardship
24.69.209.27	It seems to be an ecologically responsible way to manage the huge amounts of waste we produce
70.66.173.36	Enhancing community self sufficiency, creating a local revenue stream, re-envisioning 'waste' as a resource
75.157.10.22	More efficient use of resources.
70.66.166.92	We need to be part of a global solution to reducing waste & GHG
70.66.166.92	reduction in landfill, reuse of waste materials, alternate energy source for city
154.20.44.152	landfills are unhealthy and local solutions are preferable
70.67.46.129	Many reasons - ecological mainly.

70.66.177.196	We are running out of time to tackle climate change and this will take a huge chunk out of our GHG emissions and it comes with many co-benefits on top of that.
70.66.185.104	Landfills are not the way to move forward for the planet
71.19.248.82	A process and contemporary approach in managing waste and our future.
108.172.255.10	We all need to work towards a sustainable future
70.66.167.197	No land waste
70.66.251.119	Responding to the climate crisis by tackling GHG emissions locally is critical. The proposed project also makes sense economically. Congratulations to Esquimalt for taking the lead
154.20.32.23	Briefly, while others "talk" about reducing landfil and carbon emissions, Esquimalt is looking to "do" something. Plus, the plant is guaranteed to perform or the company doesn't get paid.
24.85.252.35	I am very concerned about climate change and believe that the facility as analyzed by your science experts is one kind of solution
192.252.235.212	Reduces GHGs, deals with non-recyclable material and diverts it from landfill while generating energy.
66.220.149.29	IRM is quite visionary and a great solution for reducing solid waste, creating clean energy to displace fossil fuel use and reducing GHGs at the same time.
70.66.166.180	It sounds like a win win.
70.66.174.100	Proactive for environmental impact reduction.
70.66.174.100	This is a much better way of dealing with organic waste than what is currently in place. Isn't garden waste for all of the CRD currently trucked to the lower mainland? There has to be a better solution.
70.66.190.248	This makes environmental and economic sense. We need to address climate action now and this is a brilliant start and one that could make the citizens of Esquimalt proud and show the rest of North America what is possible.
70.66.188.224	Really significant action are need/critical to address the climate emergency
154.20.45.136	I support any reduction in waste and creation of clean energy.
70.66.184.201	Will probably stink, be over budget

70.66.189.58	The initial capital investment is quite high for the size of Esquimalt and may not see revenues for quite some time. Why wouldn't the CRD be doing this?
154.20.47.165	Resource conservation is extremely important but I am not sure that the current proposal is the BEST solution. More research and thinking should go into this before proceeding
142.104.165.184	job creation and better for the environment
70.67.44.53	landfill ongoing issue, would be good to create local alternative
24.244.23.120	Greener waste management
209.52.88.226	Details are few but it appears to be both environmentally beneficial and economically sound.
75.154.237.174	resource recovery is a step in the right direction for reducing our municipal waste
154.20.47.19	sustainability and green aspects
173.183.121.216	Concern about the environmental impact i.e. air pollution. And no knowledge about the company behind it.
24.69.201.11	This initiative helps advance climate action in the region.
70.67.45.179	Gasification seems like an environmental approach that would fit well in Esquimalt and move us toward our goals for sustainability.
70.67.48.163	it's important for Esquimalt to explore all possibilities to reduce our GHG emissions.
142.36.177.142	landfill reduction, cost effective waste disposal
70.67.60.129	I will take literally any improvement over what we have.
70.67.53.175	GHG reduction, waste managment, etc. also I am from europe and understand how beneficial it has been there.
24.69.217.172	Benefits to the environment, creative use of garbage that would otherwise got to the landfill
204.191.179.50	More effective waste management
104.254.92.222	It's about 30 years overdue.
72.143.232.113	It’s a win win no brainer. Go for it.

70.67.58.137	Environmental benefits, business model and lack of significant local impacts
70.66.189.96	Zero waste is an admirable goal for Esquimalt
184.69.25.222	environmental impact, cost savings in the long run
70.66.172.57	The benefits of increasing our taxes with this project isn't abundently clear
24.69.209.27	Sounds like a no waste solution and I am all for that,
72.143.238.93	GHG reductions
70.67.49.219	The future is now!
154.20.44.230	The long-term environmental and fiscal benefits appear to out-weigh the costs.
70.66.173.49	I'd rather not be the first to have this in North America.
173.183.122.1	Somewhat opposed to construction of additional industrial style processing facilities. Seems like esquimalt is becoming the waste processing hub of greater Victoria with the waste treatment plant already under construction. It also seems that it would be better to use the waste to generate soil and fertilizer which is lacking on this side of the Malahat and keeps being trucked in. On the whole it seems like we're saving trucking but producing fuel instead of soil which may be more sustainable
70.66.172.217	Interested in cradle to cradle, making waste usable and not toxic
173.183.122.1	Seems like a good alternative to landfill.
209.121.229.125	Canteen Road proposed location is not acceptable as it is directly in a residential neighbourhood, not for waste biosolids held and burned in a gasifier
70.67.53.124	We have to find green solutions to manage waste and generate energy
75.154.243.84	It's the future to utilize our resources.
173.183.122.101	I'd love our community be part of reducing our cabin footprint
107.190.24.115	I have long thought that we should have a green bin program, and this is so much more inclusive than that.

3 Q2: Perception of Benefit

"How much do you think IRM in the Township of Esquimalt would be of benefit, to residents and/or to the environment?"

IP Address	Comment
192.252.235.212	reduction in GHGs, energy for pool and ice rink
154.20.45.178	Environmental benefit, cost benefit, Household waste sorting benefit
207.6.183.225	Energy opportunities, reduction of gigs, reduce use of landfill and wear on trucks
24.69.200.159	Reducing GHG emissions, providing an in-house waste management solution and simplifying waste management
70.67.45.248	The benefit is positive, though the extent of the benefit may be overstated in the materials presented. It would be more helpful to show a range based upon the scenarios as to how it is implemented.
204.191.179.50	long term renewable energy source, more self-sufficiency, less trucking of waste creating emissions in town
70.66.169.93	As the previous question, Esquimalts waste is a small portion to the greater regions waste and wouldn't stop the need for the CRD to expand the Hartland dump. Plus this concept wouldn't take in the waste from the private garbage haulers we have in Esquimalt
24.68.225.81	Because it converts 95% or more of waste into energy and biochar with negligible amount of ash. Compare that to landfill or even totally inefficient anaerobic digesters.
70.67.56.75	The township is very small in comparison to surrounding communities and thereby has less of an impact.
173.181.101.102	Reducing pollution
50.98.167.60	IRM would benefit the environment greatly.

209.52.88.94	same reasons as before. Jobs, revenue from by-product and smaller landfill waste
24.68.8.51	Will other municipalities pay us and will we sell the products
172.218.235.236	There are no easy solutions - and these technologies have never delivered the anticipated benfits. Waste prevention and circular economy solutions are the long term goals to achieve
207.194.133.9	See prior answer.
184.69.124.230	GHG reduction, reduced pressure on landfill
173.183.120.47	benefits will only accrue if it is science based and the right options are chosen
199.7.159.40	Reducing waste
70.66.169.19	The benefits are significant to me
70.66.164.224	Only if initial costs DO NOT raise property taxes. Our taxes are already one if the highest in GVRD
64.114.222.234	Moving us into the future before its too late.
70.67.44.126	This is a good start, seems very do-able, and make better ecological use of our waste. We do need to consider other ways to deal with our township's pollution.
70.66.179.239	No more trucking to Hartland, use of energy and biochar that is generated. Possible partnership with First Nations and DND.
173.183.122.88	Because the toxic exhaust it produces will make people sick.
209.205.88.238	Forward thinking municipality
70.66.167.192	Potential source of revenue, good environmental stewardship and much better use of waste!
70.67.50.169	It will reduce emissions and should provide income to help offset costs. Hartland is old fashioned and wasteful
75.154.249.172	Diversion and utilization of "waste" for positive things!
209.205.88.238	Based on the presentation and Q&A sessions there seem to be few negative sides
154.20.47.89	Again, using our own waste to create energy for our community is a great solution.

216.13.208.106	see previous answer
96.54.233.169	Energy is produced from gasification which benefits residents
70.66.254.45	prolong the use of heartland Land Fill; resource recovery benefits for Esquimalt; leading municipality in Canada for zero waste
70.66.254.45	financial return to township; opportunity to redevelop town centre with heating loop. bragging rights to be the first small community in Canada with zero waste
24.68.98.230	fuel generation, lower cost.
75.157.24.144	Great reduction in waste.
107.190.24.120	Divert solid waste from landfill, produce biochar for sale
24.69.196.61	Regardless of potential financial benefits, the reduction of landfill and using waste to heat/cool the core is a great benefit.
70.66.184.248	It would give us a lot of ecological benefits
70.66.188.88	Less to Hartland
70.66.184.248	cleans up our own backyard.
70.67.60.64	Reduction of sorting. Revenue streams, and overall imprioved environmental impact of current systems
154.5.145.40	Long term savings.
70.67.52.188	The technology works more effectively in more domains.
154.20.44.239	1. Potential to reduce taxes 2. Reduction of GHG
172.218.235.236	Environmental claims do not account for waste diversion or crd improvements at Hartland
24.69.208.85	See answer to previous question.
70.67.56.99	It will reduce our negative environmental impact and ideally create some jobs.
75.157.27.116	Reduction in waste and potential reduction in property taxes
72.143.239.77	There is no “away”. We should all be responsible for dealing with our “waste”. This “waste” should be seen as a resource.
154.20.45.179	The dump is filling and energy prices rising, all regions in the crd will have to find alternative soon

173.183.121.9	Bio char. Not talking our garbage on another site (Hartland) less transportation of garbage
70.66.167.25	We would be doing our part in waste management.
70.66.167.104	eventually will benefit to have this in place....for cost, and GHG
70.66.154.155	Cost vs benefit is the big concern. If CRD does not advance IRM with a bigger budget and staff to explore, why is Esquimalt so convinced it will work?
70.66.177.189	Higher global benefit
209.52.88.56	Less trucks to ship elsewhere
70.67.48.151	I am intrigued by the possibility of creating biochar, which is an extremely beneficial part of soil remediation and improvement.
70.67.50.8	Not convinced that everything will be as perfect and smooth as proponent says. Tough to get rid of biochar still for example. This could add costs if assumptions are that there's a market for this.
162.156.84.63	Better use of our waste, produce energy and make our community and environmental leader
24.244.23.60	Sounds like a modern ethical solution to waste issues
70.66.186.198	$360 annual return for residents sounds good. Anything to reduce property taxes will be broadly favorable and this is a better environmental approach.
154.20.47.249	Cost recovery, product is usable to heat municipal facilities
70.66.172.177	The financial balance didn't work at a regional level and it won't work at a municipal level.
24.69.196.204	Need to know the cost first
207.6.182.232	Reduced transport cost; potential to generate electricity to power garbage trucks.
70.66.177.234	lower taxes from the province, less in transportation costs, energizing community attitudes
104.142.125.194	From the PowerPoint provided for this project it looks promising for the environment
154.20.45.35	Less need to separate wastes = less contamination in waste, recycling or compost streams
70.67.50.37	I dont know enough about it.

70.67.60.39	Does not address source, but better option than status quo
70.66.161.214	the decrease of pollution
70.66.177.162	It gives us all an opportunity to participate in combatting global warming, and also makes us less dependent on using land for waste
50.92.249.27	everyone will have to breathe the fumes
206.87.177.45	If ollutants are stictly contolled.
209.205.88.211	New jobs, reduced GHG emmisions
70.67.49.173	It generate heat that can be distributed to households.
70.66.170.178	high enviromental benefits,
70.67.61.73	Value for money is critical. We need Esquimalt Neighbourhood Plans before this. Will Esquimalt have a supported plan for 50% more population.
173.183.123.56	same as before plus less sorting
173.183.122.41	Less emissions
154.5.236.152	dont know enough about iy
70.66.165.204	Avoiding burning, pile up, and harmful emissions is a good thing.
172.103.218.169	The magnitude of carbon offset is fantastic, as is the reduction of landfilling. The resulting Bio char product would prove valuable to homeowners with gardens.
70.66.170.26	Beneficial to the environment and hopefully, of financial benefit to residents
204.191.179.50	Report errors and creative use of statistics
192.99.110.132	It will save the Township from having to participate in the process of finding a new landfill.
172.98.82.13	We need to move with the times in the manner we manage our resources, how they are used
209.52.88.19	Not sure
104.142.125.239	Simplified waste streams would facilitate diversion for residents facing challenges.
24.69.209.86	Offset landfill waste, create sustainable energy/heat, viable/sellable end product (char)

70.66.165.204	Enviro friendly and potential monetary benefits
209.52.88.26	Beneficial as it provides new incentives for redevelopment of lands and existing buildings to connect to district energy loop.
70.66.166.29	Pride that treating our kitchen and garden wastes are helping the environment
70.67.56.43	I don't think the locals would notice much day-to-day benefit, but I think the environmental impact would be huge, relative to what we're capable of as a small community.
70.67.61.85	we will be reducing the amount of waste that goes into the environment endangering animals on land and sea
104.142.126.74	addresses environmental concerns and generates revenue
184.70.226.222	seems like cost efficiencies would be benefit, plus increased awareness, knowledge and pride for doing the right thing
70.66.169.165	Reduce long term waste costs and operational costs of public buildings
70.67.61.85	It's a responsible waste disposal system.
24.69.221.82	Most waste picked up by our fortnightly pick up. Saves people transporting themselves and extra vehicle traffic on road as well as the benefits of the IRM process as well.
70.66.176.146	Potential profit, reduced greenhouse emissions from reduced transport, carbon capture in biochar, district heating, biochar for residents.
24.69.196.61	Reducing landfill, gasifying should make it usable.
216.180.65.21	I've done some research on IRM and gasification and the results are mixed. Some critics say the process is actually more harmful to the environment.
24.69.210.24	Fewer GHG's
70.66.166.92	waste reduction and reuse, it what appears a lower GHG emission rate than FF burning and reduces need for waste trucking & storage, reduction in habitat loss from expanded waste dumping
70.67.46.129	Less land fill, economic benefit
70.66.177.196	It would save the town money in the long run and provide dividends to the residents. As for the environment the benefits would be massive by creating clean energy to reduce reliance on fossil fuels.

71.19.248.82	On two fronts - one -of leadership responding to protection of our environment and two- to integrating our economic interests and our social contracts.
108.172.255.10	So much better than the current approach to waste management
70.66.167.197	Recycling waste to energy
70.66.251.119	1. Economically the cheapest way of dealing with municipal waste. 2. Defers or avoids the need for expanding the landfill. 3. Massive GHG reduction
154.20.32.23	From the reports in the video, this process not only deals the plastics in waste, but the waste generates revenue, an estimated $360 annual benefit for each household
66.220.149.29	Same reason! We need to address climate change and reduce our waste stream. Esquimalt has declared a climate emergency.
70.66.166.180	We need to reduce the excessive volume of material taken to the Hartland Landfill.
70.66.174.100	It localizes and reduces waste with the added benefit of energy reduction and generation.
70.66.174.100	Any time we avoid transporting anything out of the area is a benefit to the environment. Also, any energy produced that is not releasing great amounts of carbon into the atmosphere is also beneficial to the environment. Anything that is good for the environment is good for residents in the long run.
70.66.190.248	We have the ability to do this and there is no reason why we shouldn't. It makes economic and environmental sense, the consultants are local, the Township declared a climate emergency and needs to walk its talk, and we don't have time to delay. This project is a great fit and could put Esquimalt on the map for all of North America. If there is opposition, it's either from a lack of knowledge, ignorance or personal self interest.
70.66.188.224	Just knowing that some significant action is being taken starts to bring hope that the climate emergency can be tackled
70.66.189.58	This is a study and so the benefits are based on assumptions in ideal conditions.....this seems like a high risk venture.
154.20.47.165	We have to do our part to reduce our environmental footprint. As Canadians, it's what we do best.
142.104.165.184	job creation, and attracting other like-minded businesses

70.67.44.53	reduce GHGs, create alternative source for managing hard-to-manage wastes, create alternative energy sources
209.52.88.226	It's not a panacea for either environmental or cost issues, but may help a bit with both
154.20.47.19	sustainability and green aspects of the project
173.183.121.216	Often more damage is done with treating/incinerating plastics and waste than otherwise
24.69.201.11	We need to find every opportunity to reduce our GHG emissions. This is a small but important action to help us get there. While I'd prefer the focus was on vehicles vs buildings - every step we can take in this direction is positive.
70.67.45.179	Bio-char production.Local.Good impact for our environment.
70.67.48.163	reducing waste and GHG emissions is a great benefit to the community
142.36.177.142	While not all waste is eligible, it eliminates a substantial of non-recyclable product going to the landfill.
70.67.60.129	Because it's better than going to Heartland or the sea. And presumably would generate some revenue, though I don't know how much.
70.67.53.175	make waste management more efficient. jobs, green energy, knowledge that my garbage is being disposed of in an advanced way (rather than merely being put in a hole)
204.191.179.50	probably small benefit but needed
104.254.92.222	It's the third "R".
70.67.58.137	net environmental GHG impact, relatively low cost, demonstrates leadership, possible spinoff opportunities
70.66.189.96	Green technology + jobs = a winner!
70.66.172.57	Isn't yard waste and kitchen scraps already being composted
24.69.209.27	the climate change benefits mostly
72.143.238.93	GHG reduction
154.20.44.230	This could be a very important next step in managing and protecting our environment.

173.183.122.1	On one hand it's good to process it locally to make fuel and save trucking, on the other, we are making fuel and not soil and fertilizer which may be more sustainable
70.66.172.217	Using our waste without harming ourselves lessening effect in environment
173.183.122.1	Local waste management with potential revenue
209.121.229.125	no place in a residential neighbourhood for a biosolid delivery, storage and burning facility - build it closer to municipal hall, at the township-owned lot beside or under the new public safety building so there will be no distance between the facility and its destination for the energy created
75.154.243.84	Simplified resource management and lower energy operating costs and mitigating risk of increasing price on carbon.
107.190.24.115	Jobs, reduction of waste and a cleaner environment

4 Q3: Concerns

"What is your level of concern about this Township of Esquimalt IRM initiative?"

IP Address	Comment
192.252.235.212	slight concern re risk, but there's rarely a reward without a risk
154.20.45.178	I'd love to know what the concerns are, but there don't seem to be any …
24.69.200.159	Mostly the cost and the physical risks (explosion, combustion etc.) of the plant
70.66.169.93	Concerned about not waste in engery of developing a solo plan over creating initiatives for Regional IRM solution
24.68.225.81	I this this IRM proposal should include sewage sludge for many reasons, the main one it can turn sewage sludge into energy while at the same time getting rid of the myriad of toxins and pathogenic organisms that sewage sludge contains. Esquimalt can divert its portion of sewage sludge from the CRD secondary treatment plant. This would greatly increase Esquimalt's protection of the environment and would show the CRD how it should be done.
70.67.56.75	We need businesses in our Community to drive economic growth.
173.181.101.102	Esquimalt needs to move into the future to benefit its citizens.
50.98.167.60	I trust that municipal leaders and staff members do their due diligence in proposal development. They wouldn't put this forward if they didn't best serve our community.
24.68.8.51	Too expensive
172.218.235.236	No technolgoies have delivered the benifits outlined in the video. The Enerkem facility in Edmonton has been delayed over 10 years and is not achieving what was expected in the project proposal. Project costs have also increased to $127/tonne for disposal fees as of 2018
207.194.133.9	Seems like very few downsides, other than initial cost. PLEASE DO DUE DILIGENCE ON PROCUREMENT!!!

184.69.124.230	I'm not familiar with the technology
173.183.120.47	difficulties in finding appropriate operational information based on actual plant experience throughout the world
199.7.159.40	Uncertain of neighbour extra noises through the night or other disturbances
70.66.169.19	I would like to know if the design being considered is experimental or if there are actual facilities running elsewhere in the world. Is the running plant robust in terms of continuous operation (is it prone to breaking, how much maintenance is required, how much downtime). Also, taxpayer costs and yearly costs, versus cost of not doing anything. Is potential income attainable?
70.66.164.224	Costs and effect to surrounding neighbors and properties.
64.114.222.234	We have to pay to deal with our waste now or pay a much higher price later.
70.67.44.126	I am not sure what kind of concern you are looking for. I watched the video, and it does seem that IRM is a good beginning at addressing pollution/carbon-footprint in our township.
70.66.179.239	Initial Cost of infrastructure.
70.66.172.179	What can go wrong? If things go wrong how does this affect Esquimalt and it’s residents - both financially and environmentally.
173.183.122.88	Because we're already going to spend $43M on a new fire hall we don't need. Even more pet projects are ludicrous.
209.205.88.238	It's been done before at dockside green and worldwide
70.66.167.192	I have concerns that it won't be as effective as it proposes or that it costs way more than expected.
70.67.50.169	My main cocern would be the cost and whether or not it will be expensive financially while being beneficial to health
75.154.249.172	Main risks appear to be in the finances (who pays upfornt for potential benefits as the plant becomes operational) and the operations (the realities of variations in feedstock, syngas production challenges and costs, energy needs for the gasification if syngas production is variable, characteristics and quality of biochar, etc.)
209.205.88.238	The presenters answered the questions to allay any concerns I had
154.20.47.89	I trust our council and municipal staff to make good decisions for our welfare. That us why I am against amalgamation of the diverse communities within the CRD.staff

216.13.208.106	Important that outside forces do not try to handicap thru regulation. Costs should be at least neutral.
96.54.233.169	Seems like we must do this to save the planet.
70.66.254.45	strong benefits. Few downsides; Risks can be managed with private sector shouldering the risk.
70.66.254.45	risks can be managed. Small scale and manageable. Township need the political courage to approve the project in principle subject to more detailed analysis.
70.66.185.29	Sounds to much like a Public private partnership and would not be good for us.
24.68.98.230	n/a
75.157.24.144	I think it is a great idea.
107.190.24.120	Lack of examples in N. America, lack of knowledge at local level
107.190.24.120	Concerned savings won't be passed on to residents
24.69.196.61	Like any project there are risks.
70.66.184.248	I'm not concerned
70.66.188.88	Try some thing new
70.67.60.64	Important project. Want to see my tax money well spent.
154.5.145.40	It will be beneficial to us all.
70.67.52.188	Inevitably there are risks to be overcome.
154.20.44.239	1. The benefits as described in the various literature could be overstated. 2. The technology is 'bleeding' edge and could encounter many unforeseen potentially costly problems during implementation and initial startup.
172.218.235.236	City does not have the engineer capacity to evaluate or manage the risk from commiting to an experimental technology
24.69.208.85	Is this going to impact my taxes by having a separate garbage pickup for kitchen and garden waste? I'm on a limited income and can not afford the ever increasing tax load. Like most people, I'm more concerned about COVID than I am about this initiative.
75.157.27.116	I'm just not.
72.143.239.77	Cost control is always a concern of mine.

154.20.45.179	Im worried about being about long term contracts to resell the energy and the income generated vs capital cost
173.183.121.9	Still only in exploration stage
70.66.167.25	It would be good for Esquimalt.
70.66.167.104	to blend in and not be an eyesore..... and any fumes
70.66.154.155	Being first is sometimes good, sometimes not. Why expose us to this risk?
70.66.177.189	Risk of cost over runs
209.52.88.56	do not want more taxes
70.67.48.151	Because in my opinion the present compost recycling program has not worked well, because it does not incorporate garden waste, which is an extremely important part of organics management.
70.67.50.8	I dont believe decision makers are fully informed of potential pitfalls. With the desire to reduce co2 and go green, its tempting to have blind faith and want something to work, dismissing dissenting views. Hire a professional engineer to conduct a proper feasibility study then I'd buy it.
173.183.120.227	traffic issues on esquimalt rd? So much residential building is also happy in the area...
162.156.84.63	This is the right thing to do and signals to people outside of Esquimalt that this is a community I might want to be part of
70.66.186.198	It is a very good plan - no concerns.
154.20.47.249	I would like more information on other IRMs, where they are, how successful they have been, small scale and large scale, cost effectiveness, ability to generate income, savings etc. Would like information on any areas of concerns, noise,odour, traffic, maintenance cost of these kind of plants.
70.66.172.177	I am concerned that Esquimalt will expend money on an unproven technology that in addition to financial can have environmental risks (pls assess emissions risks).
24.69.196.204	Need to know the cost to be able to give opinion
207.6.182.232	Need a proven tech, not an expensive experiment; emissions incl fumes, reliably controlled.
70.66.177.234	will we get the truth about what is being done and what it costs
104.142.125.194	I'm worried this will end up stinking up my neighborhood and increading truck traffic

154.20.45.35	I'm concerned people will only focus on the financial cost rather than the revenue and environmental stewardship. Many are having a challenging time paying anticipated costs and this could be seen as too much.
70.66.161.214	with anything there is always a level of concern
70.66.177.162	The cost and also where it would be located
50.92.249.27	Which one percenter will make the profits
209.205.88.211	Cost overruns, more industrialization of the city
70.67.61.73	this may be of interest, but not a priority compared to other work in Esquimalt. Focus on medical services, affordable housing, opioid crisis, homeless, covid, ...
173.183.123.56	cost and whether the taxpayer will be burdened
173.183.122.41	Other municipalities may want to utilize our facilities
70.66.165.204	The initial outlay of cash is large.
70.67.52.16	I'd like to a work of public art with this project
70.67.53.200	will need to be managed carefully on a continual basis
172.103.218.169	Potential cost to taxpayers like myself.
204.191.179.50	Report errors and creative use of statistics
192.99.110.132	Concern will only come when we are ready to approve the project.
75.154.238.124	cost to Esquimalt tax payers
24.69.217.96	I didnt hear anything about odours. Other than this I think it sounds very progressive.
172.98.82.13	As a senior, I can say this without bias or penalty
209.52.88.19	No interest
104.142.125.239	The tech is routine, the financial case is promising, and waste management is the domain of municipalities.
24.69.209.86	While there is some financial risk getting it up and running, the upsides outweigh status quo - plus, it's not unproven technology and Esquimalt has the opportunity to lead the way for the region
70.66.160.111	concerned about cost -if this is so good why not being looked at by other municipalities

75.157.26.155	Still learning
70.66.165.204	Cost.
70.66.174.4	Major project will be costly, easily mismanaged, new technology may not provide positive returns.
209.52.88.26	Capital costs
142.29.196.60	Depending on the cost will concern me
173.181.100.67	Concerned costs may escalate
70.67.56.43	With James Pratt involved in the project, I'm confident that due diligence will be done to prevent harm.
70.67.61.85	it has been done successfully elsewhere
104.142.126.74	Unclear why everyone isn't doing this already, so some project / implementation related risks.
184.70.226.222	taking our input, then nothing transpires from the data; nothing actually gets done
70.67.61.85	It will pacify consumers into a complacency of increasing consumption and increasing waste. We need to go forward with this and still need to disincentivise unbridled consumption.
70.66.176.146	There are risks if the waste stream changes significantly or if there are not buyers for the heating/cooling. Possible health impacts, but very small - this is a proven technology.
24.69.196.61	Implementing and costs
216.180.65.21	Cost and safety risks. Also that all the information provided has not been verified by a neutral 3rd party.
24.69.210.24	Substantial net benefit to quality of life in the Township
173.183.122.41	Heavy traffic going to the site
70.66.166.92	This is new technology. I understand it is a closed system, but still a stack is needed. What is released from the stack
70.66.177.196	Concerned that it might not be approved and that would be a step backwards if we are serious about addressing climate change.
70.66.185.104	Increases in property taxes would be a concern since they are quite high already

71.19.248.82	That purposeful distraction and others' commercial interests will mislead and distract community betterment.
108.172.255.10	I don’t live in Esquimalt
70.66.167.197	Sets a good example for other neighbourhoods in greater victoria
70.66.251.119	It's been done successfully elsewhere, many times. If anything Canada and BC are late to the party
154.20.32.23	The reports are thorough covering noise, traffic, and any emissions. The plant will be on the municipal works property and it's performance guaranteed.
24.85.252.35	Assuming that concern means worry, I believe the science
66.220.149.29	I'm concerned that it won't passed, so that means I'm extremely concerned!
70.66.166.180	These projects seldom go as planned and most often cost much more tha anticipated.
70.66.174.100	Possibility of unintended pollutants generated by process.
70.66.174.100	Undertaking a capital project in the middle of a pandemic may extend us fianancially beyond a point that we can carry. I also don't know if the plan is to expand from gasification of organic matter only to gasification of all waste materials. If that happens, naturally there are more pollutants in the by-products.
70.66.190.248	The reasons have already been stated.
70.66.188.224	I would thing that any negetive impacts of IRM would be minimal
70.66.189.58	Esquimalt residents paid high taxes for the size of municipality - nearly the same taxation as Saanich. This is a very high capital investment.
154.20.47.165	I am not sure this is the absolutely BEST overall solution. More research required
142.104.165.184	cost
70.67.44.53	new project, many variables, but am reassurred by information provided
209.52.88.226	Capital and ongoing maintenance and operational costs. Has Township considered having the facility built by a third party which would either operate it or lease back to the Township to operate, thereby avoiding significant upfront costs?
154.20.47.19	I think the project is a good idea, Esquimalt will benefit and the environment will benefit

24.69.192.18	Smell, noise, traffic
173.183.121.216	Smell, toxins in the air,
24.69.201.11	This activity will benefit generations to come.
70.67.45.179	That there is good oversight for the project.
70.67.48.163	this seems like a great idea to pursue further
142.36.177.142	Long term recovery of build costs.
70.67.53.175	this is proven technology used in other parts of the world. If run properly there will be minimal risk and nuisance.
24.69.217.172	I am very much in favour of the initiative
204.191.179.50	Cost could outweigh benefit
104.254.92.222	Inertia often stifles social progress.
70.67.58.137	larger projects like this have a tendency to go sideways, costing more and not delivering promises...
70.66.189.96	Inevitably the planning process involves delays and legal/development hurdles which together can result in unforeseen extra project costs.
70.66.172.57	How much will my taxes increase? HOw much noise will this plant generate?
24.69.209.27	No reason just being cautious
72.143.238.93	Costs- raising taxes
154.20.44.230	There appear to be no negatives for the Township in pursuing this initiative. It appears that there is sufficient international experience to date to expect a positive result.
70.66.173.49	I don't want taxes to go up.
173.183.122.1	It is a small scale processing plant and refinery after all.
70.66.172.217	Want leading edge technology with the ability to change and grow over time
173.183.122.1	Where would all the garbage be kept before processing?
209.121.229.125	seems a vanity pilot project with showcase appeal but no real benefit -- gasification plants are not benign to the adjacent residential neighbourhoods

70.67.53.124	I read the FAQs but feel my knowledge is limited and I need to educate myself more
173.183.122.101	Smell?
107.190.24.115	Just wondering where it would be built and any impact on the neighbourhood

5 Q4: Facility Location

"Do you agree with locating the IRM facility on the yard/garden and parking portions of the Public Works Yard located on Canteen Road?"

IP Address	Comment
192.252.235.212	reasonable location. should be an engineering decision, not a political one
154.20.45.178	I can't see any reason why not to
207.6.183.225	Industrial corner where public works is already situated
24.69.200.159	I feel the proximity to the DND poses a risk, but I don't know enough about the physical dangers of the gasification system
70.67.45.248	Minimizes transporting the waste, the land is available, and the technology allows close proximity to residential areas.
204.191.179.50	good location due to proximity to waste generated
70.66.169.93	If this passes it's the only logical spot
24.68.225.81	I fully trust the Pivotal IRM proposals.
70.67.56.75	Seems to be a good fit and proximity if it was taken on.
173.181.101.102	Excellent location
50.98.167.60	I'm not sure what location is best. Understanding how this would effect those living and working nearby is important.
24.68.8.51	What other municipalities options do we have
24.69.205.114	As long as it doesn't interfere with base traffic or cause even more traffic im fine with it
184.151.230.233	Yes, but I'd still like a place to take my yard waste
172.218.235.236	Not enough project details presented to assess sound, odour and any associated emissions.

24.69.201.188	This is an industrial application and should be out of the municipality entirely.
207.194.133.9	Seems like a fine site.
184.69.124.230	reduced transportation distance for waste
70.67.53.39	If yard waste is collected by trucks from houses, will there be additional bins? Right now I have the option of dropping off as much as I want to the Public Works Yard. I'm not limited by the bins...
173.183.120.47	seems practical & good right now but how much expansion can the area handle
199.7.159.40	Away from our homes
70.66.169.19	I am fine with that location but are there benefits to making it more central so that business can benefit from the energy produced?
70.66.164.224	Depends on effect to surrounding properties and traffic
64.114.222.234	It makes logistic sense. Close to where the energy it produces will be used.
70.67.44.126	Close to 'downtown Esquimalt', but outside of the major residential areas.
70.66.179.239	Need to make best decision based upon being able to use the energy. Close to DND, May be an asset.
70.67.58.149	Location is too small.
70.66.172.179	I don’t know enough about the processing of the waste and the operation of the plant (gases emitted, noise, odour, etc)
173.183.122.88	This should be placed nowhere in Esquimalt. It's insane.
209.205.88.238	Practical location
70.66.167.192	As explained in the webinar I think this is a good use of that space and close to the town centre. A good choice!
70.67.50.169	It's close to the village centre for use of the end poduct. While there is some apartments nearby the majority of the area is the dockyard and navy base
75.154.249.172	Parking area better than green space
209.205.88.238	It seems well thought out to minimize impacts
154.20.47.89	It is municipal land in an area that was traditionally industrial with the shipyards.

216.13.208.106	Not sure if this is the best location but do not have any thoughts to add. Sufficient space for expansion should be part of any consideration.
96.54.233.169	it's a good place for it.
70.66.254.45	industrial area. Close to downtown core for energy recovery
70.66.254.45	industrial site. Close to downtown core for heat recovery; close to public works yard.
24.68.98.230	Already in use for similar recycle/disposal
75.157.24.144	Great spot for it.
107.190.24.120	Natural extension of the existing space usage
24.69.196.61	There was only one location proposed. What other options are there? If they had been considered, they weren't presented clearly.
70.66.184.248	It's already used for waste
70.66.188.88	Best place for it
70.66.184.248	It already collects compost.
70.67.60.64	Site is alreayd owned and need minimal renovation. Already used for the yard waste. In a suitable area of Esquimalt
154.5.145.40	It's a logical choice.
70.67.52.188	Works well for eventual expansion with the DND and View Royal; effective location for heating public buildings.
154.20.44.239	1. Existing site already owned by the Township so there would be no additional cost for acquiring land 2. Minimal impact on existing, nearby residences
172.218.235.236	Need to continue to have a yard and garden drop off
24.69.208.85	If it goes through, then it makes sense that it be within the Public Works Yard.
205.250.53.78	Seems the most sensible location as it is already a yard waste drop off area.
75.157.27.116	Common sense.
72.143.239.77	I recommend locating as close as possible to where the heat will be used.
154.20.45.179	Its municipal land far from schools we already own.

173.183.121.9	Makes perfect sense
70.66.167.25	A good location.
70.66.167.104	close to town center and convenient .....closest to DND and not in major residential area
70.66.154.155	This is assuming having an IRM facility is a good idea. I cannot agree yet.
70.66.177.189	Makes sense
70.67.48.151	The location is very convenient and cost effective.
70.67.50.8	If there is signed supply arrangements for the energy recovery with the Base, then maybe. Otherwise you dont have a customer to us the heat energy, so benefit statements are compromised. Location only makes sense if the business model makes sense.
24.244.23.60	Just indifferent, but makes sense to me
70.66.186.198	Absolutely. Perfect location for the site with proximities yo the town centre to distribute energy recovered from the gasification plant.
154.20.47.249	I think it could be a very good location; however I would be concerned if the plants ends up taking waste product from outside of Esquimalt, that it would mean an increase in truck traffic, noise, on an already noisy part of Esquimalt rd.
70.67.58.149	Think area is too small.
24.69.196.204	What do the neighbours think?
207.6.182.232	Seems like too small a space.
70.66.177.234	most people in the township know where that is
104.142.125.194	it's a long way from me
209.121.130.228	Why this location?
70.67.60.39	Existing use is a good fit
70.66.161.214	it is good viable space
70.66.177.162	I am concerned about smells and pollution for nearby residents
209.205.88.211	Can the building look nicer than a big metal shed. Are there other locations being looked at,. I didn't see alternatives.

24.69.200.68	The David Street location is a far better location as it is more easily accessed.
70.66.170.178	not sure how, or if, this will impact unloading my garden waste
70.67.61.73	this is not a priority
173.183.123.56	govt already owns it and its not beside residences from what I could see
173.183.122.41	Already somewhat industrial and large traffic already uses that route
70.66.165.204	Existing resource.
172.103.218.169	The location makes sense, but I am not aware of the alternatives, nor the potential negative impact of consuming parking space at the Public Works yard. Building at the Public Works yard would minimize road delays during construction thanks to its location away from major thoroughfares.
70.66.170.26	The land is available and owned by the Township.
204.191.179.50	Not convince that yard waste should be included and would still want a site for this
172.98.82.13	Makes sense, it is relatively outside of the Esquimalt “downtown core”
209.52.88.19	Should be at landfill
104.142.125.239	I live in a different neighborhood, so I'm abstaining
24.69.209.86	Small footprint required, space already designated for the light industrial activities of the works yard - minimal additional impact to residents.
70.66.165.204	Makes sense
70.66.174.4	few options available
209.52.88.26	Good use of municipal owned land
70.66.166.29	It is an out of the way spot.
70.66.164.17	Smell can be an issue with methane plants.
70.67.56.43	I notice that it's quite close to a First Nations reserve and I haven't heard anything about consultation with them about the project. That should probably be done. Otherwise the site seems great to me.
70.67.61.85	it makes sense
104.142.126.74	Consistent with existing use

184.70.226.222	already used for garden wastes, some metal wastes; out of way of main traffic and residential areas
70.67.61.85	Very good location, because it is near light industrial
24.69.221.82	Unless there is other space in the industrial area of Eawuimalt that could be utilized.
70.66.176.146	Makes great sense as a means of reducing transportation impacts and being close enough for an economic district energy system.
216.180.65.21	Definitely not. It's a huge risk. There are recorded instances of fires and explosions with gasified.
24.69.210.24	Less travel required when site already available
173.183.122.41	Already used for waste
70.66.166.92	space is already there for use; proximity to city works and city centre
154.20.44.152	dont know the site. I wld ppt for minimizing new sealed surfaces and rather reuse existing sealed areas
70.67.46.129	Lots of space and good distance from residences.
70.66.177.196	It is on an unused portion of the Public Works Yard, already has trucks using it and is an industrial zone.
70.66.185.104	Area with the fewest homes
71.19.248.82	an well situated, available site.
108.172.255.10	What better location?
70.66.167.197	I do not live in that neighborhood so I don t want to answer yes
70.66.251.119	Can;t think of another location that would be accepted by the community
154.20.32.23	1) no addition land costs; 2) residents will be familiar with the sounds and activity at the site; 3) it allows proximity for the township to take advantage of the energy loop.
24.85.252.35	I am not highly acquainted with this aspect - I assume it has been given the same scientific analysis
70.66.166.180	The garden wast deposited there now does not really make good compost, as it is too full of noxious weeds.
70.66.174.100	Existing space, relatively separated from residential, but still close.

70.66.174.100	I don't know how large the gasification plant will be, and the Public Works Yard seems a fairly small space. Would Esquimalt eventually be considering expanding the gasification plant and offering to contract service for the entire Greater Victoria Region, for example?
70.66.175.144	Location is already set up, also has the new plant close by so already has several industry similar
70.66.190.248	This area is just a few blocks from my home and work space, yet I'm completely unconcerned with it being in this space as it already is a public works yard that is ideally situated. There is no need to find another location for it.
70.66.188.224	good location
154.20.47.165	Sounds like as good a place as any. Away from most residences.
142.104.165.184	not familiar enough with that location
70.67.44.53	Already existing "waste management" area; less density of residential, already owned by Township
209.52.88.226	Convenient and land already owned.
154.20.47.19	located in an industrial area yet close to town centre.
24.69.192.18	Where do we bring our garden waste?
173.183.121.216	lack of space already
24.69.201.11	not opposed.
70.67.45.179	Mostly DND property surrounds the site with minimal impact on residential areas.
70.67.60.129	Because I have no reason to disagree with it.
70.67.53.175	that looks like a good location. I trust that experts can idenify an appropriate site.
204.191.179.50	Town owns the land and it will have the least impact at that location
104.254.92.222	If smells are controlled.
72.143.232.113	There may be a better spot but I doubt it.
70.67.58.137	to the side of the primary residential area in case of possible odours, close to energy market as described
70.66.189.96	Proposed function relates to existing facilities

70.66.172.57	How much noise is this going to generate? What is the risk of explosion?
154.20.45.64	Close to base/industrial area already
70.67.49.219	We already own it. It's small in size
154.20.44.230	I'm not sure if there are other better alternative locations within the Township.
70.66.173.49	Seems like a good location, however it looks like you will have to dig up Esquimalt rd. again.
173.183.122.1	Concerned that it may smell since its located predominantly upwind from main residential areas. As much as a negative pressure building would contain the smell there will likely be ongoing maintenance on the filtration and fan systems to prevent noticing the smell. Hopefully the fan system does not work on a dilution principal only (mixing with lots of air to disperse the smell) ie. strobic fans
70.66.172.217	Suitable location
173.183.122.1	It's fairly industrial there anyways, and out of the way.
209.121.229.125	within a residential neighbourhood & far from its intended user at the town centre
173.183.122.101	I'm not sure of other options, but it seems like a good use of that land

6 General Comments

The following are the general comments provided by respondents.

IP Address	Comment
24.69.193.39	Add yard waste pickup to the kitchen scraps!
70.67.50.132	Consider traffic volumes, and noise issues for neighbours.
154.20.45.235	Nope
192.252.235.212	no
154.20.45.178	I'd really like to know more about any potential financial or technical risks if there are any. I reviewed the report and video but am not sure if there are risks that may not have been disclosed. If not, then it seems like a no brainer.
207.6.183.225	Get going
24.69.200.159	Would like to know how this will impact property taxes and utility / waste bills
70.67.45.248	Go for it!
204.191.179.50	please consider more use of wasted resources
70.66.169.93	This needs to be a regional discussion, just as a solution to the sewage was.
24.68.225.81	I think the IRM should include Esquimalt's proportion of the sewage sludge from the 2ndary plant just coming online now. This would show the CRD that Esquimalt cares about the environment by turning the toxic sewage sludge soup into energy and harmless biochar and a bit of ash.
70.67.56.75	Explain how it may directly help the recreation and sports centre in lowering costs for energy consumption. And impact to property taxes. I may support this more if that was known to me.
173.181.101.102	Any increase in employment will be a huge benefit.

50.98.167.60	No
70.67.6.24	N/a
70.67.23.220	n/a
209.52.88.94	No
24.68.8.51	No
154.5.236.85	Go for it. Good idea.
184.151.230.233	No
24.69.133.30	no
172.218.235.236	A commitment to improve the current organics diversion can achieve the necessary reduction in GHG emissions from waste. Need to look for Cicular Economy solutions. Gassification technologies have remmained very expensive, and are not long term solutions to waste managment - there is a reason why municipalities and regional districts after completing thorugh reviews and input from the engineering departments have realized they should not invest in these technologies
24.69.201.188	This is a ridiculous idea. Housing needs should take priority over waste.
162.156.84.63	Great idea
24.84.145.46	No
207.194.133.9	Please do due diligence on procurement, and creation of the contract. This seems like a great idea, but could easily run into trouble if this is not done appropriately.
184.69.124.230	no
70.67.53.39	See previous comment
173.183.120.47	Esquimalt's IRM Proposal I am a big supporter of gasification to treat municipal solid waste material, however
199.7.159.40	No
70.66.169.19	As a resident of Esquimalt, I had not heard anything about this until someone I know, who lives outside of the community, told me. It sounded interesting so I reviewed the material on the Esquimalt website. Am I really that out-of-the-loop? Or does the township need a better way to communicate with residents?
204.191.179.50	no

70.66.164.224	All stated above or within survey
64.114.222.234	Cost is something to consider. But you pay now or you pay much more later. Smell is something I'm not sure of and would like to know if it will impact residences close to it's location.
70.67.44.126	Not at the moment.
70.66.179.239	Are there other plants using this process in BC?
70.67.58.149	No
70.66.172.179	This is a major financial undertaking by the municipality. Shouldn't the voters decide on this?
173.183.122.88	Here's an idea--put it on a barge next to the Mayor's houseboat.
209.205.88.238	Great to see Esquimalt leading the way with progressive ideas for the future
70.66.167.192	I am very happy to see Esquimalt finally taking some real steps to GHG reductions, and being supportive of such innovative ideas such as district energy. I think it's a necessary step in the right direction.
70.67.50.169	At this time mainly financial
75.154.249.172	Great to see the Township showing leadership - maybe an inspiration for the CRD...?
209.205.88.238	The township should move forward with it!!
154.20.47.89	I think we need to press ahead and take this opportunity to improve our community and our environment. We cannot push this off to be someone else's problem in the future. We must act now.
216.13.208.106	Better late than never.
96.54.233.169	no
70.66.254.45	Council should vote in favour a order a more detailed feasibility study. CRD need to be brought on side with the zero waste philosophy.
70.66.185.29	If the CRD has decided against this I do not think we should be moving forward with it.
24.68.98.230	please consider utilizing the abundant biosolids that will become available
75.157.24.144	Let's do it!

107.190.24.120	A demonstration of the demand for biochar regionally would help; how far would the end product be shipped, and would that offset the reduction in GHGs from gasification plant?
107.190.24.120	Hope the initiative will be considered
154.20.4.41	Thank you for showing initiative and leadership
24.69.196.61	This sounds like a well thought out and studied proposal. I would support going forward with the gasification plant as part of the IRM.
70.66.184.248	No
70.66.188.88	None
70.66.184.248	no
70.67.60.64	Great initiative, we need more like this.
154.5.145.40	No
70.67.52.188	The webinar allayed my concerns about capital costs
154.20.44.239	If this is implemented, I would like to see post-implementation studies done at specified intervals (1, 5 and 10 years) to compare costs and benefits to the original budget that is proposed.
172.218.235.236	Leave it to the crd and follow provincial guidance to develop a successful plan
24.69.208.85	none
207.6.116.145	Waste of money (pun intended)
70.66.184.170	no
205.250.53.78	Bravo
70.67.56.99	No
70.67.44.53	Love this kind of thinking. Keep it up.
75.154.242.247	No
75.157.27.116	No
70.66.188.29	Costs. Would only want to proceed if there was 2/3 grant from the province.
24.69.208.94	No

72.143.239.77	Kudos to Esquimalt for considering and investigating IRM.
154.20.45.179	No
173.183.121.9	I think it's a great idea
70.66.167.25	Okay as it does not raise taxes too much.
70.66.167.104	cost, and more information as it becomes available
70.66.154.155	Why is Esquimalt and our taxpayers being asked to invest in unproven technology and process. While admirable, I am nervous.
70.66.172.217	State of the art required, don't worry about cost. Why is this not a CRD initiative? Is there enough waste volume to be efficient?
70.66.177.189	Should tell residents what it will look like for them. Same garbage can on the curb?
209.52.88.56	could be good..but not an increase in taxes.
173.181.102.219	is there any odour associated with these units?
70.67.48.151	I hope the biochar product is made in 10 & 20 kilo bags for people to use in their home garden, even truckload quantities for agriculture.
70.67.50.8	The second mouse gets the cheese. Let a bigger municipality with more in house expertise to manage the proposal review, negotiations, construction and operations take the plunge first. We can learn from their experience 5 years from now if it turns out to be a good idea. Too many assumptions, too much project risk (incl. permitting risk)... let CRD or others do this on their own - regional function. Wait to see it in operation elsewhere in North America first. Theres got to be a reason why it's not being kee ly adopted here yet. Just be patient and see.
70.66.176.140	No
70.67.56.73	no
107.190.20.30	No
107.190.20.30	No
192.252.234.187	None
162.156.84.63	No concerns and highly supportive
24.244.23.60	Overall sorting waste and recycling should be easier

70.66.186.198	More promotion of this is required and more highlights of the benefits so residents can understand easily. This is a great plan and could easily be viewed negatively if the story is not told right.
70.67.47.51	None at this time.
154.20.47.249	I think it is very worthwhile to consider, but residents needed to be given more information on the pros and cons. The consultant's report was quite weak in the provision of this.
70.66.172.177	I am not convinced that waste management is within the jurisdiction of a municipality. I think it is a regional district reasonability.
24.69.193.180	This is a great, forward-thinking idea.
70.67.58.149	I look at all the yard waste and wonder if it is all from Esquimalt and View Royal. I have returned to the community for 6 years and use this facility often. I have never been asked for ID or proof of address.
24.69.196.204	the cost
207.6.182.232	Na
70.66.177.234	no
70.67.52.53	Do we really want to have our town smelling like a compost bin?
104.142.125.194	Put the plant in Telegraph bay
209.121.130.228	No
209.52.88.54	No
154.20.45.35	Way to go!
70.67.62.111	No
70.67.50.37	From what I know aboutbit, it seems like a good idea.
108.172.117.87	i would like them to do all there do diligence
70.67.60.39	Would like to point out that air quality impacts from waste management will be trivial in comparison to impacts from naval base
70.67.50.83	If it helps the environment I'm all for it
70.66.161.214	no
204.191.179.50	new technology with lots of unknowns

70.66.177.162	Education of residents is probably the biggest concern. No one likes to spend money, especially when they do not understand the process.
50.92.249.27	please use the railway to transport the recycling
206.87.177.45	It can be a promising practice- but it is highly contested and can have significant problems
70.67.46.0	no
209.205.88.211	Sounds like a good idea on paper.
70.67.49.173	Keep up the good work!
24.69.200.68	I can't think of anything at the moment
70.66.170.178	Great plan
70.67.61.73	Get back to other priorities. We do not have the budget to focus on a wish list during covid which will probably require budget cuts. service cuts and staff cuts.
173.183.123.56	not really but think its a good idea and should be pursued
154.5.236.152	no
70.66.165.204	Please forge forward! This is an excellent initiative, especially if we get some provincial and federal funding.
154.20.46.154	No
70.67.52.16	kindly consider integrating a piece of pubic art to go with the plant.
70.67.53.200	no
172.103.218.169	Not at this time
70.66.170.26	Sounds like a good idea - lets get on it!
70.67.48.163	no
204.191.179.50	Would like to see more specifics about operating systems in European cities similar in size to Esquimalt. Why is CRD not also interested?
192.99.110.132	The project has merit and as one who is concerned about climate change I think it is a major step forward in reducing our carbon footprint.t.
75.154.238.124	None
24.69.217.96	no

172.98.82.13	Go for it, do not get sidetracked, stay within budget
209.52.88.19	No
104.142.125.239	N/a
24.69.209.86	Let's move on this opportunity.
70.66.178.220	None
173.183.120.210	I want to be able to put yard waste in my green bin! I've lived in four provinces and Esquimalt is the only place I've ever lived where I can't put yard wast in the green bin!
70.66.160.111	none at this time
75.157.26.155	No
70.66.190.84	Not at this time
70.66.176.78	I didn't watch and read all of the info but I didn't see anywhere that lists the cost to taxpayers to build,- increase of taxes
70.66.165.204	If we don't do this because people "don't like change" or "landfill is fine" or "composting worked for my grandma!" then our kids will pay the price with their health later on as climate change amps up.
70.66.174.4	is technology well proven?
209.52.88.26	Ensure that the revenue stream generation estimates are legitimate and factor in true lifecycle costs for the facility if there is no revenue stream. We don't want an"white elephant" for the next 30 years. Evaluation of financial costs needs to accuracy portray contingencies and operation costs within a spectrum of Financial scenarios.
70.66.166.29	I guess the cost....is it guaranteed to stay at $360/ household?
142.29.196.60	how are we going to pay this?
70.66.164.17	Might be good idea to explore a private company to own and operate the plant
173.181.100.67	Esquimalt needs to work towards a goal of zero environmental footprint
70.67.56.43	No, I'm good. Highly in favor, hope it goes through.
70.67.61.85	do it
104.142.126.74	no

70.67.49.173	Keep up the good work!
70.67.49.173	Keep up the good work!
184.70.226.222	encourage IRM not be the only action toward reducing effects of climate change, but that Township takes into account existing ecosystems to address loss of native trees, vegetation, birds, amphibians, bees, butterflies. Reducing emission has been talked about for about 25 years and targets have never been achieved. Need to supplement climate action plan with protecting our green spaces, trees, ecosystems through very creative and deliberate guidance of development in our Township. There is NO mention of this in our strategic planning or 5 year goals.
70.66.169.165	Not at this time
70.67.61.85	Don't get bogged down in paralysis analysis. This isn't my first choice in dealing with waste, but we need action, not further study.
24.69.221.82	Part of this is that the pick up be curbside for residents or ot wont work. A lot of residents don't always have the transportation to move wastes from their property so it would affect the success if this wasn't built into the plan.
70.66.176.146	I STRONGLY support this initiative. Please make this happen for our environmental and economic benefit. Esquimalt has an opportunity to lead by example.
24.69.196.61	N/a
172.218.224.222	no
216.180.65.21	NA
24.69.210.24	No concerns. I support this initiative
24.69.209.27	Not at this time
70.66.173.36	Strongly support this concept. Ensure system is modular and upgradable so it can be implemented systematically and upgraded in the future
173.183.122.41	Wondering if other municipalities would use our site
70.66.166.92	Nice to see that Esquimalt is potentially part of climate change action
70.66.166.92	no thank you
162.156.52.93	I would just encourage the township to continue an open dialogue about the project so that residents can make informed decisions about the project
154.20.44.152	combine with backyard composting program?

70.67.46.129	Ensure all residents concerns are covered.
70.66.177.196	I am in the neighbouring town of View Royal. I would love for this project to go through. Hoping that it will expand to take some of View Royal's waste or inspires the CRD to create similar systems. I think Esquimalt would be a visionary leader if they took this on. Particularly excited about the potential of the biochar.
70.66.185.104	No
70.66.185.104	No
71.19.248.82	In commitment through strong vision, informed leadership, in innovation and community investment and path-finding Esquimalt shows South Island the way forward.
108.172.255.10	No
70.66.167.197	N/A
70.66.251.119	Esquimalt would be financially and fiduciarily irresponsible if this is not pursued
154.20.32.23	I would like to commend Council for their research and preparation work on this project, and for their sincere concern for waste management. It has been very educational. Thank you.
24.85.252.35	Congratulations - keep up the good work
192.252.235.212	Great initiative!
66.220.149.29	Esquimalt council has shown incredible leadership in proposing this project. I sincerely hope that the uninformed naysayers won't prevent this from happening.
70.66.166.180	If California is promoting it, it probably is a good idea. They are so progressive re waste management.
70.66.174.100	I am pleased to see an active approach to environmental concerns on a local level.
70.66.174.100	The idea of gasification seems a sort of interim solution between what we currently do, and what we should all be doing in the future (in terms of reduced consumption of all goods, educating all citizens around environmental sustainability, and creating policy that supports it)
70.66.175.144	making sure noise or smells are accounted for with any growth of the prohect

70.66.190.248	My only concern seems to be the lack of enthusiasm by some senior staff and the lack of public awareness. Why wasn't this included in the most recent Township newsletter that was delivered to everyone's door? The postcard that was produced didn't enthusiastically point out the benefits of this project and, instead, is relying on people to go online and find out about it. It also would have been great for the Township, consultants or the ECO Team to be at all the Esquimalt Farmer's Markets leading up to this sharing information. I only saw the postcard and there wasn't any dialogue or enthusiasm from the staff person to chat about it.
154.20.45.186	No
70.66.188.224	with the urgency of the climate situation action NEEDS!!! to be taken quickly
70.67.61.78	no
154.20.45.136	No
24.69.212.127	No
70.66.189.58	Where else in BC have they implemented this type of model?
154.20.47.165	I look forward to hearing more
205.250.54.11	I believe the greatest risk to the project is that time is not being taken to effectively educate the public. Few people will ever watch the video. Most will remain uneducated about district energy. The township has failed to educate first. I'm disappointed and expect that this might be approved without the public understanding its value.
142.104.165.184	no
154.20.45.47	None.
70.67.44.53	Appreciate that Township is looking at alternatives and moving forward with options
24.244.23.120	No
209.52.88.226	Stated above
70.66.178.36	thanks for looking at solutions to environmental concerns
75.154.237.174	hoping this project is successful
154.20.47.19	Happy that Esquimalt is taking the initiative to reduce our contribution to the landfill.
24.69.192.18	Not at this time

173.183.121.216	Need more information
70.66.172.77	what the increase cost on tax payers would be
70.67.47.144	No
24.69.201.11	None on this topic. Overall I'm incredibly disappointed by the Townships action to date. Residents are feeling disengaged because we give input into these initiatives - and then we dont see action taken. When will we see a protected bike lane on Lyall Street. This is even more important now when we are in a pandemic.
70.67.45.179	I appreciate the township for considering a bold new approach in a time of the world having to move quickly to slow climate change.
70.67.48.163	I am glad this is being considered
142.36.177.142	none
70.67.60.129	Nope.
70.67.53.175	none, other than there could have been more outreach, i only hear about this today on the last day to fill the survey because someone posted it on facebook. maybe increase outreach on social media sites.
24.69.217.172	No other feedback
204.191.179.50	Smell? Costs managed? What happens if it fails?
104.254.92.222	It seems like a no-brainer.
72.143.232.113	Please go ahead with this project.
70.67.58.137	no
70.66.189.96	Nope!
184.69.25.222	would there be an option to take on other municipalities waste, for a fee?
70.66.172.57	no
154.20.45.64	No
24.69.209.27	No
72.143.238.93	No

70.67.49.219	Maybe we can reinvest the dividends into more resources for public works and parks dept. so they have bigger budgets to get the job done properly eg . Investing in new township vehicles that are fueled by electricity . Ford produces the ev Ford 150 starting in 2021. Other municipal maintenance projects could be better addressed with more resources. This could be done without raising taxes above c.o.l.a.
154.20.44.230	What might the time frame be for this project if implemented? And how would the development of and the operational success of this facility be monitored?
70.66.173.49	I would be concerned that the Township would give it away to a private operator.
173.183.122.1	Would be great to see feedback from other residents in Canada which live near a similar facility to share their experiences.
70.66.172.217	Not at this time
173.183.122.1	Hopefully this will not increase truck traffic down Esquimalt Road.
209.121.229.125	vanity project
70.67.53.124	I think it's a good idea worth exploring
173.183.120.210	no
75.154.243.84	Pleased this would meet and even exceed our community climate goals and establish Esquimalt as a leader
173.183.122.101	Nothing at this time.
107.190.24.115	Nope