Organics Processing Options: Screening Report

Prepared for:
The Capital Regional District

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RNG Pricing Redacted

RESHAPE STRATEGIES

EXECUTIVE SUMMARY

This report presents a screening-level analysis of a dedicated composting or anaerobic digestion (AD) facility for CRD organics located at Hartland Landfill. Alternatives are compared to the CRD's status quo costs for organics disposal.

Alternatives and scenarios are compared based on levelized net processing cost. This is calculated as the present value of expected project costs less any revenues from byproducts of the process (e.g., biogas and/or compost) divided by the present value of processed volumes.

The net processing cost reflects expected capital and operating costs. These are derived from information provided to CRD by technology providers in response to CRD's 2018 RFEOI. We note the indicative capital costs from the 2018 RFEOI are higher than others we have seen in recent literature and other processes, particularly for AD. The results of this study are very sensitive to capital cost assumptions.

Capital costs are amortized based on an indicative private sector model. There is very little information on hurdle rates for private proponents, which can vary with technology, market conditions, and specific contract terms. Actual capital and financing costs can have a large impact on net processing costs and also the ranking among different options. These will need to be confirmed through a competitive bidding process and detailed negotiations.

There is some evidence that AD projects tend to require higher hurdle rates, reflecting the higher capital intensity and technical complexity of AD, as well as the added risks and uncertainties surrounding the value of raw biogas or upgraded renewable natural gas (RNG). However, these risks can also be mitigated by contract terms and conditions. For example, B.C. is one of the few jurisdictions that currently offers long-term fixed price contracts for biogas / RNG sales.

The report includes sensitivity and scenario analyses on these and other key assumptions.

This study also includes a comparison of GHG (CO_2-e) emissions for various options. These are derived from a recent lifecycle GHG (CO_2-e) analysis prepared by Stantec (adjusted for alternate volumes and sizing scenarios in this study).

This screening study is to support strategic decisions and procurement design for organics processing, including technology specification and sizing targets. Some important findings of this screening analysis include the following:

- There are economies of scale for both composting and AD.
- The estimated net processing cost for a dedicated composting or AD facility is higher than status quo at small facility scales. However, at larger scales both composting and AD at Hartland could result in cost savings relative to the status quo, even if the facility is initially oversized to accommodate further growth of organics volumes. Filling spare capacity in early years with volumes from third parties could provide additional cost savings for both options.
- Composting appears to be much cheaper than a stand-alone AD plant at small scales. However, the cost difference is reduced at larger scales (and any differences at larger scales are within the range of uncertainty around inputs to the analysis).
- The proposed LFG upgrader and FortisBC Energy Inc. (FEI) interconnection have sufficient capacity to handle extra biogas volumes from organics, even under high LFG volume scenarios. Co-processing biogas from AD would not affect the expected returns on the LFG upgrader (which are based on LFG volumes only), but could reduce the risks posed by low LFG volumes as well as lower costs for processing organics.

- There may be additional savings from AD if spare digester capacity in the Residuals Treatment Facility can also be used on an interim basis for processing organics to defer some of the capital for new food waste digesters. This would not necessarily require any co-digestion of food waste and biosolids.
- Results are not very sensitive to the value of compost. However, the results are very sensitive to the price of RNG.
- There are substantial differences in GHG (CO2-e) emissions among the alternatives. In particular, AD results in net reductions of 40,000 – 100,000 tonnes of GHG (CO2-e) over 20 years compared to composting.
- The Small Plant AD scenario has a levelized net processing cost that is $108 per tonne higher than the Status Quo. However, The Small Plant AD scenario also results in significant additional GHG emissions reductions. A shadow value of carbon set at $515 per tonne GHG (CO2-e) would make the AD project equivalent in cost to the Status Quo operation. For the Large Plant scenario, because the AD project is already lower cost than the Status Quo, it has a negative shadow value of carbon, meaning a Large Plant AD project achieves GHG reductions and cost savings.

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STATEMENT OF LIMITATIONS

This report has been prepared by Reshape Infrastructure Strategies (“Reshape”) for the exclusive use and benefit of the Capital Regional District (“Client”). This report represents the best professional judgment of Reshape, based on the information available at the time of its completion and as appropriate for the scope of work. Services were performed according to normal professional standards in a similar context and for a similar scope of work.

ABBREVIATIONS

AD	Anaerobic Digestion
CRD	Capital Regional District
DR	Discount Rate
FEI	FortisBC Energy Inc (gas utility)
GHG (CO2-e)	Greenhouse Gas (CO2 Equivalent)
GJ	Gigajoules
IRR	Internal Rate of Return (Unlevered)
kWh/MWh	Kilowatt-hour/Megawatt-hour
LFG	Landfill Gas
MFA	Municipal Finance Authority
PV	Present Value
RFEOI	Request for Expressions of Interest
RNG	Renewable Natural Gas

1. INTRODUCTION

Capital Regional District (CRD) receives organics from member municipalities at Hartland Landfill (“Hartland”). These organics are currently transported to 3rd-party composting facilities for processing. CRD is exploring the development of a dedicated facility to process organics at Hartland.

In 2018, CRD issued a request for expressions of interest (RFEOI) to suppliers of organic processing technologies, asking them to provide information on possible technical solutions. The RFEOI process included suppliers of both composting and anaerobic digestion (AD) facilities.

This study estimates the potential costs and environmental benefits of a dedicated composting or AD facility located at Hartland. These are compared to status quo disposal. The analysis relies largely on information obtained from the RFEOI, with some adjustments to the AD option to reflect the opportunity to use spare capacity in the proposed landfill gas (LFG) to renewable natural gas (RNG) upgrader.

The intent of this study is to inform strategic decisions on organics processing and the design of any procurement of a dedicated facility. The analysis is based on indicative costs and financing assumptions, which will need to be confirmed through procurement and negotiation. The analysis is based on volumes not controlled by CRD so the project is also contingent on volume commitments from member municipalities or the private sector.

2. METHODOLOGY

This is a screening-level study to compare status quo disposal costs for CRD organics with a dedicated composting or AD facility. The key metric used for all comparisons is the net processing cost, which takes into account expected capital costs, operating costs, financing costs, and any revenues from the sale of compost, biogas, and/or RNG. Financing costs are based on a private sector financing model, with different financing benchmarks applied to composting and AD. The analysis is intended to approximate the expected outcome of a competitive procurement process and contract negotiation. Actual costs will depend on the final procurement model and detailed contract design.

A levelized net processing cost is calculated for each option. This is calculated as the present value of annual costs less revenues divided by the present value of processed volumes over 20 years (beginning in 2024). The cashflows reflect a private sector financing model. Present values are calculated using the CRD discount rate (assumed to be equivalent to CRD’s long-term borrowing rate).

For capital and operating costs we have relied on information from the RFEOI process, as summarized by Morrison Hershfield.[1] We have made some adjustments to capital and operating costs to reflect alternate sizing and project configurations as discussed later in this report. We note the costs derived from the RFEOI appear relatively high, particularly for AD.

[1] “Kitchen Scraps, Yard and Garden Waste Processing – RFP Scoping Document”. Morrison Hershfield, June 1, 2018.

The greenhouse gas (GHG) emissions for different options are derived from a lifecycle GHG (CO2-e) analysis prepared for CRD by Stantec.[2] Stantec's estimates have been adjusted to reflect different volumes scenarios in this study.

This report also includes additional sensitivity and scenario analyses for net processing costs under alternate input assumptions.

3. PROCESSING OPTIONS

We consider three options for organics processing (Figure 1):

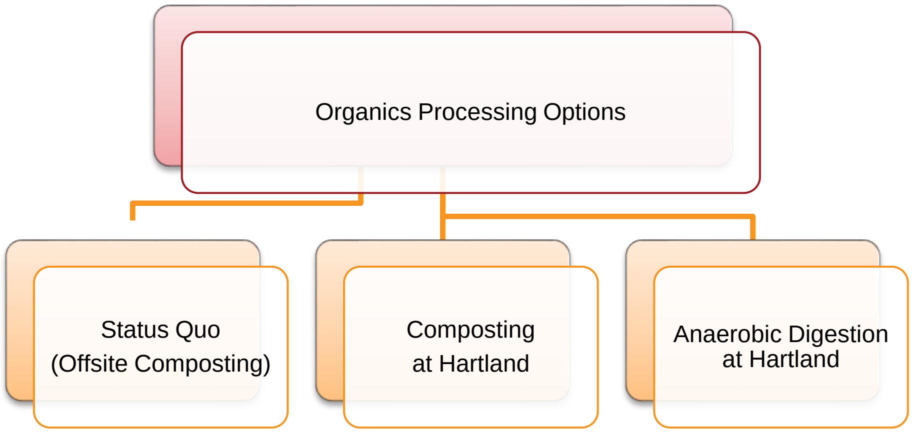
1. **Status Quo (Offsite Composting)**. Organic material received at Hartland is trucked to 3rd-party composting facilities under a contract to CRD. We assume current per-tonne processing costs (including transportation) continue into the future, with annual escalation.

2. **Composting at Hartland**. Organic material received at Hartland is processed in a new dedicated in-vessel composting facility located at Hartland. Expected revenues from compost sales are included in the calculation of net processing cost to the CRD.

3. **Anaerobic Digestion (AD) at Hartland**. Organic material is processed in a new AD facility located at Hartland. The AD facility does not include an upgrader. Instead, biogas from the AD facility is sent to the LFG upgrader at Hartland. RNG is then sold to FortisBC Energy Inc. (FEI) under the same terms and prices as RNG from LFG. Revenues from the sale of compost and RNG are included in the calculation of net processing costs to the CRD.

There is also the potential to integrate an AD facility with the spare digester capacity associated with the new Residuals Treatment Facility at Hartland. We have not assessed the technical or economic viability of this option but the costs and benefits of this approach may be considered as part of the procurement process.

Figure 1: Organics Processing Options



[2] "Life Cycle Greenhouse Gas Analysis of Organic Waste Processing Scenarios at the Hartland Landfill". Stantec Consulting Ltd, August 12, 2020.

4. KEY ASSUMPTIONS

4.1 Organic Volumes and Processing Capacity

Our analysis uses two bookends for organics volumes:

1. A flat volume of 10,000 tonnes per year (i.e. no change over time).
2. A starting volume of 24,700 tonnes per year in 2024, increasing at 1% per year.

The CRD's 2018 RFEOI provided Scenario 1 as a guaranteed, baseline volume, and Scenario 2 as a potential volume. The CRD does not control significant volumes directly, but available volumes from member municipalities are likely closer to Scenario 2.

Based on discussions with CRD, we assume an average composition of 30% yard and garden waste, and 70% kitchen scraps. The share of yard and garden waste vs kitchen scraps affects the expected biogas production from AD, as kitchen scraps have a greater potential for energy production. A greater share of yard and garden waste and correspondingly lower share of kitchen scraps will result in less biogas production from AD. In sensitivity analysis we test the impact of reduced biogas production.

Because of the wide range in volumes, each volume scenario is paired with a different processing capacity as shown in Table 1. Under the Large Plant scenario, the facility has sufficient capacity to process all organics throughout the analysis period. By year 20, annual volumes will have grown to 29,840 tonnes, or just below the facility's capacity.

While there is a wide range of uncertainty around organics volumes, CRD could potentially play a strong role in securing organics volumes for this project.

Table 1: Volume and Processing Capacity Scenarios

	Small Plant at Hartland	Large Plant at Hartland
Annual Volume	10,000 tonnes, fixed	24,700 tonnes, Increasing 1%/year.
Processing Capacity	10,000 tonnes	30,000 tonnes

4.2 Capital Costs

Table 2 summarizes capital cost assumptions for composting and AD. The assumptions are based on the RFEOI responses (escalated to 2024). Respondents to the RFEOI did not provide disaggregated cost information. For AD, we made an assumption of the cost savings from not constructing a separate upgrader, based on estimates of upgrader costs from previous studies for CRD's LFG upgrader project with conservative adjustments for losses in economies of scale for a much smaller upgrader.

We note that the capital costs received by CRD through the RFEOI are higher than we have seen from other projects. For example, from a 2017 RFI on AD, the City of London Ontario reported costs of $680 to $990 per tonne for a 25,000 tonne per year AD facility, including a biogas upgrader and land acquisition. It is possible that pricing declined significantly after the CRD's RFEOI.

It should be noted that capital costs sourced from RFEOI responses apply to commercial scale operations that must comply with strict operational specifications, including stringent odor control, leachate management, and other regulatory requirements.

This analysis has not considered the availability of grant funding to offset capital costs. There may be grant funding available - particularly for the AD facility which would reduce GHG (CO2-e) emissions relative to the Status Quo option – however we have not incorporated this into our capital cost estimates.

Table 2: Capital Cost (Unit Capital Costs), 2024$

	Small Plant at Hartland	Large Plant at Hartland
Processing Capacity	10,000 tonnes	30,000 tonnes
Composting	$11.3 M ($1,130 / tonne of capacity)	$20.3 M ($680 / tonne of capacity)
Anaerobic Digestion	$26.0 M ($2,600 / tonne of capacity)	$34.8 M ($1,160 / tonne of capacity)

4.3 Financing Costs

The financial analysis assumes that all capital costs are amortized over the expected life of the asset. A new composting facility is assumed to have a 15-year asset life. A new AD facility is assumed to have a 20-year asset life. Because we have used a 20-year analysis period, the composting option includes annualized costs for a replacement facility in years 16-20 to allow an apples-to-apples comparison of net processing costs. In reality, a contract for composting would likely be shorter than for AD, or alternatively include some buy-out for unamortized capital at the end of 20 years (assuming the proponent is required to reinvest in the project).

Capital costs are amortized using an indicative private sector financing model. It is different to obtain credible information on hurdle rates for private sector proponents. Hurdle rates require assumptions about leverage (portion of debt financing), private borrowing costs (prevailing interest rates and credit spreads), corporate taxes, and levered return on equity. These variables can vary with technology, market conditions, and the specific contract terms (length, risk transfer, etc.).

A brief review of the literature suggests higher hurdle rates for AD than composting. This likely reflects higher complexity and also higher perceived risk. The difference in perceived risk is likely a function of the capital intensity and pricing model for each technology. The bulk of revenues for a composting facility are derived from tipping fees, which tend to be fixed for a specified term. AD facilities are more capital intensive, and a larger portion of their revenues would be derived from the sale of biogas or RNG. We note in many markets these revenues are riskier because of term-limited contracts and/or pricing that is tied to natural gas or other volatile benchmarks such as renewable energy credits. The risk profile of AD is probably lower in B.C. given the availability of longer, fixed-price contracts for RNG from FEI. To be conservative we have assumed a higher hurdle rate for AD options.

Our base case assumes a hurdle rate for AD of 7.5%. This is roughly equivalent to a financing model with 70% leverage, a long-term debt rate of 4.6%, a pre-tax levered return on equity of 18% and a corporate tax rate of 26%. We assume a lower hurdle rate for composting of 6%. For comparison, FEI’s regulated after-tax weighted average cost of capital (WACC) is currently ~5.6% after tax, equivalent to ~6.5% on a before tax basis.

These are indicative rates to estimate possible prices under a competitive procurement. The level and differences in hurdle rates are uncertain, and would also be affected by specific contract terms.

Table 3: Indicative Asset Life and Financing Cost

	Asset Life	Financing Cost
Composting	15 years	6.00%
Anaerobic Digestion	20 years	7.50%

4.4 Operating Costs

Key operating cost assumptions are as follows:

- **Status Quo disposal costs** were provided by CRD staff. Pricing of $138/tonne was received in 2020. We assume continued escalation at 1.5%/year, which results in a cost of $194/tonne by 2043. We note that this pricing is for a short-term contract and may not be indicative of long-term pricing. It is unclear if this reflects existing spare capacity or if it includes costs for incremental expansion.

- **Land rent** assumes a facility sited at Hartland. Rent is based on the relative space requirements of different options from the RFEOI responses. Leases rates are derived from land value obtained from a recent 3rd party project at Hartland.

- CRD has fixed costs to operate the transfer station at Hartland where organics materials are received. Because these costs are the same for all options, including the Status Quo, they have been excluded from our analysis.

- **Processing costs** were derived from the RFEOI responses, with additional adjustments as described below, and are shown in Table 4.

The RFEOI responses provided AD processing costs for a complete facility, including an upgrader. The upgrader share of these costs can be deducted. However, there would be incremental operating expenses incurred at the LFG upgrader. In this analysis, we assigned incremental LFG upgrading costs to the AD project. We have not included any contribution to the fixed costs of the LFG upgrader. The LFG upgrader is already oversized so this capacity is available regardless. This methodology means that the IRRs for the LFG project (presented in a previous business case to the Board) will not be affected by the addition of biogas from AD.

The AD processing costs identified as part of the RFEOI (and which include the cost of an upgrader) are $59 per tonne, which is in line with the results received by London ON from their 2017 RFI.

Our analysis assumes that this AD project would incur processing costs of $39 per tonne in 2024, plus pay a fee to the LFG upgrader of $6.50 per GJ of biogas processed.

Under these assumptions, total operating expenses for the AD option (including direct processing costs as well as the upgrading fee paid to the LFG upgrader) are equivalent to the processing cost information received through the RFEOI process, for a new AD facility with its own upgrader. This analysis is likely conservative (i.e. it has likely under-estimated the cost advantage of AD Integrated with LFG due to economies of scale in upgrading costs).

We assume these costs escalate at 2%/year.

Table 4: Operating Costs per Tonne Feedstock, 2024$

	Small Plant at Hartland	Large Plant at Hartland
Composting	$91 / tonne	$51 / tonne
Anaerobic Digestion	$39 per tonne plus $6.50 per GJ of biogas	$39 per tonne plus $6.50 per GJ of biogas

Figure 2: Available Capacity in LFG Upgrader

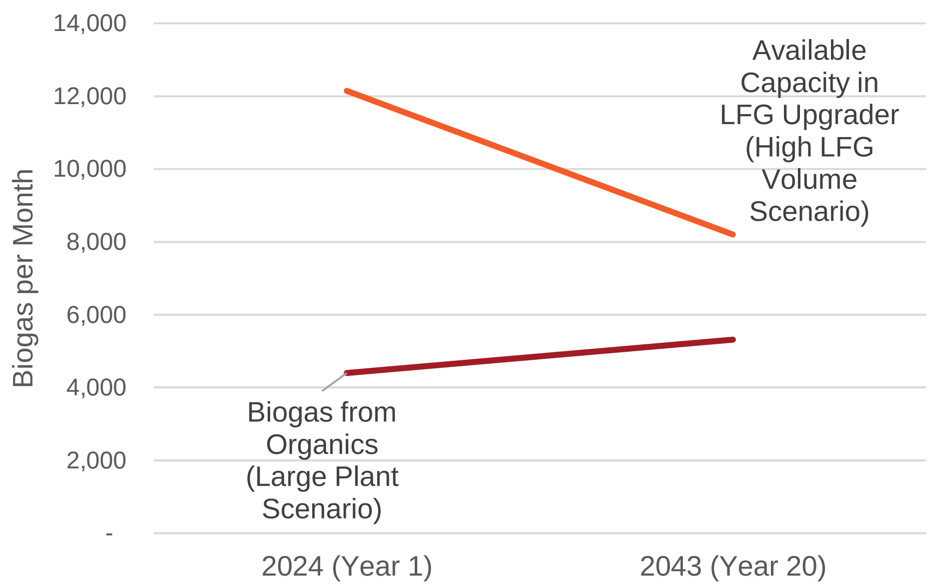


Figure 2 shows the available capacity in the LFG upgrader. Even under high LFG volumes, there is still significant available capacity in 2043 relative to the expected biogas from a large AD facility.

4.5 Revenues

There are two potential revenue streams to reduce the net cost of processing organics: the sale of compost and the sale of RNG.

Both composting and AD produce compost. However, composting produces higher volumes of compost than AD. For this analysis, we assume compost volumes equivalent to 60% and 28% of processed organics volumes for composting and AD, respectively. Our base case assumption for the value of compost is $3 / tonne (net of costs to bag, market and distribute compost). We test this assumption in sensitivity analysis.

An AD facility will also produce biogas which can be upgraded to RNG for sale to FEI. RNG production is dependent on the mix of feedstocks to the facility (yard and garden vs kitchen scraps) and recovery rates in production and upgrading. Table 5 shows the biogas production potential per tonne of feedstock under the base case assumption of 30% yard and garden waste, and 70% kitchen scraps[3].

Table 6 shows net RNG production after losses in the upgrade process, which occur during the upgrading process to produce RNG. Losses reflect expected upgrader downtime, internal energy use, and methane slip. Losses are predominantly in the form of methane converted to CO_2 through combustion. We assume losses in upgrading of 10%, in line with the assumption used in the LFG upgrader analysis.

Under all AD options, RNG is assumed to have a value of [redacted] per GJ of RNG with no escalation, in line with CRD's contract for RNG from LFG. We test the effect of different biogas production factors and RNG prices in sensitivity analysis.

Table 5: Gross Biogas Production Factors

	Yard / Garden (30%)	Kitchen (70%)	Blended Average
Biogas Potential	1.5 GJ / tonne	2.75 GJ / tonne	2.38 GJ / tonne

Table 6: Net RNG Production, 2025

	Small Plant	Large Plant
Annual Volume	10,000 tonnes	24,700 tonnes, 1% growth p.a.
2025 Net RNG Production (AD only)	21,400 GJ	53,300 GJ

[3] Biogas factors were taken from Environment Canada, "Technical Document on Municipal Solid Waste Organics Processing", PWGSC 2013.

4.6 GHG Emissions

GHG emissions have been calculated for each scenario based on a lifecycle GHG (CO2-e) analysis conducted by Stantec. Sources of emissions include:

- Construction: one-time emissions related to the construction of the organics processing facility.
- Operations: emissions from the operation of the facility, including emissions from composting, from on-site fuel consumption, and from shipping compost off-site.
- Avoided Natural Gas: avoided emissions due to the production of RNG and injection into the natural gas grid.

GHG emissions factors (CO_2-equivalents) for construction are shown in Table 7. Emissions factors from ongoing operations (including direct operations and avoided natural gas) are shown in Table 8.

The Stantec analysis also included the impact of avoided landfilling. Organics are already kept out of the landfill and our analysis compares dedicated processing options to the status quo option. We have therefore excluded emissions from landfilling in all scenarios.

Table 7: Construction GHG Emissions (kg GHG CO2-e / tonne capacity)

	Status Quo	Composting	AD Standalone	AD Integrated w LFG
Construction	-	70.6	68.9	48.2

Table 8: Operating GHG Emissions (kg GHG CO2-e / tonne feedstock / year)

	Status Quo	Composting	AD Integrated w LFG
Feedstock Transport	10.7	-	-
Composting	90.0	90.0	9.0
Shipping Compost	9.7	9.7	1.0
Other Operations	45.8	45.8	48.0
RNG – Pipeline Fugitive	-	-	0.2
Net Avoided Natural Gas	-	-	(49.5)
Total	156.1	145.5	8.7

5. RESULTS

5.1 Net Processing Costs

Table 9 summarizes results for large and small project scales. Present values and levelized net processing costs are calculated using a discount rate of 2.6%, which is intended to represent the CRD's approximate cost of borrowing. Recently, indicative long-term borrowing rates published by the Municipal Financing Authority of B.C. have dropped much lower than usual, with 20-year rates at roughly 2.25% as of the date of this report. To be conservative, we have assumed that this decline in borrowing rates is temporary and 20-year rates will increase before the project proceeds. The sensitivity analysis section of this report includes the impact of different discount rates.

At small scales, a dedicated facility is more costly than Status Quo disposal costs under our base assumptions. This also assumes current disposal costs continue to escalate at only 1.5% per year. At larger scales, a dedicated facility appears to be cheaper than Status Quo disposal costs, and AD becomes the lowest-cost option (though the cost difference between AD and composting is relatively small and within the margin of error for this analysis).

Table 9: Key Results

	Small Plant at Hartland	Large Plant at Hartland
Annual Volume	10,000 tonnes, fixed	24,700 tonnes Increasing 1%/year
Processing Capacity	10,000 tonnes	30,000 tonnes
Levelized Net Processing Costs ($ / tonne)		
Status Quo	$168	$168
Composting at Hartland	$240	$150
Anaerobic Digestion at Hartland	$276	$148
Present Value Costs ($ millions)		
Status Quo	$24.5 M	$66.5 M
Composting at Hartland	$35.1 M	$59.5 M
Anaerobic Digestion at Hartland	$40.4 M	$58.5 M

5.2 GHG Emissions

Table 10 shows the increase or decrease in cumulative GHG (CO2-e) emissions from a change from the status quo (offsite composting) to composting or AD at the Hartland Landfill Facility. Building a new dedicated composting facility at Hartland would result in a very small decrease in cumulative emissions. There would be additional emissions from constructing the facility, but these would be mitigated by a reductoin in transportation emissions. There are substantial differences in cumulative GHG (CO2-e) emissions between composting and AD.

Table 10: Cumulative Change in GHG (CO2-e) Emissions Relative to Status Quo (20 Year Analysis)

	Small Plant	Large Plant
Composting at Hartland	(1,400 tonnes)	(3,700 tonnes)
Anaerobic Digestion at Hartland	(40,100 tonnes)	(109,000 tonnes)

There are some minor GHG (CO2-e) savings compared to status quo for a dedicated compositing facility at Hartland. However, a dedicated AD facility would deliver significant GHG (CO2-e) benefits relative to status quo or a dedicated composting facility. For the AD option, we have also calculated a shadow value per tonne of GHG (CO2-e) reductions that would need to be assigned to the project to make AD cost-competitive with composting (Table 11).

Table 11: Required Shadow Value of GHG (CO2-e) Reductions from AD ($ per tonne) compared against Status Quo

	Anaerobic Digestion
Small Plant at Hartland	$515 per tonne GHG (CO2-e)
Large Plant at Hartland	($100) per tonne GHG (CO2-e)

For the Small Plant scenario, the AD at Hartland project would result in a cost premium of roughly $15.9 M relative to the Status Quo, as shown in Table 9. However, the Small Plant AD project would deliver significant GHG reductions relative to the Status Quo. Based on the cost premium and GHG reductions, the Small Plant AD project would require a shadow value of GHG reductions of $515 per tonne GHG (CO2-e). Stated differently, the Small Plant AD scenario can achieve GHG reductions at an abatement cost of $515 per tonne of GHG (CO2-e).

For the Large Plant AD scenario, because the AD project is already lower cost than the Status Quo, it has a negative shadow value of carbon, meaning that the project achieves GHG (CO2-e) reductions at negative cost (i.e. savings).

For comparison, Metro Vancouver (MV) recently adopted an internal carbon price policy of $150 / tonne GHG (CO2-e). This means that for potential projects with GHG (CO2-e) implications, MV will include a total price of $150 / tonne on all emissions. The City of Vancouver adopted a similar policy with a comparable total carbon price in late 2018.

5.3 Sensitivity & Scenario Analyses

We conducted sensitivity and scenario analyses on key inputs. Some of these are summarized in Table 13. We selected the Large Plant scenario for all sensitivity and scenario analyses because of the narrow range around net processing costs of different options at this scale. For reference, the levelized cost of Status Quo disposal is $168 per tonne.

We note the following:

- We conducted two sensitivity analyses on organics volumes. The first assumes a 20% reduction in volumes in all years, with no change in the facility size. The second scenario assumes full utilization of the facility from Year 1. This would require supplemental volumes to fill the facility as municipal volumes grow.
- Higher Compost Revenue illustrates the impact of assuming that net revenue from compost sales is $10 per tonne of compost, as opposed to the base case assumption of $3 per tonne of compost.
- There is uncertainty regarding both the mix of organics feedstocks (kitchen vs yard and garden), and the actual biogas production rates from each type of feedstock. The biogas production sensitivity analyses are intended to capture the overall uncertainty around biogas production volumes. This sensitivity does not impact the Composting option.

Table 12: Sensitivity Analysis, Large Plant Scenario (Levelized Net Processing Cost per Tonne)

	Composting	Anaerobic Digestion
Base (Large Plant at Hartland)	$150	$148
Organics Volume -20%	$171	$180
Flat 30k Volume	$141	$134
Higher Compost Revenue	$145	$145
Biogas Production +10%	$150	$144
Biogas Production -10%	$150	$151
Biogas Production -20%	$150	$155

The “Biogas Production -10%” scenario shown above corresponds to the expected biogas production rates from a feedstock mix of 50% kitchen scraps, and 50% yard and garden waste, based on the assumptions detailed in Table 5. The “Biogas Production -20%” scenario corresponds to the expected biogas production rates from a feedstock mix of 35% kitchen scraps, and 65% yard and garden waste.

In addition to the sensitivity analyses above, we conducted more detailed analysis on several other inputs. These results are summarized below.

Status Quo Costs

Status Quo disposal costs are built up from the 2020 per-tonne cost, and a future escalation rate. As of 2020, processing costs for the Status Quo option are $138 per tonne. Assuming escalation at 1.5% per year, this would increase to $194 per tonne by 2043. Under these assumptions – which are used for the base case Status Quo costs - the levelized processing cost is $168 per tonne over the 2024-2043 analysis period.

Table 13 shows status quo levelized net processing costs per tonne based on a range of starting per-tonne costs and escalation rates. The escalation rate would have to be as low as 0.5% for the duration of the analysis period for status quo costs to be lower than the cost of both composting and AD.

Table 13: Status Quo Cost Sensitivity (Levelized Net Processing Cost per Tonne)

	Status Quo
Base ($138/tonne, 1.5% p.a.)	$168
$138/tonne, 1% p.a.	$157
$138/tonne, 0.5% p.a.	$147
$138/tonne, 2% p.a.	$180
$148/tonne, 1.5% p.a.	$180

Discount Rates

The discount rate is used to calculate levelized net processing costs and the PV of net processing costs of each alternative from the perspective of the CRD. The effect of alternate discount rates on the PV of net processing costs of each alternative is shown in Table 14. The selection of discount rate affects absolute results but does not fundamentally alter the relative ranking of different alternatives.

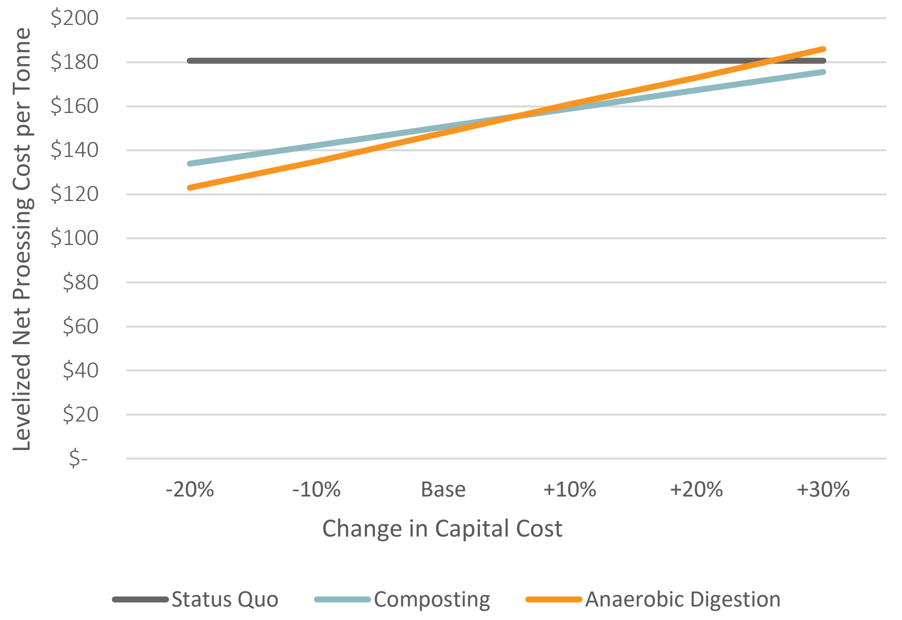
Table 14: Discount Rate Sensitivity ($ millions, PV of net processing costs), Large Plant at Hartland

	Status Quo	Composting	Anaerobic Digestion
Base (2.6%)	$66.5	$59.5	$58.5
1%	$81.2	$72.6	$71.0
4%	$56.3	$50.4	$49.9
6%	$45.0	$40.4	$40.2

Capital Costs

As noted, there is considerable uncertainty in the capital costs of alternatives. These will need to be confirmed through the procurement process. See Figure 3.

Figure 3: Capital Cost Sensitivity, Large Plant at Hartland



Upgrader transfer price

There is uncertainty in the incremental operating costs for the LFG upgrader. These will be confirmed in the procurement and detailed design phase. The base case assumption is $6.50 per GJ of biogas processed. Figure 4 shows the effect of a +/- 30% difference in incremental upgrading costs.

Figure 4: Sensitivity to Varying Upgrader Transfer Price, Large Plant at Hartland

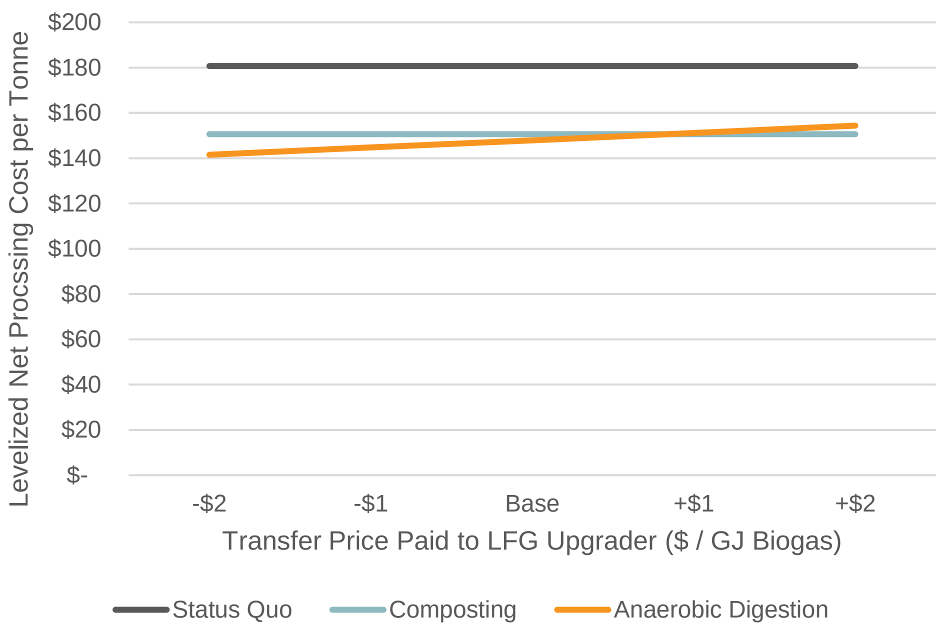
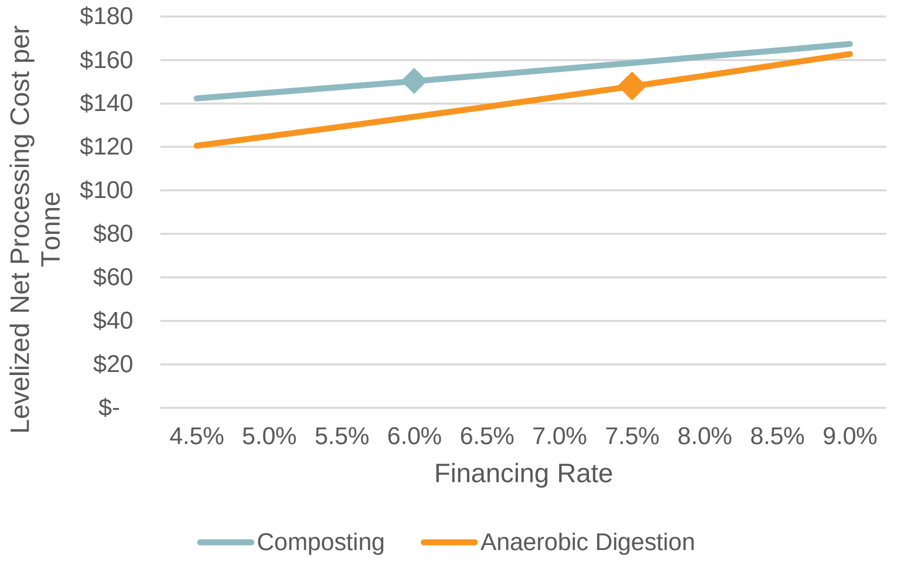


Figure 5: Sensitivity to Financing Rate, Large Plant at Hartland



The net processing cost of both options declines with lower hurdle rates. However, AD is more capital intensive and therefore more sensitive to assumptions about hurdle rates.

Financing Rates

Hurdle rates for private sector proponents are unknown. Our base case also assumes a higher hurdle rate for AD. Figure 5 shows the sensitivity of each technical solution to varying financing rates, under the Large Plant configuration. For each option, the base case assumption is marked with a diamond.

RNG Price

The base case results assume all RNG from AD is sold at the same price obtained by CRD in recent negotiations with FEI for upgraded LFG. CRD would be able to sell incremental RNG under its existing contract. However, CRD is not obligated to sell incremental RNG from other sources of biogas (beyond LFG) under the same terms and conditions as the existing purchase contract. There are no incremental costs to FEI from additional volumes of RNG (the proposed interconnection appears to have sufficient capacity). As a result, FEI may be able to pay a higher price for incremental volumes, if that is required to incent AD. Results are shown below.

Table 15: Sensitivity to RNG Prices, Large Plant at Hartland

	Anaerobic Digestion
Base (Large Plant at Hartland) RNG @ [redacted] / GJ	$148
RNG @ [redacted] / GJ	$143
RNG @ [redacted] / GJ	$137

Volumes of Organics Received at Hartland

Depending on how CRD is able to contract for organics volumes, there may be volume-related risks associated with building the Large Plant AD option. Figure 6 and Figure 7 show the impacts on present value costs and on levelized net processing costs, respectively, for this option as compared against the Status Quo. With an AD project, reductions in organics volumes only lead to modest reductions in total costs, so unit processing costs will increase if volumes decline.

Figure 6: Anaerobic Digestion, Large Plant at Hartland, Sensitivity to Reduced Organics Volumes (Present Value Cost)

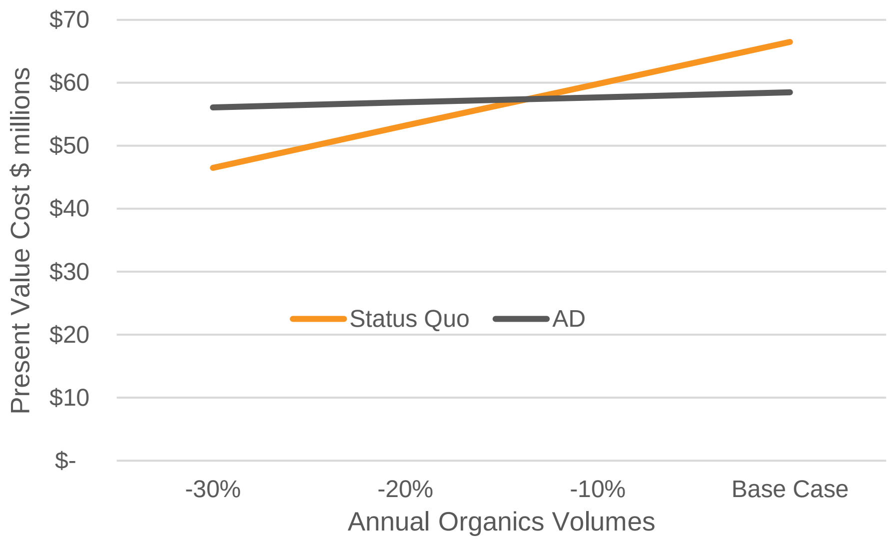
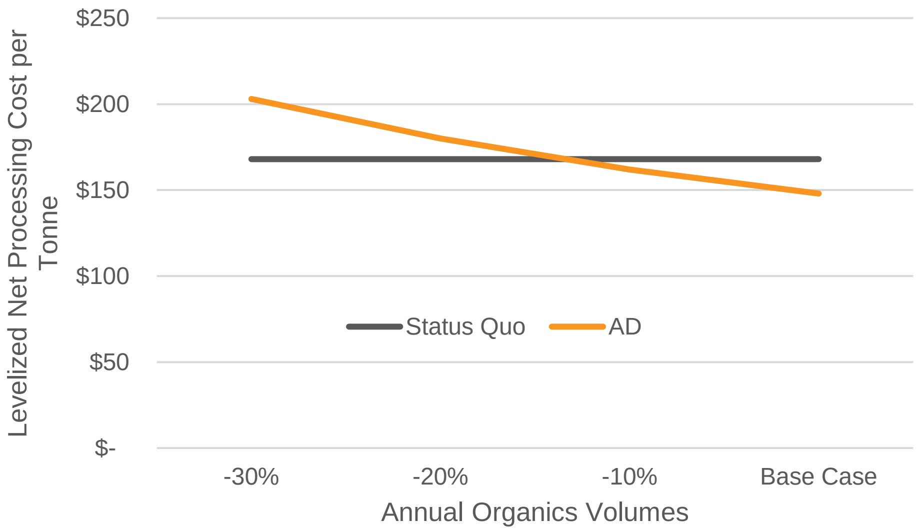


Figure 7: Anaerobic Digestion, Large Plant at Hartland, Sensitivity to Reduced Organics Volumes (Processing Cost per Tonne)



6. NEXT STEPS

Based on our analysis, the large scale AD at Hartland option has the potential to offer both financial and GHG benefits. CRD could lead its own further due diligence of the technical and economic viability of AD at Hartland, or could pursue an alternate approach where CRD focuses on securing feedstock commitments, and seeks private sector partners to conduct further due diligence and potentially develop a project at Hartland.