Report

Tri-Municipal Organic Waste Processing Facility Analysis

Submitted by:

Alex Hayes Ph.D., P.Eng.

November 30, 2017

For:
Miles Dibble M.Phil., B.Sc., B.A.
Sustainability Planner

Town of Stony Plain
4905- 51 Ave
Stony Plain AB T7Z 1Y1
m.dibble@stonyplain.com

Contact Information:
Alex Hayes Ph.D., P.Eng.
Bio-Thermo-Chemical Processing Team
InnoTech Alberta
Vegreville, Alberta
780-632-8262 Office
alexander.hayes@innotechalberta.ca

Table of Contents

Disclaimer

SUMMARY

InnoTech Alberta's analysis of the proposed Tri-Municipal Organic Waste Management Facility revealed that the expected utilization of the three municipal partners accounts for roughly half of the facility's design capacity. As designed, the proposed facility has an annual capacity of 44,000 tonnes per year with the Town of Stony Plain utilizing about 10.9% of facility capacity, the City of Spruce Grove utilizing approximately 22.3% of facility capacity and Parkland County utilizing approximately 15.9% of facility capacity. Based on 2016 data estimates, the three municipal partners would utilize 21,600 tonnes, or 49.1%, of the capacity.

The effect of a variety of incentive structures on the economics of the facility were analyzed and a combination of capital support and premium energy pricing, preferably through renewable natural gas pricing, revealed that the anaerobic digester became much more competitive than the MRF with these incentives. InnoTech Alberta estimates that capital support of 25% and a renewable natural gas price of $15 per GJ could make the anaerobic digestion facility economically feasible in the local waste disposal environment ($60 per tonne). However, the MRF would require much larger capital incentives which could put the project at risk of receiving capital support.

InnoTech Alberta recommends exploring the option of abandoning the MRF part of the project and switching to a pure source separated organic (SSO) feedstock while expanding the capacity of the anaerobic digester to reduce the capital costs on a capacity basis. In order to be successful, new sources of SSO feedstock would need to be sourced, either through engagement of the ICI sector or through the recruitment of more municipal partners such as St. Albert or possibly Edmonton.

Should the facility be envisioned as solely for residential SSO feedstock, the partners may wish to engage Edmonton to determine their level of interest in the project should that city transition to a green bin-style program. Being located west of the city, the facility would be suitable for city trucks servicing the west end. Furthermore, the transition to SSO in Edmonton would open capacity at their existing dirty materials recovery facility which could be used by Parkland County to significantly increase their diversion rate while avoiding the high capital expenditure of constructing a new MRF facility. Finally, the inclusion of Edmonton as a partner would bring relevant experience in the construction and management of such a facility. This would be advantageous since the likelihood of attracting a private company to accept the financial and operational risk in a P3 arrangement seems unlikely at current waste disposal rates.

Finally, the impact of the construction of the integrated facility on each partner's waste disposal costs was calculated assuming the facility produced RNG and achieved the breakeven tipping fee under each of the analyzed scenarios. Parkland County's waste disposal costs always increased while it took 50% capital support and $20 RNG to lower the waste disposal costs of the other two partners. In the case of building the anaerobic digester by itself, InnoTech Alberta estimated that increasing scale to reduce capital costs on a capacity basis, combined with 25% capital support, a $60 per tonne tipping fee and $15 per GJ RNG, the all-in waste disposal costs would be lowered by around 2.5% for the City of Spruce Grove after factoring in profit from the facility.

1. Introduction

The municipalities that comprise the Tri-Municipal Region – The Town of Stony Plain, The City of Spruce Grove and Parkland County, have been exploring the concept of a large centralized organic waste and materials recovery facility in the region to increase the sustainability of their waste management operations and increase waste diversion from landfill. In 2016, a Pre-FEED study by the engineering consultancy Morrison Hershfield was performed to propose a conceptual design for this facility and a high level materials and economic balance (1). The study proposed the construction of an integrated 40,000 metric tonnes per year dirty materials recovery facility and 20,000 metric tonnes per year dry batch anaerobic digestion facility at an estimated capital cost of $55.9M which includes a 10% contingency. Estimated breakeven tipping fees under different capital grant funding scenarios were performed and ranged from $140 per tonne for no funding support to $64 per tonne with 75% capital support.

Given the significant capital investment, the three municipalities are interested in performing some further analysis on their respective projected utilization of the proposed facility and how it would ultimately impact their waste disposal cost structure. Since there is currently uncertainty as to how the provincial government will proceed with respect to its bioenergy strategy, InnoTech Alberta proposed examining the effect of several possible outcomes including increased carbon pricing, premium electricity prices and premium renewable natural gas pricing which would involve switching the combined heat and power unit in the proposed facility to a biogas upgrading unit followed by injection into the natural gas grid. With this in mind, the partners contracted InnoTech Alberta (through the Town of Stony Plain), to perform the following analysis:

1. Quantify each municipality's utilization of the proposed facility through quantifying their waste streams and to which part of the facility they would ultimately be sent.
2. Quantify the incremental cost to each municipality's disposal costs should the proposed facility be built.
3. Determine the effect of proposed and potential policy changes on the incremental disposal costs and facility economics. Such as:
    a. Capital grant of 25% and 50%.
    b. Increase in the carbon levy to $50 per tonne CO_2e (proposed for 2022).
    c. Premium pricing for biogas-generated electricity of $0.10 per kWh and $0.15 per kWh
    d. Premium renewable natural gas pricing of $20 per gigajoule and $30 per gigajoule.
4. Considering the results from Step 3, assess the economics of the project as built or as a stand-alone anaerobic digester facility.

2. Facility Utilization by Each Municipality

The facility proposed in the 2016 Pre-FEED study consisted of an integrated 40,000 tonne per year dirty materials recovery facility and 20,000 tonne per year dry batch anaerobic digestion facility. Since Stony Plain and Spruce Grove both have residential source separated organic waste streams, it was envisioned that their respective curbside organics would be directly fed into the anaerobic digestion facility while

the mixed waste from all three municipalities would be fed into the dirty materials recovery facility where it would be separated into an organics fraction that would be sent to the anaerobic digester, a recyclables stream that would be marketed to recyclers, a refuse-derived fuel ready stream that would go to landfill until a viable gasification unit could be sourced and an unrecoverable residual stream that would go to the landfill. A flow diagram of the 44,000 tonne per year facility is shown in Figure 1.

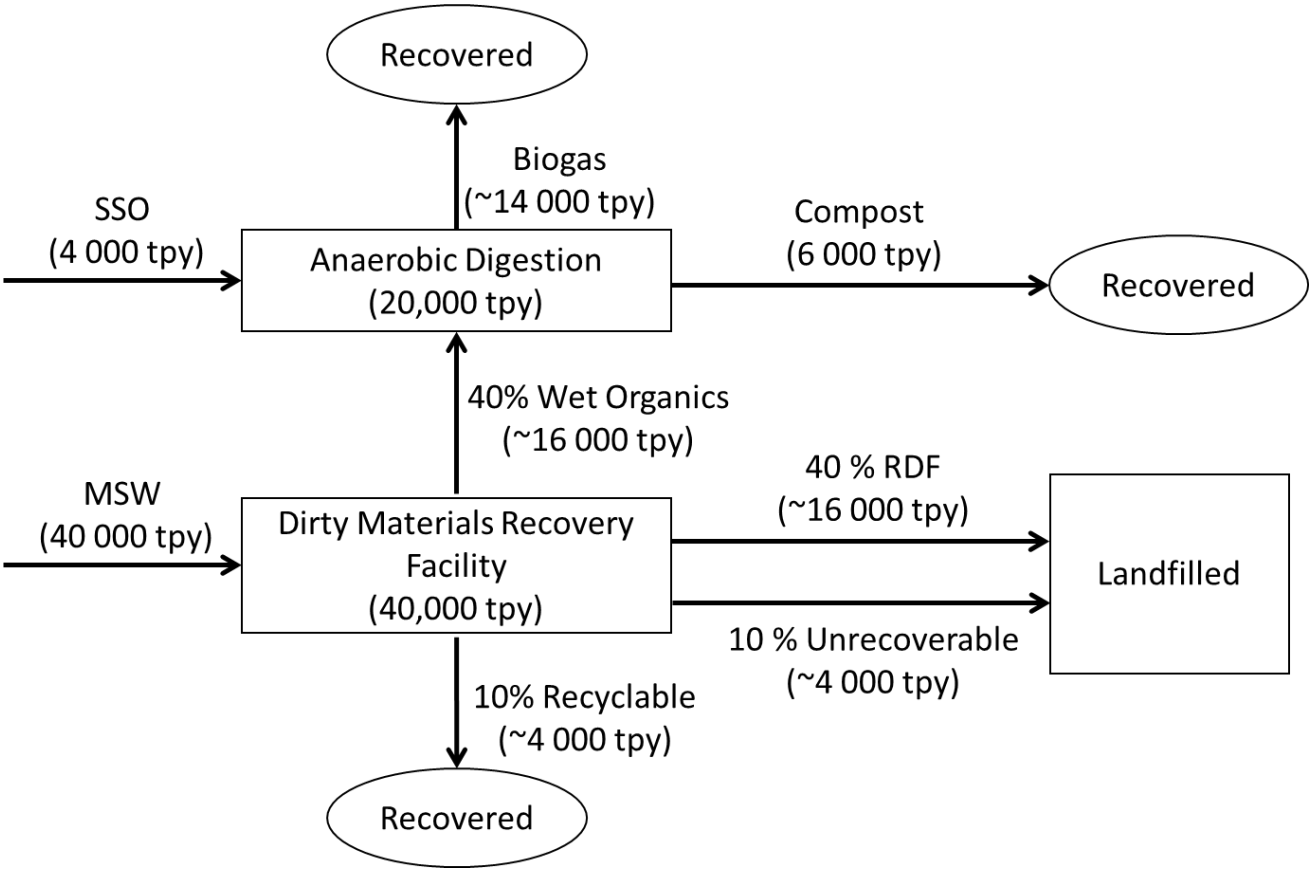

Figure 1 – Material flow diagram of the proposed Tri-Municipal Region Organic Waste Processing Utilization Facility.

As a first step, the estimated capacity utilization of the proposed facility was calculated using historical waste collection data provided by each municipality. The Town of Stony Plain is currently employing a three bin system with a mixed blue bag for recyclables that are being directed to a clean material recovery facility that is beyond the scope of this project, a green bin for organics collection including household organic waste and yard waste that is currently being sent for composting at an aerated static pile facility and a black bin for household garbage that is sent directly to landfill.

The Town of Stony Plain provided monthly data for collection of its streams both via residential curbside pickup and at the depot as far back as 2007. The annual tonnage of each of the waste streams as well as the combined waste tonnage is shown in Figure 2. An observation of the monthly data shows that the town has been diverting leaf and yard waste from landfill as far back as the data provided but began collection of source separated organics at the residential level in 2013. This is noticeable in Figure 2 as

an upward trend in the mass of the organics stream and a downward trend in the garbage stream. There is a synchronous drop in all three streams from 2014 through 2016 that could be economy-related due to the downturn in oil prices. A look at the monthly data also seems to suggest that there was a significant decrease in yard waste in 2015 suggesting that a dry summer (or a wet summer in 2014) could have also been a contributor to the decrease in organics tonnage due to its significant fraction of this waste stream. At the very least, it does give an indicator of the potential volatility of this stream year to year. This is also evident in the proportion of organics in the total waste stream from year to year with 2014 accounting for 40% of the waste stream while organics accounted for 31% of the waste stream in 2015. Estimating the capacity utilization based on the four year historical average yields resulted in annual waste tonnages for the organics and garbage streams of 2100 tonnes and 2700 tonnes, respectively. However, this could underestimate utilization should an improving economy produce equivalent waste volumes as in 2014 when organics and garbage tonnages were 2800 tonnes and 2900 tonnes, respectively.

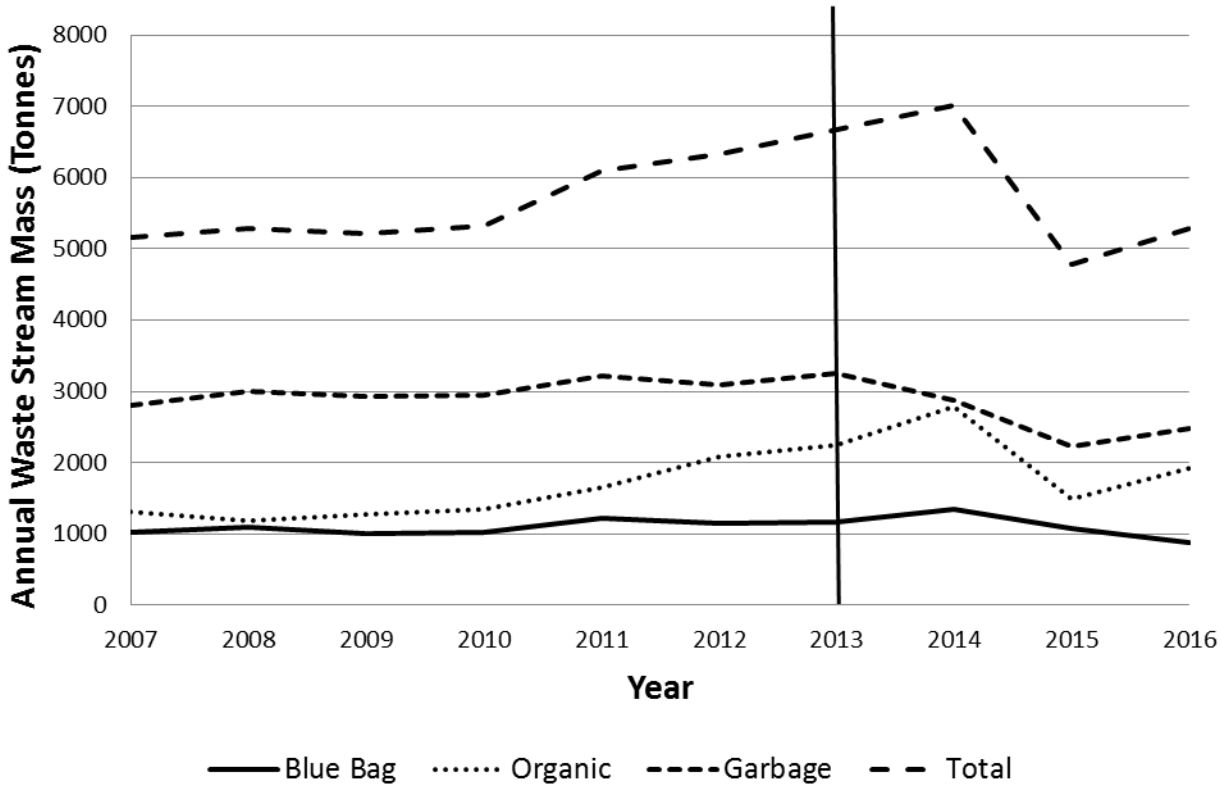

Figure 2 – Annual waste tonnages from 2007-2016 of the three different waste streams for the Town of Stony Plain. The vertical line at the year 2013 indicates when curbside residential source separated organics separation began.

The City of Spruce Grove provided waste collection data for the previous two years (2015 and 2016) for their three bin collection system which is similar to the Town of Stony Plain. The waste tonnages for these streams are shown in Table 1. As with the Town of Stony Plain, there is a noticeable uptick in tonnages from 2015 to 2016. It is also evident that the City of Spruce Grove has a significantly different

waste profile than the Town of Stony Plain. The City of Spruce Grove is recovering approximately 23% of its waste stream in the organics fraction and 14% in the recycle stream compared to 35% and 19%, respectively, for the Town of Stony Plain. Given that the City of Spruce Grove is larger than the Town of Stony Plain a likely driving force behind this difference could be a higher proportion of multi-unit housing in the City of Spruce Grove compared to Stony Plain, which traditionally have lower diversion rates than single family houses. However, these lower diversion rates are something worth exploring further as increasing source separation in both the recycling and organics stream would increase the availability of options for diversion (whether through the proposed facility or other waste management infrastructure).

Table 1 – Annual tonnages for the three waste streams for the City of Spruce Grove for 2015 and 2016 with the actual scenario on the left and the theoretical tonnages if the City of Spruce Grove were to achieve the Town of Stony Plain's diversion rates for 2015 and 2016.

	Actual		Higher Diversion	
	2015	2016	2015	2016
Garbage	6410 (66%)	6883 (61%)	4437 (46%)	5328 (47%)
Organics	1871 (19%)	2889 (25%)	2990 (31%)	4081 (36%)
Recycle	1366 (14%)	1565 (14%)	2122 (22%)	1927 (17%)
Total	9647 (100%)	11337 (100%)	9647 (100%)	11337 (100%)

As shown in Table 1, the City of Spruce Grove's annual tonnage for the garbage and organics stream is approximately 7000 tonnes and 3000 tonnes, respectively. Given the tonnages observed in 2015 and 2016 for the Town of Stony Plain were lower than before the recession, these tonnages will likely increase going forward as the economy recovers. Considering the larger size of the City of Spruce Grove, it is possible that the drop in tonnages from before the downturn was not as severe for the larger centre. Overall waste tonnages in Edmonton did not decrease during this time. If possible, it would be prudent to investigate tonnages from 2012-2014 to determine to what extent there may be a bump in tonnages as the economy returns to normal. Finally, should diversion rates increase to similar rates observed in Stony Plain, then Spruce Grove may expect to see approximately 5500 tonnes of waste and 4100 tonnes of organics annually.

Waste management in the third municipal partner, Parkland County, differs from the other two as there is no curbside pickup and waste is delivered centrally to transfer stations by residents themselves. Most of the waste in the county is delivered to the Parkland County Transfer Station as either waste or recyclables with the waste being disposed of in landfill. The data for Parkland County is shown in Table 2 and includes the waste collected from rural sites. As with the Town of Stony Plain, there is a noticeable decrease in the total waste to landfill in 2014 which is primarily driven through reduced collection at the rural sites. Generally, waste to landfill from the main transfer station was relatively consistent over the five year period although inbound waste tonnages decreased suggesting a reduction in waste diversion in the recycling stream. Current utilization of the facility for Parkland County would be estimated to be

7000 tonnes per year but as can be seen from 2014 data, the waste to landfill was previously as high as 8000 tonnes per year. However, this seems to be a bit of an outlier due to the 600 tonne increase from the previous year driven solely by an increase at the rural sites in that year.

Table 2 – Annual tonnages of waste to landfill for Parkland County from 2012 through 2016.

Year	Parkland County Transfer Station		Rural Sites Waste	Total Waste to Landfill
	Inbound to Transfer Station	Outbound to Landfill		
2012	7843	5250	1881	7131
2013	8422	5352	2044	7396
2014	8160	5385	2663	8048
2015	7990	5197	1800	6997
2016	7568	5268	1682	6950

With knowledge of each municipal partner's projected utilization of the facility, one can now estimate the relative utilization of the proposed facility. As designed, the proposed facility has an annual capacity of 44,000 tonnes per year. In total, the Town of Stony Plain would be sending approximately 4800 tonnes (2100 organics and 2700 tonnes garbage) to the facility annually and utilizing about 10.9% of facility capacity. The City of Spruce Grove would be sending approximately 9800 tonnes (2900 tonnes organics and 6900 tonnes waste) to the facility annually and utilizing approximately 22.3% of facility capacity. Finally Parkland County would be sending a total of 7000 tonnes of waste to the facility annually, utilizing approximately 15.9% of facility capacity. The total utilization based on 2016 data estimates that the three municipal partners would utilize 21,600 tonnes, or 49.1%, of the capacity. This means that the facility would effectively have to source approximately 22,400 tonnes of waste material annually from other municipalities or the local ICI waste stream. It should be noted that Parkland County could already be collecting a significant fraction of its ICI waste stream at its transfer stations so if ICI partners are included they would likely be located in Spruce Grove and Stony Plain.

While the approximate capacity utilization numbers for each municipality provide information on relative usage, it conceals the actual value of the proposed facility relative to sustainable waste management goals, which appear to be largely driven by the desire to increase landfill diversion. From the waste data provided by each municipal partner one can see that the Town of Stony Plain is currently diverting higher levels of both organics and recyclables from their mixed solid waste stream than the City of Spruce Grove. Given these higher diversion rates, it seems very likely that processing the Town of Stony Plain's curbside garbage pickup through the dirty materials recovery facility will yield lower amounts of screened organics and recoverable metals than the curbside pickup from the City of Spruce Grove. In turn, since there is no source separation of organics in Parkland County, one might expect that this waste stream would produce more recoverable organics than the City of Spruce Grove when processed through the dirty materials recovery facility. In order to assess the value of the integrated facility to each partner, one must first understand specifically where value is created in the proposed facility.

3. Economics of Proposed Integrated Organic Waste Processing Facility

In the Pre-FEED study, Morisson Hershfield presented the economics of the proposed facility through producing a Class C cost estimate on the capital costs and, utilizing mass balances and operating costs provided by both Sutco and Bioferm for their systems, estimated revenues and expenditures to estimate the breakeven tipping fee at the facility under different capital support scenarios to provide an estimate of its economic viability in the current waste disposal environment.

It is important to remember that this economic analysis was performed with consideration of the regulatory environment that existed for this type of facility at that point in time and the breakeven tipping fees will likely be reduced going forward as the provincial government moves to implement parts of the Climate Leadership Plan which will ultimately improve the economics of this facility, specifically the anaerobic digester. The government is currently reviewing the offset protocols as they relate to organic waste diversion from landfill with the expectation of the revised protocols being released in early 2018. Missing from the current set of offset protocols is the inclusion of anaerobic digestion of source separated organics as a method of diverting waste from landfill. Currently, an offset protocol exists for the diversion of organic waste to composting facilities but no such protocol has been approved for anaerobic digestion which would be a significant income stream from this facility and, without it, makes it difficult to compete with nearby composting facilities. Some composters in Alberta are able to claim 1.2 tonnes CO_2e in carbon credits for every tonne of source separated organic waste diverted through their composting facility. At $30 per tonne, a similar credit for an anaerobic digester would be worth $720,000 per year for this digester. Furthermore, a portion of the revenue collected by the carbon levy is dedicated towards promoting bioenergy development in the province. While the bioenergy strategy is still under development, this will likely take the form of some sort of premium energy pricing either through the electricity system or through production of renewable natural gas. If implemented, this would also increase the revenue stream for the anaerobic digester making it more competitive with aerated static pile composting which is currently the low cost treatment option for source separated organic waste in this province. To examine these possibilities and the associated impacts several cases were evaluated as follows.

Case 1 – Base Case Facility Economics with Carbon Credits at $30 per tonne CO_2e

In our economic evaluation of this facility, InnoTech Alberta broke down the relative costs of both the anaerobic digestion (AD) facility and the dirty materials recovery facility (MRF) as laid out in the Pre-FEED study. Table 3 presents the capital costs associated with the anaerobic digestion facility including the balance of plant costs associated directly with its construction and 50% of shared buildings such as the administration and main electrical distribution centre. Site costs and permitting were also shared 50%-50% with the MRF.

As can be seen in Table 3, anaerobic digestion is a capital-intensive process with the AD components, balance of plant and fair-share of infrastructure accounting for 55.6% of the total capital budgeted for this facility. This is despite the fact that the AD facility is processing half the total tonnage of the MRF. The cost per capacity of the AD facility is $1550 per tonne annual capacity which is quite high. For

perspective, the 40,000 tonne per year dry digester under construction at the Edmonton Waste Management Centre is reported to be approximately $975 per tonne annual capacity.

Table 3 – Capital costs of anaerobic digester and associated facility infrastructure.

Item		Cost
AD Components	$	15,526,500.00
AD Balance of Plant	$	5,938,586.00
Site Improvement (50%)	$	2,570,868.00
Administration Centre (50%)	$	578,391.50
Main Electrical DC (50%)	$	315,027.50
Overhead (12%)	$	1,128,344.76
Design Contingency (10%)	$	1,053,121.78
Construction Contingency (10%)	$	1,053,121.78
Site Cost and Permitting (50%)	$	2,900,000.00
Total	$	31,063,961.31

Information in the Pre-FEED study was also used to determine the total annual expenses of the anaerobic digestion facility (Table 4). As shown in the table below, the largest single expense is the amortization of the facility which was done at an interest rate of 5% over a 20 year facility life. All remaining expenditures add up to $800,831 which results in an operating cost of $40 per tonne of waste processed; a reasonable expectation for a facility this size.

Table 4 – Annual expenses of the proposed anaerobic digestion facility.

Expenses		Cost
AD Plant O&M	$	169,000.00
CHP O&M	$	247,000.00
Labour	$	268,828.00
Residue Disposal	$	12,000.00
Fuel	$	31,200.00
Contingency	$	72,803.00
Amortization @ 5% over 20 years	$	2,492,652.62
Total	$	3,293,483.62

In terms of revenue, the facility can be expected to generate cash flows from tipping revenue, electricity sales, carbon credit generation and liquidation and, perhaps, compost sales. In order to be self-sufficient, the revenue generated from these income streams will need to be equal (or greater) to the annual expenses of the facility estimated at $3.29M. Ultimately, the facility will be a price-taker for all of these categories because it will be a relatively low quantity electricity supplier, carbon credit revenue is

ultimately set by the government, compost markets are fairly soft and, as mentioned in the Pre-FEED study, the mechanically-separated organics used to make compost will make it difficult to market. For the revenue model, InnoTech Alberta used values of $0.05 per kWh for electricity sales, $0 for compost and 0.925 tonnes CO_2e credit per tonne of organic waste processed (which may be conservative) sold at $30 per tonne CO_2e. Essentially, this becomes an exercise in finding the tipping fee that makes the facility self-sufficient (Table 5).

Table 5 – Annual revenue generated by the anaerobic digestion facility

Revenue	Quantity		Unit Price		Value
Tipping Revenue (tonnes)	20000	$	128.00	$	2,560,000.00
Electricity (kWh)	3661000	$	0.05	$	183,050.00
Carbon Credits (tonne CO_2e)	18500	$	30.00	$	555,000.00
Compost (tonnes)	6000	$	-	$	-
Total				$	3,298,050.00

As shown in Table 5, the breakeven tipping fee for the anaerobic digestion facility under the base case scenario is $128 per tonne. This is slightly lower than the $140 per tonne estimate in the Pre-FEED study which is due to the inclusion of an estimate for the carbon credit generation of this facility under a likely to be approved offset protocol for anaerobic digestion of organic waste. Considering the fact that there is an aerated static pile composting facility operating in the area with tipping fees of approximately $50 per tonne (perhaps lower), as the cost information from Spruce Grove suggests, and landfill tipping fees in the area are approximately $60 per tonne as mentioned in the Pre-FEED study, the tipping fee is likely too high to attract the other 50% of the waste that will be needed to feed this facility; unless the MRF can provide a significantly lower tipping fee due to cost-savings driven by integrating the facilities.

A similar exercise of determining the capital costs associated with the MRF followed by expenses and required revenue to breakeven was performed. As can be seen in Table 6, the MRF is much less capital-intensive than the anaerobic digestion facility.

With an estimate of the associated capital costs, the annual expenses for operating the MRF were estimated (Table 7). Since the MRF is essentially a pre-processing step, the expenses of the MRF are heavily dependent on downstream tipping fees for its principal products. These include the organics which will ultimately be sent to the anaerobic digester and the refuse-derived fuel (RDF) which would currently be sent to landfill but could potentially go to a gasification unit in the future. As shown in Table 7, these two line items are large expenses with the organics to the digester accounting for over $2M in expenses at the $128 per tonne tipping fee. Since the RDF feedstock is currently being sent to landfill, InnoTech Alberta used an estimate of $60 per tonne for a tip fee. However, as landfill tipping fees rise, the annual expenses of the MRF will also increase. Amortization was calculated at 5% over a 20 year period.

Table 6 – Capital costs of the dirty materials recovery facility and associated facility infrastructure.

Item		Cost
Dirty MRF Components	$	9,790,000.00
Dirty MRF Balance of Plant	$	5,552,277.00
Site Improvement (50%)	$	2,570,868.00
Administration Centre (50%)	$	578,391.50
Main Electrical DC (50%)	$	315,027.50
Overhead (12%)	$	1,081,987.68
Design Contingency (10%)	$	1,009,855.17
Construction Contingency (10%)	$	1,009,855.17
Site Cost and Permitting (50%)	$	2,900,000.00
Total	$	24,808,262.02

Table 7 - Annual expenses of the proposed dirty materials recovery facility.

Expenses	Quantity	Unit Price	Cost
Maintenance and Repair	N/A	N/A	$ 371,000.00
Process Electrical	N/A	N/A	$ 58,500.00
Lighting and Ventilation	N/A	N/A	$ 7,300.00
Heating	N/A	N/A	$ 12,600.00
Fuel	N/A	N/A	$ 31,200.00
Labour	N/A	N/A	$ 946,000.00
Inorganic Disposal (tonnes)	511	$ 60.00	$ 30,660.00
RDF Landfilling (tonnes)	15279	$ 60.00	$ 916,740.00
Organics to AD Tipping (tonnes)	15794	$ 128.00	$ 2,021,632.00
Contingency			$ 285,682.00
Amortization @ 5% over 20 years			$ 1,990,679.13
Total			$ 6,671,993.13

The estimated revenue generated by the MRF was also provided in the Pre-FEED study. This was largely based on the quantity and value of recyclables that were predicted to be generated from the waste stream. Ultimately, the tipping fee would need to be set to balance revenue and expenses and this resulted in a required tipping fee of $128 per tonne.

Table 8 – Annual revenue generated by the dirty materials recovery facility

Revenue	Quantity		Unit Price		Value
Tipping Revenue (tonnes)	40000	$	128.00	$	5,120,000.00
Ferrous Metals (tonnes)	1030	$	84.00	$	86,520.00
Non-Ferrous Metals (tonnes)	687	$	1,352.00	$	928,824.00
Plastics (tonnes)	3262	$	93.79	$	305,942.98
Cardboard (tonnes)	687	$	75.00	$	51,525.00
Other Fibre (tonnes)	2750	$	75.00	$	206,250.00
Total				$	6,699,061.98

Case 2: Capital grant secured for 25% or 50% of proposed facility

As shown in the base case, the high capital cost of the facility ultimately forces the tipping fees of the facility to levels that are likely well above what the market will be willing to pay. With half of the capacity of this facility unsecured, this creates significant risk of the facility running under capacity or, more likely, realizing lower tipping fee revenues than required to breakeven. In recent years in Canada, the construction of enclosed in-vessel anaerobic digestion and composting facilities has typically required the project sponsors sourcing some sort of capital support through a government program. These have either been achieved through a funding body whose mandate is to de-risk innovative technology such as Emissions Reduction Alberta or through green infrastructure-type funding programs. Given the recent construction of dry digestion facilities in Edmonton and Surrey, it is less likely that a funding body devoted to de-risking innovation will see this as a project that fits their criteria but there has been significant discussions at both the federal and provincial level in supplying funds for green infrastructure, including waste management infrastructure, which should make securing some level of capital support for this project feasible.

As with the base case, the analysis ultimately begins with the anaerobic digestion facility. InnoTech Alberta explored the effect of securing 25% and 50% capital support on the economic feasibility of the facility. Ultimately, the capital support would reduce the required capital contribution for the anaerobic digestion portion of the facility by the project from $31.1M to $23.3M (25% support) and $15.5M (50% support), respectively. This ultimately reduces the annual amortization costs from $2.5M to $1.9M (25% support) and $1.2M (50% support) and reduces the revenue required to breakeven.

Since the revenue generated from the electricity sales, carbon credit liquidation and compost sales would not be expected to change, the decreased amortization costs essentially reduce the tipping fees required for the facility to breakeven (Table 10). Because the amortization costs are the most significant expense, capital support has a strong effect on tipping fees, lowering them to $97 per tonne at 25% capital support and $66 per tonne at 50% capital support, which essentially makes this facility competitive with existing landfills in the region.

Table 9 – Annual expenses of the proposed anaerobic digestion facility for the base case scenario, 25% capital support and 50% capital support.

Expenses	Base Case	25% Capital	50% Capital
AD Plant O&M	$ 169,000.00	$ 169,000.00	$ 169,000.00
CHP O&M	$ 247,000.00	$ 247,000.00	$ 247,000.00
Labour	$ 268,828.00	$ 268,828.00	$ 268,828.00
Residue Disposal	$ 12,000.00	$ 12,000.00	$ 12,000.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Contingency	$ 72,803.00	$ 72,803.00	$ 72,803.00
Amortization @ 5% over 20 years	$ 2,492,652.62	$1,869,489.47	$ 1,246,326.31
Total	$ 3,293,483.62	$2,670,320.47	$ 2,047,157.31

Table 10 – Annual revenue generated by the anaerobic digestion facility under the base case scenario of no capital support and at 25% and 50% capital support.

Revenue	Quantity	Base Case		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 128.00	$ 2,560,000.00	$ 97.00	$ 1,940,000.00	$ 66.00	$ 1,320,000.00
Electricity (kWh)	3661000	$ 0.05	$ 183,050.00	$ 0.05	$ 183,050.00	$ 0.05	$ 183,050.00
Carbon Credits (tonne CO_2e)	18500	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total			$ 3,298,050.00		$ 2,678,050.00		$ 2,058,050.00

The economics of the MRF are affected in two ways by capital support. First, there are savings in amortization costs as the capital costs of the MRF facility and associated infrastructure decrease from $24.8M under the base scenario to $18.6M and $12.4M under 25% and 50% capital support, respectively. Second, there is a cost saving associated with sending the organics to the anaerobic digestion facility because the required tipping fee is now lower. The annual expenses of the MRF under the base case scenario and 25% and 50% capital support are shown in Table 11.

As with the anaerobic digester, the reduced expenses ultimately lower the required tipping fee for the project to breakeven (Table 12). However, the required tipping fee for the MRF does not decrease as drastically as the anaerobic digestion facility with capital support, only decreasing from $128 per tonne under the base case scenario to $103 per tonne and $78 per tonne with 25% and 50% capital support, respectively. This is due to the more capital-intensive nature of the anaerobic digester which leads to a larger influence on amortization costs on total costs than the MRF. The MRF, on the other hand, has an inherently higher operating cost structure attributable to the need to pay downstream tipping fees.

Table 11 – Annual expenses of the proposed dirty materials recovery facility under the base case scenario of no capital support and at 25% and 50% capital support.

Expenses	Base Case	25% Capital	50% Capital
Maintenance and Repair	$ 371,000.00	$ 371,000.00	$ 371,000.00
Process Electrical	$ 58,500.00	$ 58,500.00	$ 58,500.00
Lighting and Ventilation	$ 7,300.00	$ 7,300.00	$ 7,300.00
Heating	$ 12,600.00	$ 12,600.00	$ 12,600.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Labour	$ 946,000.00	$ 946,000.00	$ 946,000.00
Inorganic Disposal (tonnes)	$ 30,660.00	$ 30,660.00	$ 30,660.00
RDF Landfilling (tonnes)	$ 916,740.00	$ 916,740.00	$ 916,740.00
Organics to AD Tipping (tonnes)	$ 2,021,632.00	$1,532,018.00	$ 1,042,404.00
Contingency	$ 285,682.00	$ 285,682.00	$ 285,682.00
Amortization @ 5% over 20 years	$ 1,990,679.13	$1,493,009.35	$ 995,339.56
Total	$ 6,671,993.13	$5,684,709.35	$ 4,697,425.56

Table 12 – Annual revenue generated by the dirty materials recovery facility under the base case scenario of no capital support and at 25% and 50% capital support.

Revenue	Quantity	Base Case		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	40000	$ 128.00	$ 5,120,000.00	$ 103.00	$ 4,120,000.00	$ 78.00	$ 3,120,000.00
Ferrous Metals (tonnes)	1030	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00
Non-Ferrous Metals (tonnes)	687	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00
Plastics (tonnes)	3262	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98
Cardboard (tonnes)	687	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00
Other Fibre (tonnes)	2750	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00
Total			$ 6,699,061.98		$ 5,699,061.98		$ 4,699,061.98

Case 3: Effect of carbon pricing of $50 per tonne CO_2e on the economics of the proposed facility.

As part of the Climate Leadership Plan, the Alberta government has already applied an economy-wide carbon levy of $30 per tonne CO_2e. In discussion at the federal level is the introduction of a national carbon price that would see this rise to $50 per tonne CO_2e by 2022. In this section, InnoTech Alberta demonstrates the effect of a $50 per tonne CO_2e carbon price on the economics of this facility. The principal effect of the increased carbon price will be to increase revenue generated by carbon credit liquidation. While it is true that the increased carbon levy will likely have some effect on operating costs, these are likely minimal compared to the gain in revenue from the carbon credit sales. Furthermore, given the importance of capital support in facility economics, InnoTech Alberta has analyzed the increase in the carbon levy to $50 per tonne CO_2e both with and without capital support.

For the anaerobic digestion facility, the annual expenses are unchanged with an increase in the carbon levy to $50 per tonne CO_2e (see Table 9). Where changes due occur is on the revenue side (Table 13) where the revenue associated with carbon credit liquidation rises to $925,000 annually from $555,000. The increased revenue allows for a decrease in tipping fees from $128 per tonne to $110 per tonne in the case of no capital support, from $97 per tonne to $78 per tonne with 25% capital support and from $66 per tonne to $47 per tonne with 50% capital support. While there is certainly a combination of carbon levy and capital support that will make this facility competitive with landfills, it should be noted that the increased carbon levy will also benefit other organic waste diversion processes such as composting. In fact, less capital intensive processes such as aerated static piles would likely see larger benefits because the increased carbon credit revenues represent a larger portion of their revenue stream.

Table 13 - Annual revenue generated by the anaerobic digestion facility at a carbon price of $50 per tonne CO_2e for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 110.00	$ 2,200,000.00	$ 78.00	$ 1,560,000.00	$ 47.00	$ 940,000.00
Electricity (kWh)	3661000	$ 0.05	$ 183,050.00	$ 0.05	$ 183,050.00	$ 0.05	$ 183,050.00
Carbon Credits (tonne CO_2e)	18500	$ 50.00	$ 925,000.00	$ 50.00	$ 925,000.00	$ 50.00	$ 925,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total			$ 3,308,050.00		$ 2,668,050.00		$ 2,048,050.00

Again, in our determination of the economics of the MRF, we have assumed that the increase in the carbon levy has a negligible effect on operating expenses. While this is not entirely accurate, the net increase would likely be small compared to other expenses. Annual expenses of the MRF are shown in Table 14 with annual revenue shown in Table 15. The net benefit of increasing the carbon levy to $50 per tonne CO_2e for the MRF is small with the tipping fee decreasing from $128 per tonne to $121 per tonne under the no capital support scenario, from $103 per tonne to $97 per tonne under 25% capital support and from $78 per tonne to $70 per tonne under the 50% capital support scenario. The decrease in required tipping fees at the MRF is entirely due to lower required tipping fees at the anaerobic digestion facility.

Table 14 – Annual expenses of the proposed dirty materials recovery facility at a carbon price of $50 per tonne CO_2e for no capital support, 25% capital support and 50% capital support.

Expenses	No Capital Support	25% Capital	50% Capital
Maintenance and Repair	$ 371,000.00	$ 371,000.00	$ 371,000.00
Process Electrical	$ 58,500.00	$ 58,500.00	$ 58,500.00
Lighting and Ventilation	$ 7,300.00	$ 7,300.00	$ 7,300.00
Heating	$ 12,600.00	$ 12,600.00	$ 12,600.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Labour	$ 946,000.00	$ 946,000.00	$ 946,000.00
Inorganic Disposal (tonnes)	$ 30,660.00	$ 30,660.00	$ 30,660.00
RDF Landfilling (tonnes)	$ 916,740.00	$ 916,740.00	$ 916,740.00
Organics to AD Tipping (tonnes)	$ 1,737,340.00	$1,231,932.00	$ 742,318.00
Contingency	$ 285,682.00	$ 285,682.00	$ 285,682.00
Amortization @ 5% over 20 years	$ 1,990,679.13	$1,493,009.35	$ 995,339.56
Total	$ 6,387,701.13	$5,384,623.35	$ 4,397,339.56

Table 15 – Annual revenue generated by the dirty materials recovery facility at a carbon price of $50 per tonne CO_2e for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	40000	$ 121.00	$ 4,840,000.00	$ 95.00	$ 3,800,000.00	$ 70.00	$ 2,800,000.00
Ferrous Metals (tonnes)	1030	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00
Non-Ferrous Metals (tonnes)	687	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00
Plastics (tonnes)	3262	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98
Cardboard (tonnes)	687	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00
Other Fibre (tonnes)	2750	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00
Total			$ 6,419,061.98		$ 5,379,061.98		$ 4,379,061.98

Case 4: Effect of premium electricity prices of $0.10 per kWh and $0.15 per kWh on the economics of the proposed facility

As the province develops its bioenergy strategy, it is highly likely that any such strategy will include some sort of mechanism to generate above market prices for energy produced from biomass such as would be done at this proposed facility. Ultimately, this would generate some sort of price received by the facility that is above current levels which have been as low as $0.02 per kWh in the past year. In this section, InnoTech Alberta explored the effect of premium prices received in the as-built facility of $0.10 per kWh and $0.15 per kWh. Given the project's potential to receive capital support, InnoTech Alberta also investigated the combination of premium electricity prices with 25% and 50% capital support for the facility.

Whatever hypothetical mechanism the government may use to increase the competitiveness of biogas-fired electricity it will ultimately be reflected in receiving a premium price for electricity exported from this facility. It should be noted that this will only be the case for biogas-fired electricity and not total electricity exports. The CHP in the Pre-FEED study is sized for 640 kW with the exported electricity resulting from anaerobic digestion estimated at 3661 MWh per year. This effectively still leaves approximately 1300 MWh of available electrical export capacity even after we factor in the parasitic load of the facility. This extra capacity could be used efficiently through co-firing the CHP with natural gas but at a $0.05 per kWh electricity price and a $5 per GJ for the delivered natural gas the process is effectively a wash with income amounting to approximately $65,000 for expenses of $61,000 (assuming 38% CHP efficiency and no effective use for the heat). Thus, utilizing the extra capacity has been omitted from the calculation for simplicity. Conceivably, one may argue that the natural gas portion of the CHP is being used to feed the parasitic load of the plant with the facility exporting more biogas-fired electricity but this may further muddy the waters with how the total carbon credits are calculated in the offset protocol. Given the uncertainty and complexity of this issue, it has been omitted and it was assumed that 3661 MWh per year will be exported from the facility which is effectively the lowest return scenario.

At $0.10 per kWh, the net effect on the anaerobic digestion facility is that there are no changes in expenses (see Table 9) and an increase in the value of electricity exports. Table 16 shows the revenue model under this scenario. A comparison of the electricity exports at $0.10 per kWh with the base case scenario reveals that the doubling of the price received for the electrical exports provides enough revenue to cover the CHP operating and maintenance costs. This highlights the challenges of bioenergy projects in low-price energy jurisdictions, such as Alberta, as the conversion of the biogas to electricity is essentially a money-losing operation (although necessary to monetize the value of the biogas).

The net effect of increased revenue from electricity exports is a reduction in the necessary breakeven tipping fee. The tipping fee decreases from $128 per tonne to $119 per tonne for no capital support, from $97 per tonne to $88 per tonne with 25% capital support and from $66 per tonne to $57 per tonne with 50% capital support.

Table 16 - Annual revenue generated by the anaerobic digestion facility at a biogas-fired electricity price of $0.10 per kWh for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 119.00	$ 2,380,000.00	$ 88.00	$ 1,760,000.00	$ 57.00	$ 1,140,000.00
Electricity (kWh)	3661000	$ 0.10	$ 366,100.00	$ 0.10	$ 366,100.00	$ 0.10	$ 366,100.00
Carbon Credits (tonne CO_2e)	18500	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total			$ 3,301,100.00		$ 2,681,100.00		$ 2,061,100.00

The change in tipping fees at the anaerobic digestion facility reduces the expenses at the MRF accordingly (Table 17) with the breakeven tipping fee at the MRF decreasing accordingly (Table 18). As was the case with the increased carbon levy, the net benefit to the MRF is less than that for the anaerobic digestion facility. Breakeven tipping fees decrease from $128 per tonne to $124 per tonne with no capital support, from $103 per tonne to $99 per tonne with 25% capital support and from $78 per tonne to $74 per tonne in the case of 50% capital support.

Table 17 – Annual expenses of the proposed dirty materials recovery facility at a biogas-fired electricity price of $0.10 per kWh for no capital support, 25% capital support and 50% capital support.

Expenses	No Capital Support	25% Capital	50% Capital
Maintenance and Repair	$ 371,000.00	$ 371,000.00	$ 371,000.00
Process Electrical	$ 58,500.00	$ 58,500.00	$ 58,500.00
Lighting and Ventilation	$ 7,300.00	$ 7,300.00	$ 7,300.00
Heating	$ 12,600.00	$ 12,600.00	$ 12,600.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Labour	$ 946,000.00	$ 946,000.00	$ 946,000.00
Inorganic Disposal (tonnes)	$ 30,660.00	$ 30,660.00	$ 30,660.00
RDF Landfilling (tonnes)	$ 916,740.00	$ 916,740.00	$ 916,740.00
Organics to AD Tipping (tonnes)	$ 1,879,486.00	$1,389,872.00	$ 900,258.00
Contingency	$ 285,682.00	$ 285,682.00	$ 285,682.00
Amortization @ 5% over 20 years	$ 1,990,679.13	$1,493,009.35	$ 995,339.56
Total	$ 6,529,847.13	$5,542,563.35	$ 4,555,279.56

Table 18 – Annual revenue generated by the dirty materials recovery facility at a biogas-fired electricity price of $0.10 per kWh for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	40000	$ 124.00	$ 4,960,000.00	$ 99.00	$ 3,960,000.00	$ 74.00	$ 2,960,000.00
Ferrous Metals (tonnes)	1030	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00
Non-Ferrous Metals (tonnes)	687	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00
Plastics (tonnes)	3262	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98
Cardboard (tonnes)	687	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00
Other Fibre (tonnes)	2750	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00
Total			$ 6,539,061.98		$ 5,539,061.98		$ 4,539,061.98

In a scenario of a biogas-fired electricity price of $0.15 per kWh, the economics of the anaerobic digestion facility continue to improve. Revenue generated from the anaerobic digestion facility is presented in Table 19. The breakeven tipping fee continues to decrease reaching $110 per tonne with no capital support, $79 per tonne at 25% capital support and $48 per tonne at 50% capital support.

Table 19 - Annual expenses of the proposed anaerobic digestion facility at a biogas-fired electricity price of $0.15 per kWh for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 110.00	$ 2,200,000.00	$ 79.00	$ 1,580,000.00	$ 48.00	$ 960,000.00
Electricity (kWh)	3661000	$ 0.15	$ 549,150.00	$ 0.15	$ 549,150.00	$ 0.15	$ 549,150.00
Carbon Credits (tonne CO_2e)	18500	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total			$ 3,304,150.00		$ 2,684,150.00		$ 2,064,150.00

In the case of the MRF, the decreased tipping fees at the anaerobic digestion facility continue to reduce its expenses marginally (Table 20). Breakeven tipping fees are shown in Table 21. For the MRF, the breakeven tipping fee will decrease to $120 per tonne with no capital support, $96 per tonne at 25% capital support and $71 per tonne at 50% capital support.

Table 20 - Annual expenses of the proposed dirty materials recovery facility at a biogas-fired electricity price of $0.15 per kWh for no capital support, 25% capital support and 50% capital support.

Expenses	No Capital Support	25% Capital	50% Capital
Maintenance and Repair	$ 371,000.00	$ 371,000.00	$ 371,000.00
Process Electrical	$ 58,500.00	$ 58,500.00	$ 58,500.00
Lighting and Ventilation	$ 7,300.00	$ 7,300.00	$ 7,300.00
Heating	$ 12,600.00	$ 12,600.00	$ 12,600.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Labour	$ 946,000.00	$ 946,000.00	$ 946,000.00
Inorganic Disposal (tonnes)	$ 30,660.00	$ 30,660.00	$ 30,660.00
RDF Landfilling (tonnes)	$ 916,740.00	$ 916,740.00	$ 916,740.00
Organics to AD Tipping (tonnes)	$ 1,737,340.00	$1,247,726.00	$ 758,112.00
Contingency	$ 285,682.00	$ 285,682.00	$ 285,682.00
Amortization @ 5% over 20 years	$ 1,990,679.13	$1,493,009.35	$ 995,339.56
Total	$ 6,387,701.13	$5,400,417.35	$ 4,413,133.56

Table 21 - Annual revenue generated by the dirty materials recovery facility at a biogas-fired electricity price of $0.15 per kWh for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	40000	$ 120.00	$ 4,800,000.00	$ 96.00	$ 3,840,000.00	$ 71.00	$ 2,840,000.00
Ferrous Metals (tonnes)	1030	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00
Non-Ferrous Metals (tonnes)	687	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00
Plastics (tonnes)	3262	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98
Cardboard (tonnes)	687	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00
Other Fibre (tonnes)	2750	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00
Total			$ 6,379,061.98		$ 5,419,061.98		$ 4,419,061.98

Case 5: Effect of premium renewable natural gas (RNG) prices of $10 per GJ and $20 per GJ on the economics of the proposed facility

Another possible outcome from the development of Alberta's bioenergy strategy is an avenue to generate value from produced biogas through upgrading it to pipeline quality natural gas and injecting it into the pipeline as renewable natural gas (RNG). The Canadian Gas Association has an aspirational goal of 5% RNG in its system by 2025 and 10% by 2030. ATCO, the largest natural gas distributor in Alberta supports this goal and has been lobbying to have the provincial government provide a mechanism to realize this objective. There has been an RNG-pricing system in BC for several years with FortisBC paying up to $15 per GJ for RNG supplied to the system. Going forward, FortisBC has received regulatory approval to pay up to $30 per GJ depending on the economics of the project. In this section, InnoTech Alberta investigates how converting the anaerobic digestion facility to produce RNG affects the economics of the project should the facility be able to realize RNG prices of $10 per GJ or $20 per GJ.

RNG production from biogas typically requires a biogas upgrading system such as a water scrubber or pressure swing adsorption unit to remove carbon dioxide and other contaminants from the biogas stream to produce pipeline quality natural gas. This unit would replace the existing CHP and affect the economics of the project in the following way:

1. Change in capital costs of the anaerobic digestion facility due to CHP substitution with biogas upgrader.
2. Change in operating costs as the CHP operating and maintenance costs would no longer be included but the biogas upgrader would have its own operating and maintenance costs.
3. The CHP was supplying the facility with all of its internal power and heat which would now need to be supplied externally through purchased electricity and natural gas.
4. Different revenue generation from RNG sales versus electricity sales.

In terms of changes to capital costs, InnoTech Alberta assumed an installed price of the 640 kW CHP of $2000 per kW or $1.28M. In a technology review performed this year, InnoTech Alberta developed a capital cost model for biogas upgrading units (2). At a raw biogas flowrate of 300 Nm^3 per hour,

InnoTech Alberta estimates that the installed biogas upgrader would cost approximately $7000 per Nm^3 per hour capacity or $2.1M. We have not included other changes in capital costs which could include grid interconnection for the CHP or pipeline connection for the scrubbing unit as these are smaller costs than the units themselves. Considering the above, the new capital cost model for the anaerobic digestion facility is shown in Table 22. The capital costs associated with the anaerobic digestion facility increase to $31.9M from $31.1M. With 25% or 50% capital support, the contribution from the project sponsor becomes $23.9M and $15.9M, respectively.

Table 22 – Estimated capital costs of anaerobic digester and associated facility infrastructure after substituting RNG upgrader for CHP unit.

Item		Cost
AD Components	$	16,346,500.00
AD Balance of Plant	$	5,938,586.00
Site Improvement (50%)	$	2,570,868.00
Administration Centre (50%)	$	578,391.50
Main Electrical DC (50%)	$	315,027.50
Overhead (12%)	$	1,128,344.76
Design Contingency (10%)	$	1,053,121.78
Construction Contingency (10%)	$	1,053,121.78
Site Cost and Permitting (50%)	$	2,900,000.00
Total	$	31,883,961.31

The annual expenses of the anaerobic digestion facility are also affected by switching to RNG upgrading from combustion in a CHP. For a 300 Nm^3 per hour biogas upgrader, InnoTech Alberta estimates the operating and maintenance costs to be approximately $0.05 per Nm^3 of raw biogas or $131,500 at maximum capacity. Replacing the estimated 640675 kWh of electrical load to the facility supplied by the CHP would cost approximately $32,000 annually at $0.05 per kWh and the estimated 2233 GJ of natural gas consumption would cost $11,100 at $5 per GJ for a combined internal energy substitution charge of approximately $43,000 per year. The estimated annual expenses of the anaerobic digestion facility are shown in Table 23.

The estimated annual revenue for the anaerobic digestion facility at a $10 per GJ RNG price is shown in Table 24. InnoTech Alberta estimates that the facility will produce approximately 44675 GJ of RNG annually. The estimated breakeven tipping fees under this scenario are $115 per tonne for no capital support, $83 per tonne at 25% capital support and $51 per tonne at 50% capital support. The benefit of switching to the RNG pricing route compared to a premium electricity price is evident when comparing RNG revenue to the biogas upgrading operating and maintenance costs which are clearly being covered. This is further aided by the fact that all of the produced methane is receiving premium pricing and not just the portion converted to electricity in the CHP unit (typically around 38%) and exported to the grid.

Table 23 - Annual expenses of the proposed anaerobic digestion facility at an RNG price of $10 per GJ for no capital support, 25% capital support and 50% capital support.

Expenses	No Capital Support	25% Capital	50% Capital
AD Plant O&M	$ 169,000.00	$ 169,000.00	$ 169,000.00
Biogas Upgrader O&M	$ 131,500.00	$ 131,500.00	$ 131,500.00
Labour	$ 268,828.00	$ 268,828.00	$ 268,828.00
Residue Disposal	$ 12,000.00	$ 12,000.00	$ 12,000.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Contingency	$ 72,803.00	$ 72,803.00	$ 72,803.00
Internal Energy Substitution	$ 43,203.08	$ 43,203.08	$ 43,203.08
Amortization @ 5% over 20 years	$ 2,558,451.55	$1,918,838.66	$ 1,279,225.77
Total	$ 3,286,985.62	$2,647,372.74	$ 2,007,759.85

Table 24 - Annual revenues of the proposed anaerobic digestion facility at an RNG price of $10 per GJ for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 115.00	$ 2,300,000.00	$ 83.00	$ 1,660,000.00	$ 51.00	$ 1,020,000.00
RNG (GJ)	44675	$ 10.00	$ 446,750.00	$ 10.00	$ 446,750.00	$ 10.00	$ 446,750.00
Carbon Credits (tonne CO_2e)	18500	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total			$ 3,301,750.00		$ 2,661,750.00		$ 2,021,750.00

As for the MRF, the expenses are largely unaffected by switching the anaerobic digestion facility to RNG production with the exception of the change to the organics tipping fee. The expenses of the MRF are shown in Table 25. Breakeven tipping fees for the MRF in this scenario are shown in Table 26. With no capital support the MRF would require tipping fees of $123 per tonne while 25% and 50% capital support would require $98 per tonne and $75 per tonne, respectively.

Table 25 - Annual expenses of the proposed dirty materials recovery facility at an RNG price of $10 per GJ for no capital support, 25% capital support and 50% capital support.

Expenses	No Capital Support	25% Capital	50% Capital
Maintenance and Repair	$ 371,000.00	$ 371,000.00	$ 371,000.00
Process Electrical	$ 58,500.00	$ 58,500.00	$ 58,500.00
Lighting and Ventilation	$ 7,300.00	$ 7,300.00	$ 7,300.00
Heating	$ 12,600.00	$ 12,600.00	$ 12,600.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Labour	$ 946,000.00	$ 946,000.00	$ 946,000.00
Inorganic Disposal (tonnes)	$ 30,660.00	$ 30,660.00	$ 30,660.00
RDF Landfilling (tonnes)	$ 916,740.00	$ 916,740.00	$ 916,740.00
Organics to AD Tipping (tonnes)	$ 1,816,310.00	$1,310,902.00	$ 805,494.00
Contingency	$ 285,682.00	$ 285,682.00	$ 285,682.00
Amortization @ 5% over 20 years	$ 1,990,679.13	$1,493,009.35	$ 995,339.56
Total	$ 6,466,671.13	$5,463,593.35	$ 4,460,515.56

Table 26 – Annual revenues of the proposed dirty materials recovery facility at an RNG price of $10 per GJ for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	40000	$ 123.00	$ 4,920,000.00	$ 98.00	$ 3,920,000.00	$ 75.00	$ 3,000,000.00
Ferrous Metals (tonnes)	1030	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00
Non-Ferrous Metals (tonnes)	687	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00
Plastics (tonnes)	3262	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98
Cardboard (tonnes)	687	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00
Other Fibre (tonnes)	2750	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00
Total			$ 6,499,061.98		$ 5,499,061.98		$ 4,579,061.98

An increase in the realized RNG price to $20 per GJ provides further benefits to the project because it improves the economics of the anaerobic digestion facility considerably. While annual expenses remain the same, revenue generated from RNG sales double which ultimately drives down breakeven tipping fees (Table 27). With no capital support, the breakeven tipping fee of the anaerobic digestion facility is $91 per tonne while with 25% and 50% capital support it is $60 per tonne and $28 per tonne, respectively.

Table 27 - Annual revenues of the proposed anaerobic digestion facility at an RNG price of $20 per GJ for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 91.00	$ 1,820,000.00	$ 60.00	$ 1,200,000.00	$ 28.00	$ 560,000.00
RNG (GJ)	44675	$ 20.00	$ 893,500.00	$ 20.00	$ 893,500.00	$ 20.00	$ 893,500.00
Carbon Credits (tonne CO_2e)	18500	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total			$ 3,268,500.00		$ 2,648,500.00		$ 2,008,500.00

The annual expenses of the MRF in such a scenario are shown in Table 28 with the revenues with breakeven tipping fees being shown in Table 29. With no capital support, the MRF requires tipping fees of $113 per tonne while 25% and 50% capital support would require $88 per tonne and $63 per tonne, respectively.

Table 28 - Annual expenses of the proposed dirty materials recovery facility at an RNG price of $20 per GJ for no capital support, 25% capital support and 50% capital support.

Expenses	No Capital Support	25% Capital	50% Capital
Maintenance and Repair	$ 371,000.00	$ 371,000.00	$ 371,000.00
Process Electrical	$ 58,500.00	$ 58,500.00	$ 58,500.00
Lighting and Ventilation	$ 7,300.00	$ 7,300.00	$ 7,300.00
Heating	$ 12,600.00	$ 12,600.00	$ 12,600.00
Fuel	$ 31,200.00	$ 31,200.00	$ 31,200.00
Labour	$ 946,000.00	$ 946,000.00	$ 946,000.00
Inorganic Disposal (tonnes)	$ 30,660.00	$ 30,660.00	$ 30,660.00
RDF Landfilling (tonnes)	$ 916,740.00	$ 916,740.00	$ 916,740.00
Organics to AD Tipping (tonnes)	$ 1,437,254.00	$ 947,640.00	$ 442,232.00
Contingency	$ 285,682.00	$ 285,682.00	$ 285,682.00
Amortization @ 5% over 20 years	$ 1,990,679.13	$1,493,009.35	$ 995,339.56
Total	$ 6,087,615.13	$5,100,331.35	$ 4,097,253.56

Table 29 - Annual revenues of the proposed dirty materials recovery facility at an RNG price of $20 per GJ for no capital support, 25% capital support and 50% capital support.

Revenue	Quantity	No Capital Support		25% Capital		50% Capital	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	40000	$ 113.00	$ 4,520,000.00	$ 88.00	$ 3,520,000.00	$ 63.00	$ 2,520,000.00
Ferrous Metals (tonnes)	1030	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00	$ 84.00	$ 86,520.00
Non-Ferrous Metals (tonnes)	687	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00	$ 1,352.00	$ 928,824.00
Plastics (tonnes)	3262	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98	$ 93.79	$ 305,942.98
Cardboard (tonnes)	687	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00	$ 75.00	$ 51,525.00
Other Fibre (tonnes)	2750	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00	$ 75.00	$ 206,250.00
Total			$ 6,099,061.98		$ 5,099,061.98		$ 4,099,061.98

Summary of Economic Analysis:

In this section, InnoTech Alberta explored the economics of the proposed facility through determining the tipping fee required to breakeven under a variety of possible funding and operating scenarios that could be available to the project sponsor. This included the effect of some level of capital support from a higher level of government, a rising carbon levy, and a premium energy pricing mechanism achieved through either the electricity market or an RNG price.

The analysis of the facility dictates that some level of capital support will likely be necessary for this project to advance. Historically, Alberta has helped finance biogas projects through capital assistance in the 25%-33% range but some projects have received more assistance through stacking of two separate capital support programs. Given the interest at both the federal and provincial government in funding green infrastructure, it is possible that this project could secure some sort of assistance, likely in the 25% capital support range. Capital support is inherently more advantageous for the capital-intensive anaerobic digester than for the less capital-intensive MRF. As a result, the analysis showed that the economics of the MRF is challenging under all scenarios explored with capital support levels of upwards of 50% combined with policies to improve the competitiveness of the anaerobic digester being required to reduce the tipping fee at the MRF to current market levels in the $60 per tonne range.

Given the possibility of the carbon levy increasing in the years ahead, InnoTech Alberta analyzed the effect of increasing the carbon levy to $50 per tonne CO_2e. The effect is quite favourable for the anaerobic digestion facility but it needs to be kept in mind that it would also likely be at least as beneficial for a composting facility. In order to increase the competitiveness of an anaerobic digester versus a composting facility, higher energy prices are required because this is a revenue stream available only to a digester and is not realized through composting. This higher revenue stream can be used to pay off the higher amortization costs of the anaerobic digester.

The analysis of premium energy prices demonstrated that the project will ultimately benefit from policies that deliver premium pricing whether this is through the electricity market or the establishment of an RNG price. However, the preferred path would appear to be through upgrading to RNG. In the case

of a premium electricity price, even at $0.15 per kWh the project would require elevated tipping fees compared to local waste disposal options. Using the established premium in the provincial government's previous Bioenergy Producers Program of +$0.06 per kWh as a guideline, this would only result in $0.11 per kWh at a market price of $0.05 per kWh, which will result in uncompetitive tipping fees. In the case of RNG production, at 25% capital support, the project would require RNG prices of under $20 per GJ for the anaerobic digester to breakeven at current tipping fees in the region. Given that this is in the price range under discussion for RNG pricing, the RNG route provides a higher probability of the facility being built while providing a more stable cash flow as the facility would face less competition in the RNG space than in the electricity market.

InnoTech Alberta's analysis of the proposed integrated facility ultimately revealed that the more competitive piece of the facility going forward will likely be the anaerobic digester. In the current environment, the breakeven tipping fees at each facility are the same at $128 per tonne. However, under every analyzed scenario of capital support, increased carbon levy and premium energy pricing, the breakeven tipping fee decreased more for the anaerobic digester than the MRF (Figure 3). In fact, reduced breakeven tipping fees at the MRF were typically due to the increased competiveness of the anaerobic digestion facility, which required lower tipping fees and ultimately reduced expenses at the MRF. Considering the main benefit of the MRF is the diversion of organics (as no outlet for the RDF feedstock currently exists) and that two of the three municipal partners are already source-separating their residential organic waste, InnoTech Alberta decided to explore the economic feasibility of the anaerobic digestion facility by itself.

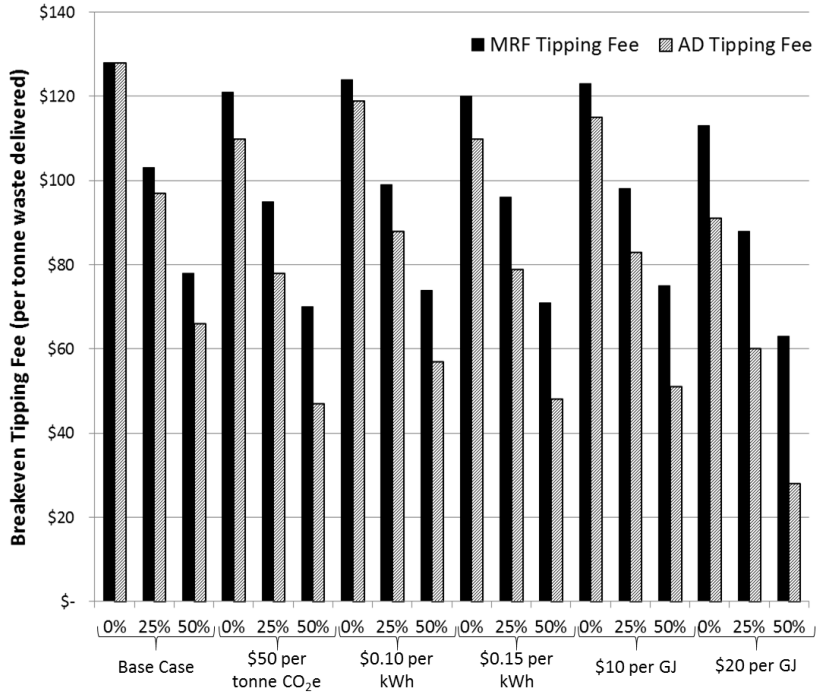

Figure 3 – Breakeven tipping fee at the MRF and AD facility under analyzed scenarios of capital support and bioenergy incentives.

4. Economics of Dry Batch Digestion Facility Alone

The result of InnoTech Alberta's economic analysis of the proposed organic waste processing facility indicate that, of the two facilities that make up the integrated organic waste processing facility, the anaerobic digester will be increasingly competitive in the waste disposal landscape should bioenergy incentives be introduced by the province. The MRF, on the other hand, simply has its competitiveness improved through the increased competitiveness of the anaerobic digester and increasingly becomes a net drag on project economics as incentives improve the competitiveness of the anaerobic digester.

Considering the above, InnoTech Alberta explored the feasibility of constructing only the anaerobic digester portion of the project to produce RNG and abandoning the MRF. Abandoning the MRF creates several issues that would need to be discussed by the project partners. The main issue being that the facility would require source-separated organic waste (SSO) as the feedstock. This is currently done in the City of Spruce Grove and the Town of Stony Plain but not in Parkland County so Parkland County's ability to directly participate in the project would require the introduction of some form of organics separation. However, switching to a source-separated feedstock would also likely result in slightly higher gas yields, improving the economics of the digester further while providing a cleaner, more visually acceptable compost product from the facility that is more likely to be used and possibly generate a net revenue stream of its own.

In exploring the economic feasibility of the anaerobic digester alone, InnoTech Alberta assumed a pure residential SSO feedstock going to the facility and estimated that this would produce 49000 GJ annually from 20000 tonnes of feedstock and realizing an RNG price of $15 per GJ. It was assumed that compost would have negligible net value after transport, the carbon levy was maintained at $30 per tonne CO_2e and, ultimately, the realized tipping fee of the facility would be $60 per tonne which was referenced as the disposal cost from the MRF in the Pre-FEED study. As in the Pre-FEED study, the operating costs of the anaerobic digestion facility were estimated at $40 per tonne. Finally, capital cost of the facility was estimated at $31.9M ($1595 per tonne annual capacity). Given the large influence of capital costs on project economics, InnoTech Alberta explored the effect of reduced capital costs on project economics as well. In constructing their anaerobic digestion facility, the Edmonton Waste Management Centre installed 40,000 tonnes per year annual capacity for an estimated $39M ($975 per tonne annual capacity). This compares to an initial budget of $31M ($775 per tonne annual capacity). InnoTech Alberta explored project economics for the construction of the anaerobic digester at these three different capital costs with 25% capital support (Table 30).

As shown in Table 30, construction of the anaerobic digestion facility at a capital cost of $1595 per tonne annual capacity will result in negative operating income at a tipping fee of $60 per tonne. While some cost savings were identified in the Pre-FEED study to reduce capital costs, these amounted to approximately 4% of total capital. In order to find significant cost savings, this would likely involve increasing the capacity of the facility closer to the scale of the anaerobic digester at the Edmonton Waste Management Centre (40,000 tonnes per year). At this scale, capital costs will soon have been demonstrated to come in at approximately $975 per tonne annual capacity in the region and with the predicted revenue stream the operating income would be almost $588,000, annually, (scaled to 20,000

tonne per year capacity). In the case of the capital cost scenario of $775 per tonne annual capacity the annual operating income would be $829,000 (scaled to 20,000 tonne per year capacity).

Table 30 – Estimated annual operating income from the anaerobic digestion facility under three different capital cost scenarios assuming 25% capital support.

Revenue	Quantity	$1595 per tpy		$975 per tpy		$775 per tpy	
		Unit Price	Value	Unit Price	Value	Unit Price	Value
Tipping Revenue (tonnes)	20000	$ 60.00	$ 1,200,000.00	$ 60.00	$ 1,200,000.00	$ 60.00	$ 1,200,000.00
RNG (GJ)	49000	$ 15.00	$ 735,000.00	$ 15.00	$ 735,000.00	$ 15.00	$ 735,000.00
Carbon Credits (tonne CO_2e)	18500	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00	$ 30.00	$ 555,000.00
Compost (tonnes)	6000	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenue			$ 2,490,000.00		$ 2,490,000.00		$ 2,490,000.00
Operating and Maintenance			$ 728,534.08		$ 728,534.08		$ 728,534.08
Amortization @ 5% 20 years			$1,918,838.66		$ 1,173,547.84		$ 932,820.08
Operating Income[1]			-$ 157,372.74		$ 587,918.09		$ 828,645.85

1 – Assume assets depreciate to zero over life of project.

The realistic possibility of the anaerobic digestion facility to be profitable at a $60 per tonne waste tipping fee should the facility be able to be constructed for a similar cost as the existing digester at the Edmonton Waste Management Centre raises several questions. First, is the profitability enough to attract a private company to construct and operate the facility? This could play out as a P3 type model, similar to the Surrey Biofuel Facility in BC, where the municipal partners would play the role of waste supplier at a defined price. This could be attractive to the municipal partners as it keeps them out of the waste management business and does not expose them to the financial and operational risk of the facility. A second question that arises is that if increased scale is needed at the anaerobic digestion facility where will all the SSO feedstock be sourced?

To answer the first question, whether the project may be attractive to a private company, one essentially must evaluate the project in terms that a private sector company would evaluate the project. Given the significant capital investment of the facility, the pool of likely candidates to own and operate this facility will likely be small with the main example in the Canadian market being Orgaworld Canada, a division of Renewi PLC. Another large company operating such facilities in Canada is Suez, the operator of the Edmonton Waste Management Centre. In discussions with waste management companies operating in this space, InnoTech Alberta learned that these projects are evaluated using a variety of financial metrics and tools include IRR, NPV, ROI and discounted cash flow analysis. Generally speaking, an IRR above 20% is likely a minimum to attract private investment.

InnoTech Alberta has modeled the discounted cash flow from the proposed anaerobic digester facility alone using a discount rate of 5.5%, similar to Waste Management Inc.'s weight associated cost of capital, and at an interest rate of 5% for the three scenarios discussed plus a fourth scenario. In this fourth scenario, InnoTech Alberta assumed the project could be built for $775 per tonne annual

capacity, receive 33% capital support, that the waste suppliers were willing to pay $65 per tonne as a tipping fee and that the carbon levy was $50 per tonne with the RNG price being $15 per GJ. As shown in Figure 4, it is only in this fourth scenario that the IRR is above 20%. While it is conceivable that all of the above may occur, the project would still contain significant risk to the company as approximately half of the revenue would be derived from government incentive programs and the existence of lower cost disposal options in the region effectively caps tipping fee revenue in the near to medium term. In the baseline scenario, a $60 per tonne tipping fee does not even cover the cost of the project, producing an IRR of only 4.0%. Reduced capital costs, likely achieved through adding scale to the facility, ultimately allow the project to produce a positive return while keeping tipping fees at a $60 per tonne level that appears to be in line with the going rate in the waste disposal market.

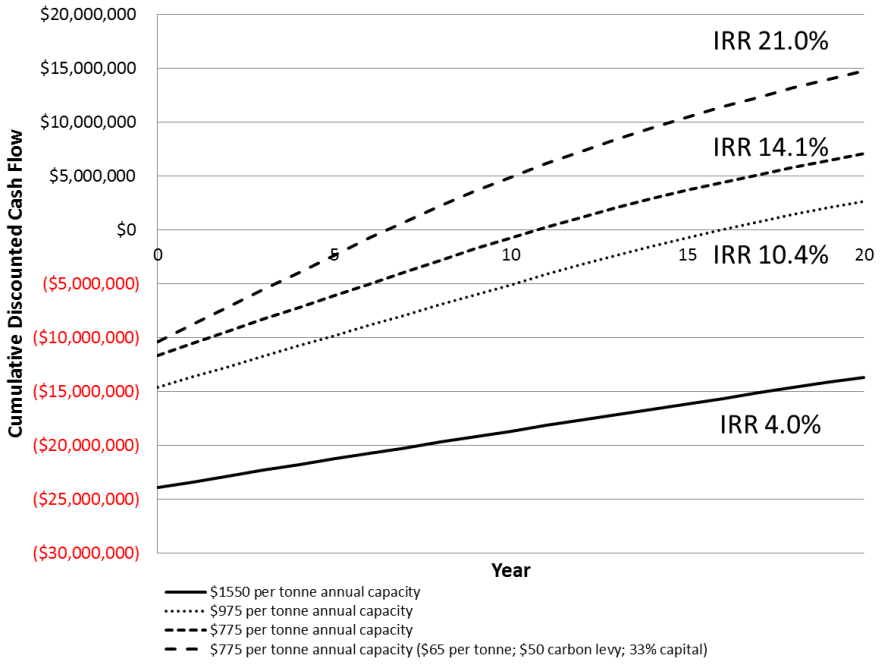

Figure 4 – Cumulative discounted cash flow and IRR for the anaerobic digestion facility alone under several scenarios.

Whether or not the project attracts a private sponsor, the anaerobic digestion facility will likely need to build scale in order to achieve the desired reduction in capital costs. Inclusion of larger neighboring municipalities that surround Edmonton such as St. Albert could add an approximate 6000-8000 tonnes of residential SSO annually to the facility (assuming St. Albert has similar diversion rates to Spruce Grove and Stony Plain). However, to achieve 40,000 tonnes per year which would result in the approximate capital costs required for the project to be economical it is likely that either the ICI sector would need to be included or Edmonton would need to transition to a green bin system and join the project as a partner.

The latter option could be particularly attractive to all three project partners as a transition to a green bin program in Edmonton could facilitate the transition to a regional approach to waste management. The proposed location of this facility is convenient and likely cheaper for delivery from the west end of

Edmonton than the existing Edmonton Waste Management Centre and the proposed site is closer to Spruce Grove and Stony Plain than Cleanit Greenit where their SSO is currently managed, creating negligible transportation cost differences. Bringing Edmonton on as a partner would add experience with the construction phase and managing such a facility while also opening up capacity at their existing dirty materials recovery facility where Parkland County could send their existing waste stream to increase their diversion rate without having to carry the higher costs of constructing a new dirty materials recovery facility.

5. Impact on Waste Disposal Costs of Each Municipal Partner

In determining the cost impact of construction of the integrated facility, InnoTech Alberta explored the option of the conversion of the anaerobic digestion facility to produce RNG as we believe that this will be the most advantageous use of the biogas going forward. The absolute cost increase for each municipal partner was estimated under the two different RNG prices and three capital support scenarios (Table 31). It should be noted that this assumes that the tipping fees projected in the economic analysis in Section 3 are realized for the whole facility and does not reflect the risk of losses should the municipal partners be equity owners and not realize the breakeven tipping fees. InnoTech Alberta assumed local tipping fees for garbage of $60 per tonne and organics of $50 per tonne in this assessment. The City of Spruce Grove provided its total waste disposal costs for 2015 and 2016. In 2016, total waste disposal costs at the city were approximately $2.24M. In the calculated scenario, the all-in disposal costs for the City of Spruce Grove in the $10 per GJ RNG scenario would increase 28% in the case of no capital support down to a 4.8% increase in the case of 50% capital support while in the $20 per GJ scenario, they would increase 21.6% with no capital support to a decrease of 1.9% with 50% capital support (assuming a negligible effect on transportation due to the facility siting).

Table 31 – Change in waste disposal costs for each municipal partner should the MRF and AD facility be constructed to produce RNG.

	Annual Tonnage		$10 per GJ RNG			$20 per GJ RNG		
	Garbage	Organics	0% Capital	25% Capital	50% Capital	0% Capital	25% Capital	50% Capital
Town of Stony Plain	2700	2100	$ 306,600.00	$ 171,900.00	$ 42,600.00	$ 229,200.00	$ 96,600.00	-$ 38,100.00
City of Spruce Grove	6900	2900	$ 623,200.00	$ 357,900.00	$ 106,400.00	$ 484,600.00	$ 222,200.00	-$ 43,100.00
Parkland County	7000	0	$ 441,000.00	$ 266,000.00	$ 105,000.00	$ 371,000.00	$ 196,000.00	$ 21,000.00

InnoTech Alberta also explored the scenario of constructing the anaerobic digester as a standalone facility. Assuming the facility could be built at an equivalent of $975 per tonne annual capacity with 25% capital support and an RNG price of $15 per tonne, the increase in tipping fees for Stony Plain and Spruce Grove would be $21,000 and $29,000 annually, respectively, at a tipping fee of $60 per tonne and local organics tipping fee of $50 per tonne. However, should the municipality take an equity stake in the facility equal to their utilization, their fair share of the operating income would be $61,700 and $85,200, respectively. This would result in a net decrease of $40,700 and $56,200, respectively, not

including taxes, on current all-in waste disposal costs. For the City of Spruce Grove, this amounts to a savings of approximately 2.5% on their total waste disposal costs.

6. Conclusion

InnoTech Alberta's analysis of the proposed organic waste management facility revealed that the expected utilization of the three municipal partners accounts for roughly half of the facility's design capacity. As designed, the proposed facility has an annual capacity of 44,000 tonnes per year with the Town of Stony Plain utilizing about 10.9% of facility capacity, the City of Spruce Grove utilizing approximately 22.3% of facility capacity and Parkland County utilizing approximately 15.9% of facility capacity. Based on 2016 data estimates, the three municipal partners would utilize 21,600 tonnes, or 49.1%, of the capacity. As a result, the economics of the facility would be particularly sensitive to local waste disposal costs which are currently estimated at approximately $60 per tonne. An economic analysis of the facility revealed that under the current regulatory environment the expected breakeven cost of the facility would be $128 per tonne (with an equivalent tipping fee at both the MRF and the anaerobic digester) which is more than double the current market rate for waste disposal in the region.

The effect of a variety of incentive structures on the economics of the facility were analyzed and a combination of capital support and premium energy pricing, preferably through renewable natural gas pricing, revealed that the anaerobic digester became much more competitive than the MRF with these incentives. InnoTech Alberta estimates that capital support of 25% and a renewable natural gas price of $15 per GJ could make the anaerobic digestion facility economically feasible in the local waste disposal environment ($60 per tonne). However, the MRF would require much larger capital incentives which could put the project at risk of receiving capital support.

InnoTech Alberta recommends exploring the option of abandoning the MRF part of the project and switching to a pure source separated organic waste feedstock while expanding the capacity of the anaerobic digester to reduce the capital costs on a capacity basis. In order to be successful, new sources of SSO feedstock would need to be sourced, either through engagement of the ICI sector or through the recruitment of more municipal partners such as St. Albert or possibly Edmonton.

Should the facility be envisioned as solely for residential SSO feedstock, the partners may wish to engage Edmonton to determine their level of interest in the project should that city transition to a green bin-style program. Being located west of the city, the facility would be suitable for city trucks servicing the west end. Furthermore, the transition to SSO in Edmonton would open capacity at their existing dirty materials recovery facility which could be used by Parkland County to significantly increase their diversion rate while avoiding the high capital expenditure of constructing a new MRF facility. Finally, the inclusion of Edmonton as a partner would bring relevant experience in the construction and management of such a facility given the likelihood of attracting a private company to accept the financial and operational risk in a P3 arrangement seems unlikely at current waste disposal rates.

Finally, the impact of the construction of the integrated facility on each partner's waste disposal costs was calculated assuming the facility produced RNG and achieved the breakeven tipping fee under each

of the analyzed scenarios. Parkland County's waste disposal costs always increased while it took 50% capital support and $20 RNG to lower the waste disposal costs of the other two partners. In the case of building the anaerobic digester by itself, InnoTech Alberta estimated that with 25% capital support, $60 per tonne tipping fee and $15 per GJ RNG, the all-in waste disposal costs would be lowered by around 2.5% for the City of Spruce Grove after factoring in profit from the facility.

7. References

1 – Morrison Hershfield – Pre-FEED Study Report for an Organic Waste Processing/Utilizing Facility in the Tri-Municipal Region in Alberta. July 14, 2016.

2 – Hayes A, Jenson E, Ekwe S, Wispinski D, Johnston J, Mohammed A, Tak J. 2017. Investigation into RNG Uptake, Technology and Criteria. Final Report to Environment Sector. March 2017.