Zero Waste Discussion Paper

Attachment to the AR "Zero Waste Process" dated June 11, 2018

Summary

Approximately 64% of municipal solid waste (MSW) collected by COSA is currently diverted from landfill, thanks to a successful source separation program that allows recyclable materials (blue bags) and organics (green bins) to be sent for recycling and composting respectively. The City's target is to have 75% diversion by 2020. Since the inception of recycling in the 1990s, the general goal of recycling has been to make it cost neutral to rate payers and that has yet to be realized. It remains mostly subsidized by ratepayers with the largest weight of the profits going to the private sector waste industry. If existing technologies remain in place, the only diversion increases that can be gained are from additional resource costs such as additional education, enforcement, sorting efficiencies, etc. These incremental costs will only increase with larger production, thus further nullifying any incremental revenue or cost efficiencies. In order to provide better performance at the same or lower cost, small scale processing with new technology is a better solution economically, socially and environmentally.

To achieve 100% diversion (or "Zero-Waste"), higher than the current goal of 75%, the residual waste (whether diversion is 64% or 75%) will still require further processing. The target is the "Recover" segment of the 4Rs: Reduce, Reuse, Recycle, Recover. Large-scale, centralized facilities able to process residual waste, such as those that have been built in other jurisdictions, are technically and regulatorily feasible within larger urban areas. However, the costs to process the incoming waste stream, in particular the pre-sorting facility costs, are currently higher than the cost of landfilling. Achieving sustainability considers the optimal solution of economic, environment and social aspects. Large scale assets, such as incinerators or mass burn combustion, or landfills, do not provide the optimal sustainable solution as the environment is impacted (consumption of valuable land, potential for impact to environmental receptors, and greenhouse gas generation). Furthermore, the investment profile of both conventional technology (landfilling) and large scale centralized facilities is unattractive as a result of overbuilding long-term capacity for future growth. Smaller scale de-centralized facilities offer the opportunity to mitigate the investment risks as a result of smaller, more frequent capital outlays, providing a better "on demand" matching of waste generation with waste processing capability.

Considering these factors, issues and constraints, Administration reviewed emergent smaller-scale, de-centralized technology that is able to process unsorted MSW. Scalable, local units have the potential for achieving lower costs than large conventional facilities in that they require little to no pre-sorting as well as no permanent foundation. This emergent technology is currently being demonstrated in Canada, supported

through a grant application to the Green Municipal Fund (FCM) and the involvement of a local University, and CSA approval is expected by the end of 2018.

A high-level review of Zero Waste Processes also revealed numerous additional Utility Services and Economic Development opportunities. With respect to Utility Services, Zero Waste Processes can be paired with Waste to Energy (WTE) processes that generate power and heat that can be supplied via micro grids and district heating systems to nearby large industrial users or urban agricultural producers (e.g. Aquaponics, Vertical Farming) in business parks ("Eco-Industrial Parks"), or high density residential developments (including "net-zero" developments). Also, wastewater recycling technologies that separate-out biosolids, a highly desirable organic energy input, have the potential to provide additional feedstock for WTE processes, and provide non-potable but still potentially usable water ("purple water") that may reduce traditional infrastructure servicing requirement (e.g. the size of pipes required to deliver water and/or remove wastewater from a development), thereby lowering servicing costs and resultant off-site levy charges, stimulating development.

With respect to Economic Development Opportunities, Zero Waste Processes generate post process ash, metal, plastic, and glass that can be used as commodity inputs for local manufacturers and/or offset municipal capital project costs through use of these materials. Also, the attraction of knowledge based industries can arise from the establishment of Zero Waste Processes – which in turn can lead to the attraction of training and research institutions invested in the environmental/clean tech space, and other "Smart" industries that align with a sustainability brand.

Furthermore, additional Utility Services and Economic Development Opportunities can provide incremental net revenues ("profit") through a Municipal Utility Corporation, and increase non-residential assessments through additional economic impacts, thereby mitigating anticipated future operating deficits and capital demands and providing benefit to all St. Albert taxpayers and ratepayers.

Discussion

Current State of Diversion in the City

"Zero Waste Process" in the context of this report, is defined as the technologies and techniques used together to convert all, or nearly all, municipal solid waste (MSW) generated within the City of St. Albert into recoverable products, thereby eliminating the need for landfilling. This includes ancillary processes such as power and heat generation and distribution, water and wastewater recycling, and delivery and use of commodity outputs for use in agriculture or manufacturing.

Striving toward a Zero Waste Process for the City of St. Albert is desirable on a sustainability basis (triple bottom line of economic, environmental and social factors):

- Economic. There is no active landfill or recycling facility within the city limits, and therefore residents and businesses are price takers when it comes to landfill tipping fees or recycling costs (both which include costs for Lifecycle decommissioning); by achieving a Zero Waste Process this is mitigated with new revenue generation. Also, Zero Waste processes, if integrated with ancillary systems (water, wastewater, power and heat), may realize cumulative incremental economic benefits (e.g. net revenues, cost savings or both), turning the waste from a cost into a commodity for the City.

- Environmental. A Zero Waste Process is an environmental practice that long-term will reduce demands on the environment, potentially mitigating climate change by lowering the carbon intensity of landfilling (e.g. buried waste decomposes into methane, which has 25x greater global warming potential than carbon dioxide), energy production and water reuse, as well as reducing the burden on land (e.g. consuming valuable agricultural land) and surface water pollution risks associated with landfilling (e.g. from unwanted leachate migration)

- Social. If implemented, a Zero Waste Processes has the potential to provide a social good by attracting knowledge-based industries to an "Eco-Industrial Park" in the city, thereby strengthening the rise in non-residential to residential assessments, allowing the City to maintain its current level of services provided to residents minimizing property tax and/or service cost increases. Furthermore, there is the possibility of using a portion of the benefits to help fund educational institutions if relocated to the area and expanding our local social safety net (e.g. community production of local food including for those in need).

The traditional methodology for waste minimization is to "Reduce – Reuse – Recycle" (Figure 1). Greater awareness by consumers and businesses as to these principles, due to policy initiatives from governments (such as source separation), has been successful in diverting a substantial percentage of waste from landfill over the past decade. However, WTE processes have also been recognized as diversionary practices in many countries, in both the developed and developing world (e.g. Sweden and Ethiopia).[1]

[1] For example, Sweden has been practicing diversion via Waste to Energy (WTE) plants since the 1970s, and aims to have a "zero-waste" future attainable by 2020 (https://www.globalcitizen.org/en/content/sweden-garbage-waste-recycling-energy/). Also the City of Addis Ababa is using WTE technology to clean up an existing problem landfill, while simultaneously providing clean water for drinking and ash for the production of bricks (https://www.weforum.org/agenda/2018/05/addis-ababa-reppie-trash-into-energy?utm_source=Facebook%20Videos&utm_medium=Facebook%20Videos&utm_campaign=Facebook%20Video%20Blogs)

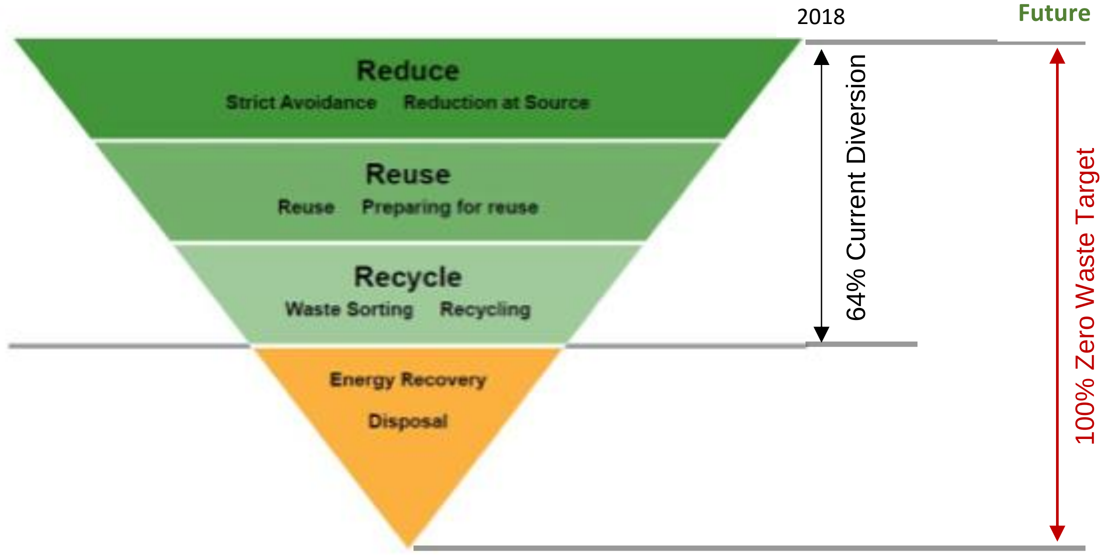

Figure 1. The Zero-Waste Triangle. The yellow area (garbage) has declined proportionally over time but the overall quantity of garbage may remain or even grow slightly as population grows.[2]

COSA collected approximately 22,000 tonnes of MSW in 2017. This is composed primarily of source separated recyclables (blue bags), organics (green bins) and a remainder of garbage (brown bins).[3] The recyclables and organics are considered to be "diverted" since they are not buried in a landfill. As of Q4 2017 the diversion rate of the MSW collected by the City was approximately 64%. The City has a current goal of increasing diversion to 75% by 2020, primarily through planned programs of public outreach that aim to further reduce the amount of organics and recyclables ending up in garbage. To achieve this goal, additional costs will be required for greater education and likely enforcement efforts.

The MSW waste streams collected by COSA (or its contractors[4]) are ultimately trucked outside of the city and are either processed and/or disposed of at an external Material Recycling Facility (MRF) or landfill. At present recyclables are taken to and processed at a contracted MRF in Acheson, approximately 16 km southwest of the city limits; recycled products are then sold by the facility owner into the marketplace but there is no revenue sharing arrangement with COSA. Organics currently end up at the Roseridge Waste Facility in Sturgeon County approximately 16 km by road north of the city limits.[5]

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[2] Image courtesy of "European Week for Waste Reduction" (http://www.ewwr.eu/en/project/main-features)
[3] Paint, solvents, batteries, electronics, motor oil, tires and appliances are also voluntarily brought by residents to the Recycle Depot for disposal. An additional 148 tonnes of e-waste were collected by the City at the Recycle Depot in 2016.
[4] St. Albert currently contracts out the collection and processing of blue bag recyclables and green bin organics but manages the brown bin garbage stream with City equipment and staff.
[5] The Roseridge facility has an estimated 50-year life remaining and tipping fees include lifecycle costs to decommission landfill cells.

The organics are composted by being spread about on the surface and stirred at regular intervals – the resultant product is then given away to users.[6] The remainder of garbage collected by COSA is also taken to Roseridge where it is ultimately buried in the landfill cells. In total the cost to residents on average to collect and process recyclables (blue bags) is approximately $298/tonne, while the cost to dispose of organics (green bins) is approximately $141/tonne, and the cost to dispose of garbage (brown bins) is approximately $166/tonne[7]. In total the average resident is paying approximately $605 per tonne. This price point is the benchmark in a cost/benefit analysis of other methods, noting this is "net" – inclusive of revenues and expenses.

In addition to the MSW collected by COSA, large additional waste streams exist both within the city and the surrounding region. An estimated 47,500 tonnes of institutional, commercial and industrial (ICI) waste is also generated within the city every year.[8] This waste is collected by private waste disposal companies, then trucked outside of the city for ultimate processing and/or disposal. Outside of the city limits, but in the adjacent surrounding region, large amounts of agricultural and other biomass wastes are generated, such as spoiled crop residues, well in excess of 100,000 tonnes per year.[9]

The current volumes of waste in the city and the surrounding region are summarized in Table 1 below.

[6] Roseridge is a Class II landfill and the compost produced is category A according to the "Canadian Council of Ministers of the Environment" guidelines; its use is unrestricted for the agricultural sector, however it is currently given away and no revenue is derived from its sale. The majority of organic material (75%-85%) is converted to compost and the screened out material (15-25%) is landfilled.
[7] The costs given for organics and garbage include landfill tipping fees at Roseridge.
[8] Estimated value for 2016.
[9] For example, in a 50km radius surrounding the Alberta Industrial Heartland, there is a large biomass supply consisting of spoiled crop seed, crop residue, livestock manure and woody materials (see "Pre-Feasibility Scan of Potential Biomass Supply", Alberta's Industrial Heartland Association, 2014).

Waste generated within:	St. Albert city limits				Surrounding region
Collected by:	The City of St. Albert			Others	
Type:	MSW (Residential)			ICI	Agricultural
Source Separation:	Organics (Green Bins)	Recyclables (Blue Bags)	Garbage (Brown Bins)	unknown	unknown
Tonnes (2017)	9,860	4,200	7,960	47,500(est)	>100,000(est)
Cost per tonne (est)	$141	$298	$166	unknown	unknown
% Diverted from Landfill	← 100% collected by the City →			unknown	unknown
	Yes 64%		No 36%		
Typical Contents:	Food waste, yard waste	Glass bottles and jars, plastic, cans, paper, cardboard	Styrofoam, non recyclable plastics, glass housewares, broken glass, ceramics, textiles	Medical, grocery, restaurant, construction (lumber, drywall, rubble)	Manure, deadstock, brushing, chaff, crop spoilage
Contractor:	GFL	GFL	COSA	Unknown	Unknown
Sent to:	Roseridge	Edmonton	Roseridge	Unknown	Unknown
Ultimate Process:	Composting	Recycling	Landfilling	Unknown	Unknown

Table 1. Summary of waste generated within the city and surrounding region.

Conventional Large-Scale Centralized Zero Waste Processes

Despite best efforts to divert waste by the City of St. Albert, a substantial amount of "garbage" will likely remain using current methods. Indeed, diversion rates have plateaued for roughly 5 years (since 2012) while the total amount of "garbage" has been going up due to population increases. The education and possibly enforcement to encourage greater source separation (which will require further funding), without full eventual recyclability of all products, will still not get the City to full diversion.

Furthermore, the City is still at risk of disruptions in the recyclables markets beyond its control. For example, the amount of "garbage" can increase overnight if there is a change in the recyclables marketplace, such as what happened recently when China announced increased standards on recycled products accepted.[10] Such events can place stains on communities heavily invested in source separation, such as what recently occurred in Douglas County Oregon where the City had to suspend recycling collection due to China's changes.[11]

According to council motion Administration was instructed to "…prepare a report for Council's review…of the potential feasibility, land requirements, estimated capital and operating costs, social and environmental and economic benefits, and risks of implementing a zero-waste process and ancillary processes and infrastructure in St. Albert to manage its solid waste, similar to what is being implemented in the Wood Buffalo Region, with up to $25,000 approved to complete the cost-benefit analysis funded from the Stabilization Reserve."

In order to assess potential feasibility, land requirements, estimated capital and operating costs, and the risks of implementing a zero-waste process and ancillary processes and infrastructure, Administration commissioned a consultant report to examine these Zero Waste Processes.

St. Albert is somewhat unique, in that it does not have its own active landfill. However, the consultant study revealed that the garbage (e.g. brown bins, ICI) could be sorted further within the City at a new centralized Material Recycling Facility (MRF) by mechanical means, with some recoverable material (e.g. metals, glass, ceramics) being collected and then sent for reuse or remanufacture. The remainder of energy-containing material (e.g. non-recycled plastics, wood or paper materials) could be sent to either a pyrolysis process where it is heated into a biologically stable oil or char suitable for use in other applications, or for processing into a Refuse Derived Fuel (RDF) which then is sent to a gasification process to create syngas.[12] The syngas could

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[10] Recently China increased standards on the recycled products accepted, causing temporarily recyclables into garbage (see http://www.cbc.ca/news/canada/calgary/how-chinese-recycling-ban-impacts-calgary-1.4474619)

[11] https://www.statesmanjournal.com/story/news/2018/05/25/douglas-county-oregon-suspends-recycling-service-due-chinese-ban/644092002/

[12] Pyrolysis is the thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen whereas gasification is a process that converts organic or fossil fuel based

then be sent for further processing to create other value-add products (such as methanol/ethanol as is being done in Edmonton[13]) or it could simply be combusted in an engine to create power and heat at a Waste to Energy (WTE) facility. Remaining material, either ash or/or vitrified material, could be repurposed as well into other products, although the market for this material is not well known.

The consultant study also revealed that the establishment of a MRF along with a thermal treatment facility, and an optional WTE facility is possible within the current regulatory structure within City limits, and compliance with provincial regulations, mandated primarily through Alberta Environment and Parks (AEP), the City's own development bylaws, as well as Alberta Utilities Commission (AUC) rules (for a WTE facility), although not well defined as a process, is possible.

In order to estimate capital and operating costs, the consultant report examined a hypothetical 25,000 tonne per year mock facility located within the City-owned lands in the Lakeview Business District able to process all of the MSW collected yearly by COSA.[14] The mock facility included a pre-sorting facility, an MRF (material recycling facility) to process recyclables, an anaerobic digestion facility to convert the organic waste stream to biogas and digestate, a gasification facility to reduce garbage to syngas and output products suitable for reuse. The estimated cost of such a facility is estimated to cost between $25 and $35 million, with annual operating costs between $1.4 and $1.5 million. If a waste to energy facility was added the estimated cost is between $47 and $90 million, with an annual operating cost between $2.4 and $2.5 million. On an estimated equivalent annual cost (EAC) basis a total cost of $491 to $1,923 per tonne would be realized, which includes the amortized return of capital[15], but does not include the logistics of collecting and transporting the waste to the facility, nor the cost of land or land servicing costs for the facility site.

Approximately 10 acres would be required for a facility that could process on average 25,000 tonnes per year, thereby accommodating the entire yearly tonnage collected by COSA.

With respect to risks, the consultant report highlighted some technology risk in that waste "…if not properly prepared, could create a problem for the process as the heterogeneous (mixed) nature of certain wastes can cause difficulties with gasification, syngas quality, syngas clean up, emissions, and syngas utilization systems" An in-depth review of this risk, potentially including a waste characterization study would have to be completed to assess both the amount of unwanted materials and variability in the

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carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide (Syngas) in a high temperature oxygen-starved environment. Incineration, the simple combustion of material in an abundance of oxygen, although possibly less expensive than pyrolysis and gasification, was rejected as an option by Administration due to the potential for unwanted emissions.

[13] Ethanol is the proposed output of Edmonton's Enerkem facility.

[14] Note that the City owned lands in the Lakeview Business District are also not yet serviced with infrastructure services and that the cost estimates in this report do not include this cost of servicing.

[15] 25 years at 3%

waste stream as well as potential means to mitigate or eliminate (such as pre- and post-process cleaning) if the City were to pursue the concept of a large facility further. With respect to regulatory risks, there appears to be no hard regulatory impediment to the construction of Zero Waste facilities, however several permitting gates will have to be met, including meeting Environmental Protection and Enhancement Act (EPEA) mandates, and according to the consultant report the "…application for Approval or Registration of such facilities may (and likely will) require an Environmental Impact Assessment Report (EIAR)…" and that "…effective consultation with the public, is a key point for mitigating long timelines with respect to permits and approvals".

Emergent Technology Zero Waste Processes

As instructed by Council motion, Administration also examined technology that was being considered for deployment in the Wood Buffalo Region. In addition to other initiatives designed to reduce waste going to landfill, Wood Buffalo had been working with an emergent "low temperature gasification" technology provider.[16] The technology had been demonstrated successfully outside of Canada, but proponents were working with regulatory and permitting bodies to become approved for commercial use in Canada. Unfortunately, the technology provider left the project and RMWB selected a different, more conventional, large scale centralized technology. Even then, the economic downturn, the wildfire and MGA amendments that significantly impacting RMWBs established tax ratio structure drove other priorities for RMWB. City of St. Albert Administration made contact with the emergent technology provider in late 2017 and found that efforts to attain CSA approvals had been reinitiated elsewhere in Canada; and with a license from a Provincial Sustainable Development Department, was progressing a demonstration project in Canada. This was being carried out in cooperation with a Canadian University for independent assessment of emissions using a variety of input feedstocks. The technology demonstration has also applied for Federation of Canadian Municipalities (FCM) and Sustainable Development Technology Canada (SDTC) funding support at various stages.[17]

This emergent technology, using "low temperature gasification" technology has four main advantages:

- Little to no pre-process sorting is required. Low temperature gasification can accommodate a wider range of heterogeneity ("mixed-ness") and variability in the waste streams than high temperature gasification, thereby avoiding intensive and costly mechanical and manual pre-sorting or pre-processing of waste streams.

[16] Low temperature gasification occurs as a first stage, then the products of gasification are combusted at much higher temperatures in a second stage so as to fully react all combustion components, thereby rending emissions inert according to prevailing standards.
[17] Approximately $350k in funding was applied to from FCM. Note however, such funding only serves to de-risk a demonstration project, and ultimately a larger business case must be supportable without subsidy.

Therefore, this method eliminates the need for source separation by residents, improving collection efficiencies. Furthermore, organic waste streams, if sufficiently dewatered, can also be used as input streams. Therefore, the use of wastewater biosolids as an additional high-quality fuel source can also be integrated.

- Recycling is still possible post process. High temperature gasification post process materials (ash, glass, plastic, metal) comes out as congealed vitrified (glassy) solids that are difficult to repurpose, whereas low temperature gasification has post process materials come out in more useable forms. For example, a tin can going through a low temperature process will still come out the other end as a tin can, merely with label and food converted to energy. Therefore, low temperature post process materials are easier to deal with and convert back into usable products; metal and glass remnants can be made into building products while the remnant ash can be used in non-structural concrete. Plastic is separate, either it is removed prior to the process or it is converted to energy through the process.

- The technology is modular. The emergent technology is designed to fit into a standard shipping container and requires no permanent foundation. Therefore, the technology can be deployed and re-deployed easily, and also scaled accordingly as required, thereby lowering capital at risk. It is estimated that one shipping container sized machine can process approximately 8 tonnes of unsorted MSW per day[18]. If operated 249 days per year, approximately 2,000 tonnes per year per machine can be processed. It is estimated over 500 MWh of electricity, and over 2000 GJ of usable heat can also be generated per machine per year if suitably equipped to provide power and heat. Being scalable, total capacity can be increased accordingly for every additional machine added in parallel. For the operation of 1-2 machines an approximate footprint of only 4-5 acres is required, primarily for garbage truck entry and turn-around. Note a minimum of 2 machines would be required for continuous operation since they operate a on batch process.[19] If waste were scheduled to arrive “Just In Time”, no storage of waste would be required on location.

- Overall logistics are simpler. Since little to no pre-process sorting is required, little to no education or enforcement efforts are required to increase diversion. For customer use, it creates complete ease of use and higher recycling rates through this involuntary simpler approach. Operationally, waste collection can be performed with one truck in place of three; there may be less overall spending on truck investment and operations, including maintenance and fuel. .

[18] This capacity can be roughly doubled if the MSW is baled prior to being put in the container.
[19] Electrical production can also be continuous by using biodiesel to provide energy at times when the batch process is not able to.

Currently, performance and cost data for this technology is proprietary and not available. However, the demonstration project underway in Canada and its timing (commencing in August 2018) provides opportunity for St. Albert to monitor the project and utilize the results in its own analysis with no risk incurred by outlaying funds. Part of such an analysis cannot be limited to only costs relative to other technologies. Sales of commodities (including energy) and greenhouse gas credits realized from this alternative to traditional methodologies must also be considered and validation of current practices' costs must be validated to ensure they are representative of the Lifecycle costs (e.g. landfill land allocation, design, construction, operations, closure and post-closure monitoring) for comparison purposes.

Utility Services and Economic Development Opportunities

Private waste-handling corporations such as Waste Management Inc. are already building strategies around providing utility services thereby enabling additional revenue streams.[20] In reviewing Zero Waste Processes, Administration compiled numerous potential beneficial connections integrating Zero Waste Processes with expanded utility services offerings. These utility services, whether provided through existing departments on a cost recovery basis, or through a for-profit Municipal Utility Corporation, have the potential to provide incremental net sustainability benefits and reduction in servicing costs to stimulate development.

- Local Production of Electricity. Gasification processes typically give off excess heat that can be captured and used to produce electricity. This electricity can be used in micro-grids to supply adjacent users (such as City operating centers, sports facilities, businesses, agricultural or aquaponics operations, eco-industrial parks, net zero developments, etc.) or to supply, possibly through battery storage, electric vehicles such as electric buses, garbage trucks, City light duty vehicles and/or passenger vehicles.

- Local Production of Heat. Usable excess heat still remains after electricity is produced, and this can be sent by hot water pipeline distribution to nearby City facilities, businesses and/or net zero communities that have connectivity through district heating systems. Note that if a district heating system is built, numerous other heat sources can be integrated, such as geothermal[21], wastewater heat

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[20] See https://www.bloomberg.com/news/articles/2012-04-03/trash-saved-by-waste-management-worth-up-to-40-billion and https://www.forbes.com/sites/stevencress/2018/03/12/bill-gates-is-betting-on-waste-management-we-figured-out-why/#7e7c92a06cf8

[21] For example, the Blatchford project in Edmonton will use the heat from geothermal wells drilled underneath a nearby storm pond to supply the district heating system (https://globalnews.ca/news/3897279/edmontons-blatchford-area-could-see-residents-begin-moving-in-by-2019/)

recovery[22] or heat from nearby industrial processes. Note district heating systems work best with high density areas (e.g. high number of dwelling units per unit area), and therefore these systems may become increasingly feasible in the region due to increasing EMRB density requirements.

- Local Production of Carbon Credits. The above processes can provide an environmental benefit if the organic content of the feedstock material is high, thereby producing power and heat at a lower carbon intensity that traditional carbon-based energy sources (coal- and natural gas-produced electricity and natural gas heating). Also, carbon credits may be realized by lower landfill emissions of methane (due to less organic material being sent to landfill), relative to a baseline value.[23] Furthermore, there may be an additional benefit if a portion of this energy supplies local food growers (e.g. aquaponics, vertical farming[24]) thereby reducing the cost of the produce, the carbon footprint of the food produced through the reduction in trucking distances, a lower impact on surface water quality through avoidance of fertilizer, and conservation of valuable agricultural land. Similarly, a reduction in trucking fuel consumed in both transporting waste to a closer location (within the City), and in a reduction in trips due to combining waste streams into one, could give rise to carbon credits. Ultimately the decision is council's whether to utilize these credits towards revenue generation, towards achieving carbon neutrality or some combination thereof. Such a decision will in part be based on the opportunity and resultant revenue from sales of new goods and services in the City's offering such as heat and electricity.

- Local Processing of Biosolids. If waste water is processed adjacent to a Zero Waste facility, the captured and de-watered bio-solids could be used as feedstock to a gasification process. A direct financial benefit can be realized in that the biosolids provide more energy for the production of electricity and heat, while an indirect financial benefit may be realized through potentially reducing the size and throughput of local wastewater pipelines, and potentially reducing the size of water supply pipelines due to water recycling *in situ* – for example using "purple water" to water lawns thereby reducing the amount of potable water being used for non-potable applications, or as utility water in commercial/industrial applications with approximately 80% of the water demand in these being used for non-potable uses.[25] City Administration is currently working with a local company that has modular

[22] For example, heat can also be captured from wastewater pipelines (http://www.startribune.com/minneapolis-neighborhood-could-be-heated-with-sewage/468218893/).
[23] Methane has 25x the global warming potential compared tocarbon dioxide.
[24] See http://www.cbc.ca/news/canada/toronto/start-up-city-ripple-farms-1.4588450
[25] "Grey water" is gently used water from bathroom sinks, showers, tubs, and washing machines, whereas "Black" is toilet water. The effluent output from a Waste Water Treatment Process that filters grey and black water is considered "Purple".

technology able to separate biosolids. Such decentralized systems are already common in the United States and Europe.

There is also significant Economic Development potential in implementing Zero Waste Processes:

- Reduction in Land Servicing Costs. Alternative methods of servicing using Zero Waste and its ancillary processes have the potential to reduce the size of water and wastewater infrastructure required for green and brownfield developments. For example, if biosolids are extracted locally from wastewater streams for use in Zero Waste Processes, the resultant treated effluent could be reused locally in non-potable applications (for example watering lawns). This could simultaneously reduce the demand for potable water pipeline and pumping infrastructure, while reducing the large diameter wastewater pipe and lift stations required to transport it outside of the City. Furthermore, if the effluent were used as a heat transfer medium in a district heating system, the need for heating infrastructure could also be reduced. The reduction in servicing costs would serve to make St. Albert levies competitive, and would assist in attracting land developers.

- Long Term Reduction in Utility Costs. Note when costs of infrastructure are lower than conventional, there should also likely be a long-term reduction in ongoing utility costs for businesses and residents, since a substantial portion of ongoing utility costs are the capital payback on infrastructure, which is ultimately borne by end users.

- Local Manufacturing Advantage. The output of the Zero Waste Processes – ash, metal, plastic, and glass, may provide a cost advantage to local businesses that use these materials as commodity inputs. In particular, manufacturing processes within the city that ultimately export products outside of the city provide an economic multiplier effect, creating additional economic impacts and local jobs.

- Attraction of Educational Institutions. Zero Waste Processes and associated services are knowledge-based industries that may attract and grow clean-tech businesses and expertise to the city, which may in turn attract learning institutions, research and development facilities, and training centers to return to the City. As added incentive a small percentage of net revenues (e.g. 5%) could be dedicated to funding.

- Attraction of Businesses. The establishment of an Eco Industrial Park centered around Zero Waste Processes may serve to attract Foreign Direct Investment (FDI) from companies that are serving environmental markets, and even companies in other markets that want Smart City and sustainability associated with their brands (for example Google partnering with the Toronto East Wharf development aligns with corporate sustainability goals).[26]

Next Steps

In cooperation with the forthcoming discussions on delivering utility services and alternative servicing through a Utility Corporation, it is recommended that Zero-Waste Processes, in particular the emergent technology discussed herein and the resultant Utility Services and Economic Development opportunities, be assessed further for technical, regulatory and financial feasibility and risk analyses. This should include a comparison of cost-recovery performance (e.g. city provided services) with for-profit performance (e.g. Municipal Utility Corporation) and account for the increased revenue through synergies. The analyses should include detailed assessments (through tabletop examination) of:

- Capital costs
    - Regulatory costs, including assessment of permitting processes and timelines
    - Installed costs of gasification units with Waste to Energy (WTE) technology, and ancillary processes – wastewater treatment units to separate biosolids, district heating systems, energy storage systems, micro grids serving adjacent facilities and equipment (including electric buses and electric garbage trucks)
    - Land and land development costs where equipment is to be situated

- Revenues
    - Power and Heat sales; primarily Waste to Energy (WTE) but also enhanced through use of other energy inputs; biosolids, sewer heat recovery, use of turbines in gravity-fed waste water pipeline infrastructure, low-grade heat sharing between local industrial facilities/commercial buildings, solar and geothermal heat sources, etc.
    - Carbon Credits from all sources, including organic landfill methane emissions avoidance

- Operating costs
    - Using full mass, energy and water balances, assess logistics and costs of waste handling, operating and maintaining equipment and trucking materials

- Funding Models
    - Possibilities for grant funding (e.g. FCM), regional collaborations, Private Public Partnerships (traditional and non- traditional)

[26] https://www.bloomberg.com/news/articles/2017-10-17/alphabet-unit-to-build-digital-district-from-scratch-in-toronto

- Economic and Social Impacts
  - assessment of business attraction provided by reduced land development and utility costs through integration with district heating systems in Eco-Industrial Parks and/or net zero residential subdivisions
  - assessment of the attraction of: knowledge-based industries through sustainability branding, recycled products manufacturing businesses, local food producers, technology start-ups and educational institutions

- Assessment of Environmental Benefits
  - assessment in the reduction in land and water impacts water (including providing greater shortage resiliency, diversity of supply, etc.)

- Public and Private Stakeholder Relationships
  - Administration, in a collaborative spirit, should assess synergistic relationships with:
    - local industry and businesses,
    - business associations (e.g. the Canadian Homebuilder's Association (CHBA) and the Urban Development Institute (UDI))
    - related emergent technology providers through the Northern Alberta Business Incubator (NABI)
    - the GOA and its ministries
    - neighboring municipalities