Memo

Date:	June 6, 2014
To:	Jason Johnson, City Manager John Sturdy, AD Engineering
From:	Allison Ashcroft
Department:	Engineering and Public Works
Regarding:	Summary Research Anaerobic Digestion Facilities and Surrey's AD Plan

Purpose

This report is intended to provide a highlevel overview of municipal solid waste (MSW) management of residential organics, and discuss emerging trend in MSW management re waste to energy facilities, with emphasis on those treating organic waste. This report places special emphasis on exploring anaerobic digestion (AD) of organic waste for generation of transport fuel (biomethane, otherwise known as renewable natural gas (RNG)), and provides a more in-depth review of the proposed AD facility in Surrey and Edmonton are discussed.

Finally, based on this highlevel overview, some general conclusions have been reached regarding the likelihood and appropriateness for the City of Victoria of a biofuels facility sourced from residential organic waste using anaerobic digestion. Where conclusions cannot be reached from this preliminary work, key considerations and unanswered questions have been identified to help direct management with further investigating the opportunities for such a facility in Victoria.

A. Municipal Solid Waste Management (MSW) and Hartland Landfill

Landfills, or burying garbage, are the oldest kind of waste treatment and the way the CRD's currently manages the disposal of its solid waste. When garbage is buried, the organic waste comprised in it, decomposes over a long time and must be monitored for air pollution, groundwater and soil contaminations.

Landfills have limited life spans; the life span of a landfill is a function of its size and the amount of waste it receives and compacts annually. Hartland landfill receives approximately 150,000 tonnes of refuse annually, with over 6M tonnes of refuse already in place. The facility was expected to be full by 2035 with waste reduction a key strategy to extend the lifespan of Hartland to 2045.

Finally, when organic waste decomposes, it produces methane, a dangerous greenhouse gas known to cause climate change. The production of landfill gas is the largest human caused generation of methane globally. Landfill gas can be captured to produce energy and to reduce greenhouse gases causing climate change. The methane produced at landfills, if not captured, contributes significantly to the warming of the climate, an impact that is almost 20 times that of carbon dioxide when compared over a 100 year period. Due to the toxicity of methane gas, strategies to reduce GHGs from landfill can have a significant impact on overall climate change mitigation efforts.

Trends in MSW
Municipalities and regional districts are:
- Looking to alternatives to landfills for managing MSW.
- Seeking out strategies to prolong the life of their existing landfills through greater diversion of waste that can be recycled or reused, including organics.

- Exploring resource recovery opportunities to extract value from waste through the recovery and sales of metals and energy; and the generation and sale of electricity and/or compost.
- Taking action on climate change and seeking to reduce the carbon footprint of their municipal operations, as well as, the greenhouse gases generated in their community from buildings, transportation and waste (51%, 43% and 6% respectively for Victoria [2007 CEEI]).

What are Waste to Energy Systems and Facilities?

As a result of the trends noted above, municipalities and regional districts are taking a serious look at different waste to energy (WTE) facilities and technologies as a means of better managing some or all of their MSW. Put simply, at Waste to Energy (WTE) facilities, "waste" garbage is converted into energy like steam, electricity, hot water or fuel.

Generally, those municipalities investing in waste to energy facilities have the following objectives, in order of priority:

1) To extend the life of landfills and save space,
2) To manage waste, including odor and air quality concerns,
3) To reduce greenhouse gases generated at landfills and mitigate climate change,
4) To produce and utilize energy from waste for buildings, transportation, or industrial processes. This energy can be produced from different sources, using different technologies, and for different end use purposes.

Process Flow of WTE Facilities

1. <u>Inputs</u> - All organic materials contain energy whether plant or animal-based. Plastics are also a source of energy if burned. Inputs will vary depending on the technology used and the MSW objectives of the municipality.
2. <u>Processing</u> - Waste can become energy through different processing methods depending on the technology used (thermal vs. non-thermal treatment) and subject to the type of waste being processed.
3. <u>Output</u> - Waste can produce energy or fuel to operate buildings, vehicles, or industrial production processes. Generated electricity can be fed into the grid and distributed to power buildings and industry, hot water (and potentially steam) can be used for district heating for nearby homes, businesses, large institutional buildings, and in industrial production processes. (Note: steam is most often used by nearby industry in its production processes). Biogas from these facilities can also be refined into biomethane otherwise known as, renewable natural gas (RNG) and used to fuel medium and heavy duty vehicles with natural gas engines, likes buses and garbage trucks. Residual waste, or by-products, are also produced and must be managed and disposed of. These by-products vary depending on the type of waste being treated and the process/technology employed. Some by-products can access markets for sale thereby generating revenues, whereas some by-products require special handling and disposal and add to operating costs of facilities.

Waste Treatment Technologies for Processing Organic Waste

There are 2 types of WTE systems for dedicated organic waste streams relying on anaerobic decomposition for the generation and recovery of energy. These systems involve non-thermal treatment (non-combustible) of organic waste (as opposed to thermal treatment of waste such as by incineration or gasification). For the purpose of this report, thermal treatment technologies will not be discussed, as the emphasis of this report is on anaerobic decomposition of organics and specifically on anaerobic digester facilities.

a) Bioreactor landfills

Anaerobic digestion already occurs naturally in landfills that contain organic waste. Anaerobic digestion (AD) is a simple and proven biological process called biomethanation or methane fermentation, basically, as organic waste decomposes it produces methane. Bioreactor landfills are highly controlled landfills that promote accelerated decomposition of organics, such as food scraps, yard trimmings and paper products. Bioreactor landfills capture landfill gas and generate electricity.

Bioreactor landfills require a large land base and skilled operators, but do not require separation of organics and are less expensive than other types of thermal and non-thermal treatment WTE facilities.

Hartland landfill is a bioreactor landfill, capturing landfill gas and generating electricity (1.6MW, enough to power 1,600 homes annually). Sainte-Sophie Landfill in Montreal, PQ is another example of a bioreactor landfill.

b) Anaerobic Digestion (AD)
Anaerobic digesters use airtight tanks rather than large landfills to starve the organic waste of oxygen and promote decomposition and collect the biogas produced. AD works for many types of biomass feedstock including sewage, manure, wood waste, and agricultural waste. The amount of biogas produced and the quality of the digestates will vary according to the feedstock used.

The primary benefits of AD of MSW are to a) to divert organics from landfill, and b) to mitigate climate change. The controlled process of AD systems over natural decomposition at landfill also reduces odor and liquid waste disposal problems. Another secondary benefit is energy production.

B. Anaerobic Digestion Facilities Generating Biofuels

AD facilities can produce energy using Combined Heat and Power technology and/or can produce biofuel, otherwise known as biomethane which is often marketed as Renewable Natural Gas.

AD's Energy Recovery and Generation Process

1. Organic waste is separated from other garbage
2. Organic waste breaks down in airtight tanks (or landfills) where biogas is collected
3. Biogas is collected and
   - **a.** used as renewable energy for combined heat and power (CHP), and/or
   - **b.** purified to extract CO2, water and other impurities to make Renewable Natural Gas (RNG), also known as biomethane.

Products from biogas

Raw biogas collected at either landfills or in ADs range from 45-65% methane content with C02 most of the remainder.

1) Electricity or Heat - Raw biogas can power electricity generators or run boilers.
2) Vehicle Fuel - To make vehicle fuel, refinement is required to remove the C02, water and other trace chemicals from the biogas to transform it into biomethane (also known as renewable natural gas (RNG)).

RNG Distribution, Uses and Benefits

- To deliver RNG to the vehicle market, it must first be compressed or liquefied. It can then be dispensed directly from a refueling station on the production site or be delivered by truck to a distant fueling station. If compressed, the RNG can simply be added into existing natural pipelines for distribution too
- RNG replaces fossil fuels used in fleets of medium and heavy duty fleets. RNG can directly replace or supplement CNG or LNG fuel in vehicles equipped with natural-gas engines. RNG is interchangeable with fossil-fuel based natural gas and can be mixed with it in any proportion. RNG also provides a renewable alternative to conventional trucks and buses, etc. which typically running on diesel upon replacement of fleet vehicles.

- RNG reduces dangerous emissions by a) capturing methane from organic waste as it decomposes thereby avoiding landfill emissions, and b) reducing emissions at tailpipe by providing alternative to conventional fossil-fuels.

Benchmarks and Trends for RNG produced from AD Facility treating organic waste

1. Feedstock Sources

MSW kitchen scraps and yard clippings, sewage, and agricultural waste are all viable sources of feedstock. Most importantly, is that feedstock is reliable and meets a minimum threshold for plant to run efficiently. ADs must be sited close to generators of large quantities of organic waste. MSW provides that feedstock, and if organics are collected separately, AD and RNG can be viable for cities of varying sizes.

Wastewater sludge from wastewater treatment plants (WWTP) is relatively low in energy content. Ideally if AD is receiving sludge from a WWTP, this waste can be supplemented by high-strength organics wastes (fats, oils, food wastes) generated nearby from factories, farms, institutions, MSW collection, in order to boost the biogas yield.

2. Physical Characteristics

a) Siting

Ideally, AD plants are sited near or collocated with either or both of the sources of their feedstock and the customer for RNG fuel. They are located along major arterials to facilitate transport as needed, and they located in areas zoned for industrial use consistent with neighbouring property uses.

Best siting opportunities include:

- Wastewater Treatment Plants (WWTPs) - In the US, nearly 10% of wastewater treatment plants have anaerobic digesters to manage biosolids in a safe, odorless, and efficient manner. Most of these anaerobic digesters at WWTPs do not yet produce energy (they're purpose is to control odour and kill pathogens).
- Transfer Stations – Where residential and ICI wastes are aggregated. Large composters – it may be possible to extract biogases from the waste stream through AD without reducing the volume of soil and fertilizer products which are the primary product being produced.

b) Plant Capacity - There is no known rule of thumb re how much waste is enough waste to make AD for RNG viable, but quantity of waste is less important than the type of waste stream and the technology to be used assuming feedstock meets a certain minimum threshold

3. Owner Characteristics

Quite often, the RNG fuel user (customer) is the same entity that generates or owns the waste. For example, the owner would most likely be a municipality or large company that both manages waste and owns or contracts with fleets.

4. Economics of RNG from AD Facilities

Other than the economics provided in the individual case studies below, there are few rule of thumb costs cited for AD facilities whether producing biofuel or heat and electricity. There are benchmarks and known cost drivers for more common WTE facilities, namely incineration facilities. These drivers and cost differentiators should hold true for all types of WTE facilities, including Anaerobic Digestion, although some technologies will be more/less influenced by certain attributes than others. Absent specific benchmarking data for the economics of AD, the following is provided to allow cautious extrapolation of benchmarking info from other WTE facilities, again primarily based on the most common of these WTE facilities which is incineration (over 800 worldwide).

General Benchmarking/Trends for WTE Economics

WTE Costs

Costs fluctuate greatly based on technology, size of facility and local characteristics. Further, there are few representative examples in North America from which to develop reliable benchmarks**.**

Cost Drivers for WTE facilities include the following:

1. Size - Larger facilities have lower cap and operating costs per tonne of capacity, can affect cost by up to 28%
2. Configuration - of equipment can affect costs of up to 25%
3. Architecture/design - high profile location will require more expensive aesthetics and landscaping, etc could be 35-50% more than industrial zone facility
4. Availability of local infrastructure - Elec, natural gas, water, wastewater, transportation networks
5. Potential for Energy Utilization - net cost/tonne declines based on increased ability to sell energy. If able to sell heat directly to the market, will result in lowest net costs/tonne, followed by facilities that market both electricity and heat, and the most expensive being those selling electricity only. These costs/revenues are affected by infrastructure required to access those markets and the market price for electricity and heat. In Canadian context, ability to market heat is limited given the few district heating systems in use or initiatives to advance DE. Ability to market heat increases when have access to industrial users of heat (steam) and /or commercial areas where infrastructure for DE heating could reasonably be considered.
6. Market price for energy - For natural gas/electricity, but also existence of energy policy initiatives that discourage dependence on fossil fuels and favour renewable sources and waste to energy systems.

Cost Differential Determinants between Technologies:

1. Preprocessing of MSW – If technology requires clean feedstock then this preprocessing increases capital and operating costs of facility
2. Energy recovery – Some technologies require more electricity and/or fossil fuels to operate. This increases operational costs and reduces the proportion of energy recovered available for sale.
3. Emissions and odour control – Different technologies require different air pollution and odour control systems.
4. Reliability – Newer and/or more complex technologies are typically less reliable and have higher scheduled and unscheduled downtime than more conventional systems.

WTE Revenues

Direct revenue streams from WTE facilities include:

1) Tipping fees
2) Sale of energy (heat, electricity, or biofuel)
3) Sale of recovered materials (i.e. metals), more significant, if waste is not pre-separated.

The value of the revenue streams is contingent on the market for these commodities.
Vancouver Island Fees

C. Case Studies

1. **Edmonton High Solids Anaerobic Digestion Facility with Combined Heat and Power (CHP)**
   - Location: Edmonton Waste Management Centre in Edmonton, AB. Collocated with transfer station and composting facility and soon to be operating gasification plant producing biofuels.
   - Capacity = 40,000 tonnes of organic waste per year
   - Inputs (Waste source) – residential, industrial, commercial and institutional organic solid waste
   - Outputs (End Use) – production of compost and renewable energy in form of electricity and heat (CHP = Combined Heat and Power).
   - Capital Cost = $31M ($775/tonne)
   - Funding = $10M from Provincial agency (Climate Change and Emissions Management Corporation), $1M U of A
   - Ownership/Operation – City of Edmonton's Waste Management Services. Waste Management Services includes 3 areas of operation- collection, processing and disposal, and community relations. Projected FTEs – 10 new jobs
   - Partners – U of A is identified as a partner contributing 1,500tonnes of organics and providing experiential research opportunities for students benefitting the City
   - Emissions reductions projected = 199K tonnes of C02e over 10 years

2. **Surrey Proposed Biofuel Processing Facility Utilizing Anaerobic Digestion**

   Physical Characteristics
   - <u>Facility/Operations – </u>The facility will include pre-processing (sorting) of organic waste, anaerobic digestion, biogas production and recovery, and by-product management (composting and other). CNG fueling facility may be included on property for residential waste collection trucks of BFI, and/or be injected into Fortis pipeline. BFI will fuel their trucks with RNG from Surrey's biofuel facility adjacent to the transfer station where waste is delivered. Excess biomethane will be injected into Fortis pipeline.
   - <u>Location</u>: Adjacent to Surrey's Regional Waste Transfer Station, the proposed site is 6.6 acres at 9752 192nd Street within the Port Kells Industrial Park in Surrey, BC The City will consider consolidating the two sites of the existing transfer station and the proposed 6.6 acre site for a total of 10 acres from both parcels, but preference of the City is to only use the 6.6 acre site. Both sites are owned by the City. The facility in addition to be sited next to the regional waste transfer station is also located along two major truck routes. The combined site will include anaerobic digestion with biofuel production, a compost transfer station, and a CNG fueling station.
   - <u>Capacity</u>: The facility will process 80,000 tonnes of organic waste annually. Metro Vancouver's organics diversion requirement in 2015 is estimated at 265K tonnes; this facility will account for approximately 30% of the organics diversion requirement. The facility will have the capacity to process all of Surrey's organic wastes, including expected future increases. The facility will also expect to accept commercial food waste from Metro Vancouver.
     The project partner can construct the facility from the outset to meet required capacity at end of Term, or use a phased approach to construction. The project partner can also submit a proposal to the City at any time during the operating period to add unplanned capacity in response to favourable market conditions for ICI waste.

   Project Economics:
   - <u>Business Case – </u>Prior to issuing an RFP, the City of Surrey developed a business case to determine the most economical option and service delivery model. The business case was based on an 80,000 tonne/year AD facility that will process into a renewable fuel grade natural gas the City's curbside organic waste (collected

through contractor BFI) , and organic waste from ICI sector sources. The business case found it would cost more for Surrey to build an RNG fueling facility itself and provide fuel to the contractor carrying out the municipal waste disposal services, thus the City chose to have a private sector proponent design, build, own, operate and maintain the RNG facility for its service delivery model. The business case also recommended a long-term transaction structure that would ensure key project risks were allocated to the party most able to manage such risks and costs effectively.

- Capital Budget: $68M. The Federal government is contributing $16.9M (25%) of the capital costs, including project management costs, through its "Public Private Partnerships Canada" fund.
- Project Management Budget: The indirect capital costs related to project management is $2.7M, 25% of which is eligible for funding from P3 Canada, for net cost to City of 2.2M. The PM budget includes $795K for Partnerships BC who was contracted to provide procurement advisory services and project management to the project team. Also included in the PM budget is $400K in honorarium to be split between the two unsuccessful proponents to the RFP, 820K for advisory services ($225K for legal, $188K for financial, 221K for technical, $475K for construction phase project management, and $200K contingency.
- Capital Financing: The budget, net of federal funding, will be provided by the project partner. The partner is permitted to propose either project or corporate financing where project financing is defined as 60% or more of total capital costs being financed by third party lender acting at arms' length; funding by a third party below this threshold will deem the proposal a corporate finance solution and will require additional documentation to evaluate the company as a going concern. The City will repay the partner for this capital investment through fees.
- Operating Arrangement, Fees and Revenues:
    - Biogas production:
        - The City will take responsibility to sell or use 100% of the biomethane produced for fueling the garbage trucks used for its residential collection and selling excess to Fortis BC. Surrey's residential MSW collection is managed under contract with BFI. BFI is required to use exclusively packers with natural-gas engines.
    - City payments:
        - The City will pay tipping fees based on 3 bands of pricing. This tiered pricing is designed to ensure adequate feedstock is delivered to the AD by the City's MSW.
    - Revenue sharing:
        - The City will receive a revenue share for any ICI tipping fee or digestate (compost) revenues above a certain dollar threshold.
        - The project partner will share in revenues for biomethane production in excess of an agreed-upon threshold. If biomethane production falls short of a certain minimum threshold, the project partner will be required to compensate the City for the full value of the shortfall.

Service Delivery Model

- Ownership/Operating Model: Surrey is developing the facility through public-private partnership under a 25 year operating agreement. The City's partner will design, build, operate, maintain and finance the facility via a long term agreement for the facility to be constructed on City-owned land.
- Responsibilities – The project partner is responsible for 1) accepting all City of Surrey organic waste and managing seasonal variability in composition and volume, 2) recovering biogas and producing biomethane for deliver to Fortis BC pipeline infrastructure installed adjacent to the facility, 3) ensuring odour levels are acceptable, managing all feedstock residuals and processing by-products in a sustainable manner, and 4) facilitating and hosting tours of the facility.

Regulatory Processes

- Rezoning - The City has completed a rezoning of both parcels in order to accommodate the uses of the proposed facility. Impact studies completed in support of the rezoning included an environmental assessment, noise impact study, odour impact study, traffic impact study and tree retention report. Public consultation was also conducted as part of rezoning process.
- Environmental Certificates - The City also obtained environmental certifications (certificates of compliance) for both sites in 2002 when the Surrey transfer station was under development. No other regional, provincial or federal environmental assessments are required for the project.
- Permitting – the partner (TBD) will be responsible for obtaining all permits and approvals for the deisgn, construction, operation and maintenance of the facility, including a DP and building permit from the City, utility connections and other matters from the City; regional operating permits from Metro Van (air quality permit, water quality permit); and if composting of residual waste will be done, the appropriate Provincial plans and specifications must be prepared by a Qualified Professional and all Provincial permits and approvals obtained prior to beginning operations.

GHG reductions: GHGs avoided through diversion from landfill is estimated at 25K tonnes of CO2e per year.

Timeline: Surrey's RFP will be awarded to one of Iris Solutions, Plenary Harvest Surrey, or Urbaser S.A. with an agreement in place by late 2014. Construction is expected to begin in early 2015 with facility operational by late 2016.

D. Proposed Next Steps to Assessing Feasibility of Anaerobic Digestion Facility/Renewable Gas Production for Victoria

1. ID policy goals to determine if RNG and AD are best suited to address. Is City's primary goal landfill space saving, organic waste processing/disposal, or renewable energy production? What problem is City looking to address?

   RNG supports the following policy goals figuring prominently in government today:
   i. Independence from fossil fuels/energy security
   ii. GHG reduction/climate change mitigation
   iii. Air quality
   iv. Economic - Taxpayer savings, green jobs, economic development

2. ID site opportunities and partnerships - landfills and wwtps that already produce biogas, sites that manage large concentrations of organic waste, and sites where an AD might be built to process multiple sources of waste generated locally.

3. ID "waste shed" – geographic area of waste to be collected and managed. Consider ownership and jurisdictional issues vis-a-vis regional waste aggregation at landfill or wastewater treatment plant (wwtp).

4. ID customers and measure the market for RNG - Need to ID local public and private fleet owners of CNG, or that could benefit from investing in natural gas engines. Due to higher vehicle costs for these engines, likely candidates are large fuel users such as medium and heavy-duty buses and trucks.

5. Economic Feasibility- Prepare a business case
   a. Measure inputs - There is no need to evaluate every possible site, zero in on the biggest waste concentrations and begin to assess feasibility
   b. Project outputs –

    i. Assess size of vehicle market for RNG (CNG and LNG existing and potential). Determine if vehicle market is sufficiently sized to pay back expense of the digester within the desired timeframe.
    ii. Factor in other revenue sources from tipping fees and combined heat and power generation (the latter a supplemental use of biogas until vehicle market for RNG grows).

c. Identify available source of funds – While it's possible to find a private partner to finance the majority of the AD/Biofuels facility, both the City of Edmonton and City of Surrey were able to contribute 33% and 25% of capital costs respectively by accessing provincial and federal government contributions.
d. Identify the preferred Service Delivery Model Option. Contracts can be
    i. Design/build
    ii. Design/build/operate
    iii. Design/build/finance/operate (P3 – Surrey)
    iv. Design/build/own/operate (Edmonton)

<u>Factors to assist with Economic Feasibility</u>

- On Vancouver Island, tipping fees for MSW waste including organic waste ranges from $110-$137/tonne, electricity costs $0.09 per KWh and the cost of natural gas (excluding dispensing fees and infrastructure) is $12/GJ ($0.04/KWh or $0.43/diesel litre equivalent).
- Methane content of raw biogas is between 45-65% (lower at landfill, higher at ADs)
- Conversion Factors - To convert volumes of methane gas to gigajoules (GJ) and diesel litre equivalents for operating cost calculations and comparison to other fuels use:
    i. 1 GJ of natural gas = 27.7 litres of diesel
    ii. 1 kg of natural gas = 1.462 litres of diesel
    iii. 1 m3 of natural gas = 1.032 litres of diesel

6. Recruit expertise – waste mgmt companies, landfill owners and operators, wwtp managers, organics recycling and composting agencies and companies, environmental groups, natural gas utilities, public and private fleets exploring alternative fuels, universities and labs specializing in alt fuels, organics recycling, agriculture, consulting and engineering service provides for local waste management companies and wwtps and other digester projects, provincial and federal agencies with regulatory responsibility for waste handling, natural resource protection, sustainability and climate action.