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CORE AREA LIQUID WASTE MANAGEMENT COMMITTEE
Notice of a Special Meeting on **Wednesday, February 18, 2015, at 8:30 a.m.**
Board Room, 6th floor, 625 Fisgard Street, Victoria, BC

N. Jensen (Chair)	S. Brice (Vice Chair)	M. Alto	R. Atwell
D. Blackwell	J. Brownoff	V. Derman	B. Desjardins
C. Hamilton	L. Helps	B. Isitt	C. Plant
D. Screech	L. Seaton	G. Young	

AGENDA

1. Approval of Agenda

2. Chair's Remarks

3. Presentations/Delegations

4. Supplemental Report – Biosolids Treatment and Funding : Report: "Background and Current Status of the Resource Recovery Centre"

5. Adjournment

To ensure quorum, please advise Nancy More at 250-360-3024 if you or your alternate cannot attend.

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SUPPLEMENTARY

CAL 15-02

**REPORT TO CORE AREA LIQUID WASTE MANAGEMENT COMMITTEE
MEETING OF WEDNESDAY 18 FEBRUARY 2015**

SUBJECT **BACKGROUND AND CURRENT STATUS OF THE RESOURCE RECOVERY CENTRE**

ISSUE

The Core Area Liquid Waste Management Committee, (CALWMC) at its meeting of February 11, 2015, requested a status update on the Hartland Resource Recovery Centre (RRC) (Where are we now? What has been done so far? How shovel ready are we?). In addition, the Committee requested additional information about gasification (How can gasification be added on to the digestion process? What would the process look like if the CRD excluded digestion and went straight to gasification?).

BACKGROUND

Early on in the planning stages (March 2007), a team of Capital Regional District (CRD) advisors (Associated/CH2MHill) identified anaerobic digestion as the preferred residual solids treatment process for the CRD because it provided the most likely means to recover energy, reduce solids mass and create an end product that provided multiple disposal options that could be used beneficially. In March 2009, a third-party *Peer Review Team* of North American experts reviewed the CRD wastewater program and also concluded that anaerobic digestion was "an appropriate choice." Later on (November 2009), a second team of CRD consultants, (Stantec/Brown & Caldwell) prepared a *Biosolids Management Plan* (BMP), which evaluated a number of options using the triple-bottom-line criteria. This evaluation also concluded that anaerobic digestion was the best option for the CRD.

The residual solids treatment process that was identified as the preferred process in all of the studies was also part of the public consultation materials over the last several years. The inclusion of this process in the LWMP was approved by the CALWMC on November 18, 2009 and then by the Board. The BMP was included in Liquid Waste Management Plan Amendment No. 7 and was approved by the Province in 2010. This Amendment included the requirements to recover biogas and struvite (phosphorus fertilizer) from the residual solids and utilize the ensuing biosolids in a beneficial way. See the attached schematics (in Appendix A) that show the approved residual solids treatment process, a gasification process and the two processes combined.

Agreement and inclusion of an acceptable BMP, and the other provisions included in the LWMP, was the foundation for the successful negotiation of the funding agreements with the provincial and federal governments. The funding agreements were approved by the Board on December 12, 2012. The federal agreements and the provincial agreement are designed to complement each other, thus they both have specific conditions on resource recovery for BMP as a required outcome. The funding agreements with 3P Canada and other federal agencies remain confidential, as set out in the terms of the agreement by these agencies, and have been circulated to Board members as confidential information.

As a result of the decision to pause the Seaterra Program in June 2014, CRD staff were directed to contact the funding agencies and report back to the Board with respect to the potential implications of not proceeding with the BMP in accordance with the funding agreements. The following motion was passed at the Core Area Liquid Waste Management Committee meeting of February 11, 2015:

> *Staff be directed to commence discussions with PPP Canada to explore enhancements to both the alternatives in the staff report, and report back to the Core Area Liquid Waste Management Committee with implications and recommendations to move forward while maintaining the existing funding commitment.*

E-mail correspondence has been received from Minister Lebelle's office confirming the availability of staff from the Minister's office to meet with the CRD. With direction from the Board Chair, staff are in the process of arranging a joint conference call for the Board Chair, the Chair of the Eastside and Co-Chair of the Westside Select Committees. Staff have also arranged a conference call with PPP Canada for Feb 20 to further discuss options regarding agreement extensions.

CURRENT STATUS

Subsequent to the RRC being approved by the Province in 2010, and the negotiation of funding agreements, the following actions have been completed:

- An environmental impact assessment for the site based on the current approved plan;
- Approval of land for the RRC facility in an area north of Hartland Landfill (outside of the landfill area footprint with separate access off of Willis Point Road). This land was transferred from the CRD to the Core Area municipalities after approval by the CALWMC and the Board;
- Preliminary design of power supply requirements by BC Hydro;
- Preliminary assessment of water supply requirements by the District of Saanich;
- A Request for Qualifications (RFQ) was issued for the RRC in December 2013 and 36 firms responded. The Seaterra Commission subsequently shortlisted four international consortia:
  - Capital Clear
  - Harbour Resource Partners
  - Plenary Group/Veolia
  - Synagro/EQT
- A Request for Proposals (RFP) was issued in May 2014 to the four shortlisted consortia and was subsequently suspended. The four shortlisted international consortia are still intact.
- A Request for Proposals (RFP) for the disposal of biosolids was issued in December 2013. Four consortia responded and a recommendation for award has been made to the CALWMC. The recommended proponent would commit to taking 100% of the dried biosolids generated by the RCC for 25 years. The biosolids would be utilized in a beneficial manner on Vancouver Island.

Should the committee decide to resume the process based on the current approved plan, it would take approximately 18 months to start construction (RFP process, close financing, design and mobilization) and the plant could be completed by the end of 2020. Alternatively, if a new plan is prepared, construction would not likely start until 2018, due to the required approvals process, and completed by 2022 (depending on the complexity of the changes).

TECHNOLOGIES

As part of its current review of the wastewater treatment program, the committee has inquired about the potential to re-examine thermal destruction processes (specifically gasification) for residual solids instead of the provincially-approved anaerobic digestion process. The thermal destruction technology processes are noted below, along with some brief information:

1. Waste-to-Energy (WTE) Facilities

This technology is primarily used for thermal destruction of municipal solid waste (MSW). An example of this technology is Metro Vancouver's WTE facility in Burnaby, which has a capacity of about 300,000 tonnes per year. Some points to consider with this technology:

- Primarily used for MSW. This is not part of the mandate for wastewater treatment.
- Ministry of Environment will not approve a WTE facility until the CRD has an approved Solid Waste Management Plan (SWMP) with a minimum reduce, reuse, recycle target of 70% before considering the use of WTE technologies for managing MSW (the CRD's current approved SWMP has a target of 50%).
- The gasification of MSW or source-separated kitchen scraps would require an amendment to the SWMP and public consultation.
- The capital cost to implement a MSW – WTE for 200,000 tonnes per year, including residual solids – is approximately $310 million, depending on complexity and resource recovery options.
- A 200,000 tonnes per year MSW – WTE facility, including residual solids, would generate revenues from energy recovery and this can be applied to pay for part of the annual operating costs. The facility is very complex to operate.
- The proposed facility would require a review under the provincial Environmental Assessment Act (anticipated timeline 2+ years). A federal (CEAA) process would not be triggered by the project.
- The proposed facility would also require a provincial Waste Discharge Permit from the Ministry of Environment. There would be some concurrent steps with the environmental assessment process, such as air monitoring, dispersion monitoring, and risk assessments but the process would be finalized only after the Environmental Assessment Review. As well, the regulatory component would require First Nations consultation as well as a public process to address any local siting or air pollution concerns (anticipated timeline 1+ year).
- This technology is not compliant with the provincial and federal funding agreements

2. Gasification Facilities

This technology was used in the past to convert coal into synthetic gas, but is still new when using residual solids or biosolids as a feedstock. The use of this technology for residual solids or biosolids applications was previously reviewed in December 2013 (see the attached technical memo updated to February 13, 2015 in Appendix B). Also see schematic of the gasification process in Appendix A. Some points to consider with this technology:

- Technology still being developed in small pilot-type demonstration facilities (only a few facilities world-wide and none at the scale that would meet the CRD's sludge generation capacity).
- If the purpose is to combine residual solids with MSW or source-separated kitchen scraps, the Ministry of Environment will not approve a WTE facility until the CRD has an approved SWMP with a minimum reduce, reuse, recycle target of 70% before considering the use of WTE technologies for managing MSW (the CRD's current approved SWMP has a target of 50%).
- The gasification of MSW or source-separated kitchen scraps would require an amendment to the SWMP and public consultation.
- A gasification facility requires some of the same components as anaerobic digestion, in order to convert the residual solids to a feedstock that can be utilized in a gasification facility – residual solids thickening, dewatering and drying.
- The capital cost to implement a gasification facility and all of its required components at the scale required for the CRD is about $300 million. In addition, given the inability of the process to store the incoming residual solids, there is a need for 100% redundancy, which further increases the costs.
- The annual operating costs would be approximately $7-10 million. The facility is very complex to operate. The annual revenues from energy recovery would be approximately $0.5 million (if processing residual solids only).
- This facility generates toxic gases that require complex emission control systems.
- The proposed facility would require a review under the provincial Environmental Assessment Act (anticipated timeline 2+ years). A federal (CEAA) process would not be triggered by the project.
- The proposed facility would also require a provincial Waste Discharge Permit from the Ministry of Environment. There would be some concurrent steps with the environmental assessment process, such as air monitoring, dispersion monitoring, and risk assessments, but the process would be finalized only after the Environmental Assessment Review. As well, the regulatory component would require First Nations consultation as well as a public process to address any local siting or air pollution concerns (anticipated timeline 1+ year).
- The footprint of this facility is slightly smaller than the footprint for an anaerobic facility. See layouts for anaerobic and gasifier facilities in Appendix C.
- This technology is not compliant with the provincial and federal funding agreements.

Gasification is a promising technology but it is extremely complex and operation costs are higher. There is no full-scale application of gasification for raw sludge in North America. This technology is only operating at a demonstration scale. The existing gasification installation in British Columbia (i.e., Dockside Green) is only licensed to use wood waste, not residual solids, as their primary source of fuel and has not been operational for more than 2 years as it is not economical to operate.

3. **Anaerobic Digestion**

Anaerobic digestion is used as the residual solids processing technology for approximately 80% of all wastewater treatment facilities across North America and Europe. Many of these jurisdictions are reaffirming their commitment to this process by continuing to explore options to optimize and increase the energy generation from these facilities. Some points to consider with this technology:

- Better carbon offset than thermal destruction facilities (9,000 tonnes CO_2e per year for anaerobic digestion versus 1,470 tonnes for WTE and negative 90 tonnes CO_2e per year for gasification). The recovery of biogas and dried biosolids from anaerobic digestion provides a carbon offset when it is used to displace fossil fuels such as natural gas and coal, whereas recovered electricity from a WTE or gasification process provides very little carbon offsets because BC Hydro's generated electricity has a very low carbon footprint.

- The capital cost of anaerobic digestion is $270 million; annual operating cost is $6.1 million with potential revenues of $3.1 million. This facility is much less complex to operate.

- This facility provides better health and safety as biosolids produced from anaerobic digestion are a pasteurized product with the organics (including superbugs) stabilized. Conversely, raw residual solids fed into a thermal destruction process (WTE or gasification) poses significant health risks during handling. Raw sludge is very odourous and putrescible. The Peer Review Team indicated that "feeding raw wastewater sludge as a fuel supplement must be done with great care to the design, equipment selection and operation to ensure that pathogenic organisms are not released to the environment and prove a risk to worker and public health and safety."

- This facility has better redundancy as the anaerobic digestion facility has four digesters with one as a backup to be used during maintenance.

- This technology is compliant with the Provincial and Federal funding agreements

4. **Anaerobic Digestion Combined with Gasification**

It is possible to combine the anaerobic and the gasification process, as they have several sub-processes in common (residual solids thickening, dewatering and drying). In the anaerobic process, the biosolids are utilized offsite in a beneficial manner. If desired, this can be changed and the dried biosolids can be fed into a gasifier. This change is depicted in the schematic in Appendix A. Some points to consider with this approach.

- The combination of these technologies is not ideal as the costs associated with adding a gasifier and associated generating equipment for generating electricity is not cost efficient.
- The cost for adding a gasifier is significantly higher than the cost of the offsite solution.
- The combination of these technologies would increase the land area required at Hartland.
- This facility generates toxic gases that require complex emission control systems.
- The footprint of this facility is larger than the footprint for an anaerobic facility.
- The proposed facility would require a review under the provincial Environmental Assessment Act (anticipated timeline 2+ years). A federal (CEAA) process would not be triggered by the project.
- The use of gasification at Hartland may require an amendment to the SWMP and public consultation.
- The proposed facility would also require a provincial Waste Discharge Permit from the Ministry of Environment. There would be some concurrent steps with the environmental assessment process, such as air monitoring, dispersion monitoring, and risk assessments but the process would be finalized only after the Environmental Assessment Review. As well, the regulatory component would require First Nations consultation as well as a public process to address any local siting or air pollution concerns (anticipated timeline 1+ year).
- This combination of technologies is not compliant with the provincial and federal funding agreements

CONCLUSION

The analysis to date has shown that the preferred residual solids processing option for the CRD is anaerobic digestion. This processing option provides the greatest opportunities for resource recovery, enhances volatile solids reduction, gas production and through co-digestion of fats, oils and greases. Anaerobic digestion also stabilizes the biosolids to a safe Class A level and dried biosolids product that will be used as a fuel substitute at an existing offsite WTE facility or at a future CRD Municipal Solid Waste facility. In addition, this process provides synergies with the landfill operations at Hartland as the gas generated by the landfill can be utilized in the process.

Appendix D provides a summary table comparing WTE, gasification and anaerobic digestion technologies as related to various evaluation criteria.

RECOMMENDATION

That the Core Area Liquid Waste Management Committee receive this report for information.

Albert F. Sweetnam, P.Eng.
Project Director Seaterra Program

for Larisa Hutcheson, P.Eng.
General Manager
Parks & Environmental Services Department

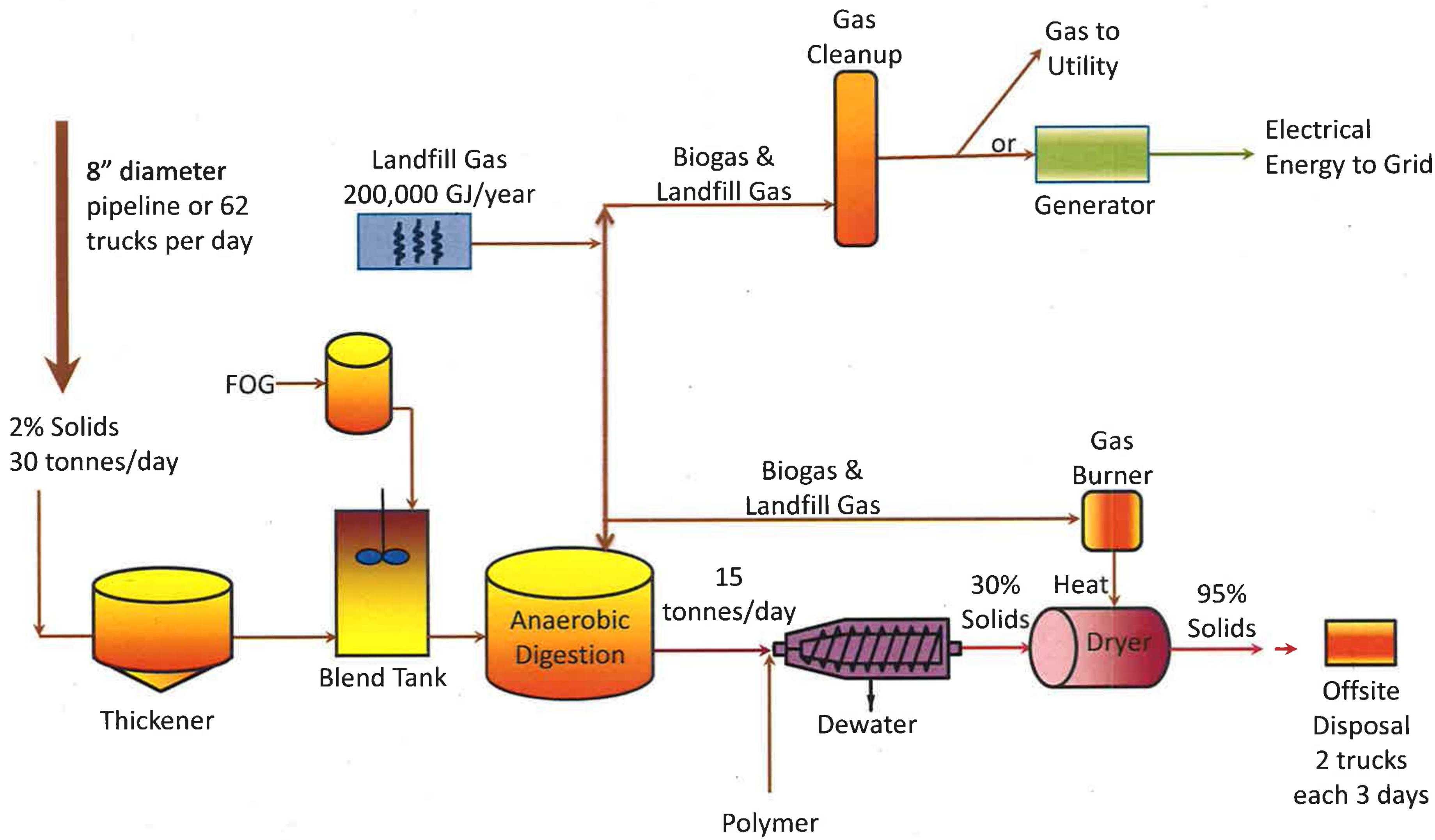
Diana E. Lokken, CPA, CMA
General Manager
Finance & Technology Department

Robert Lapham, MCIP, RPP
Chief Administrative Officer
Concurrence

AFS:ll/cl

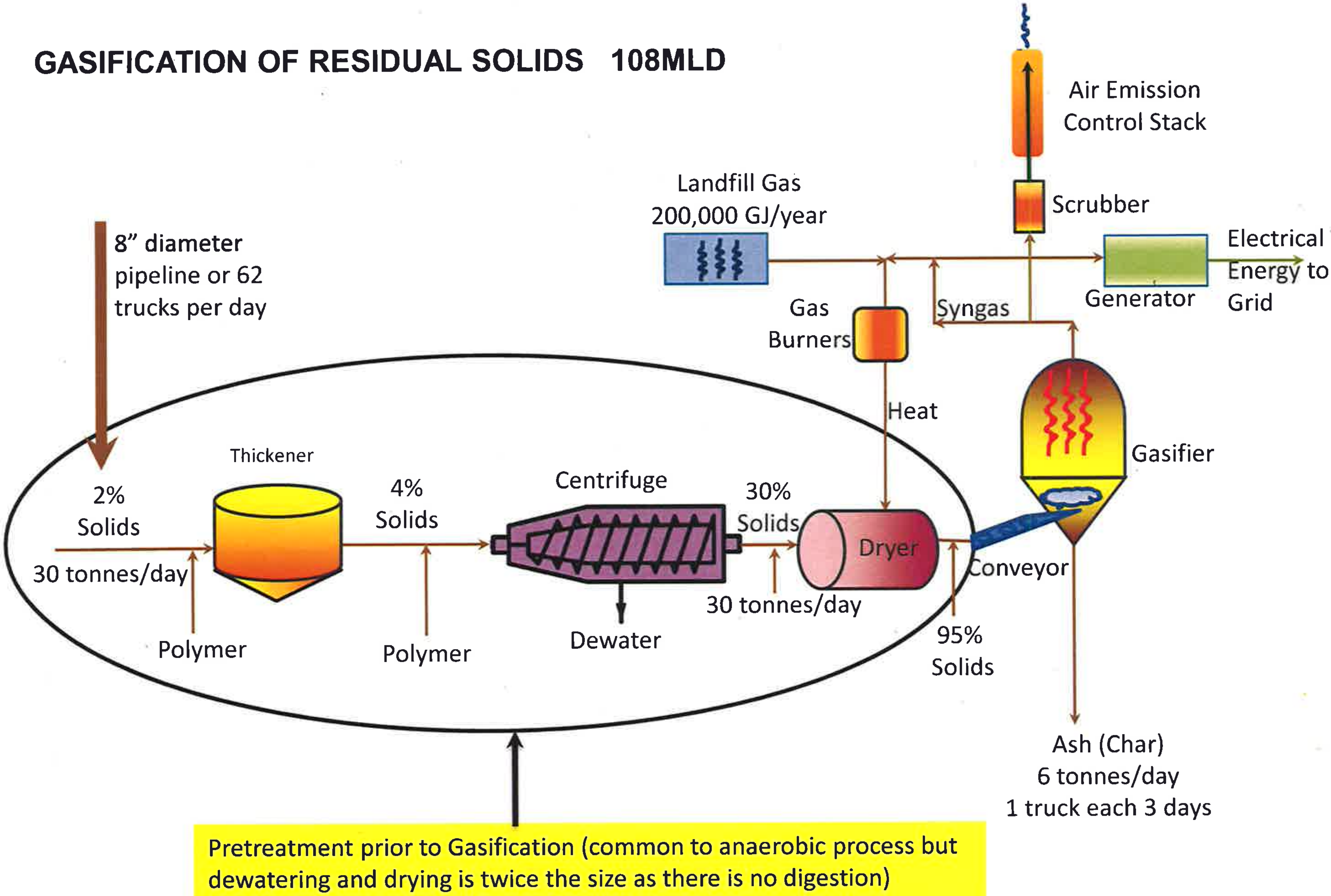
Attachments: 4

ANAEROBIC DIGESTION to DRIED BIOSOLIDS – Approved LWMP (108MLD)



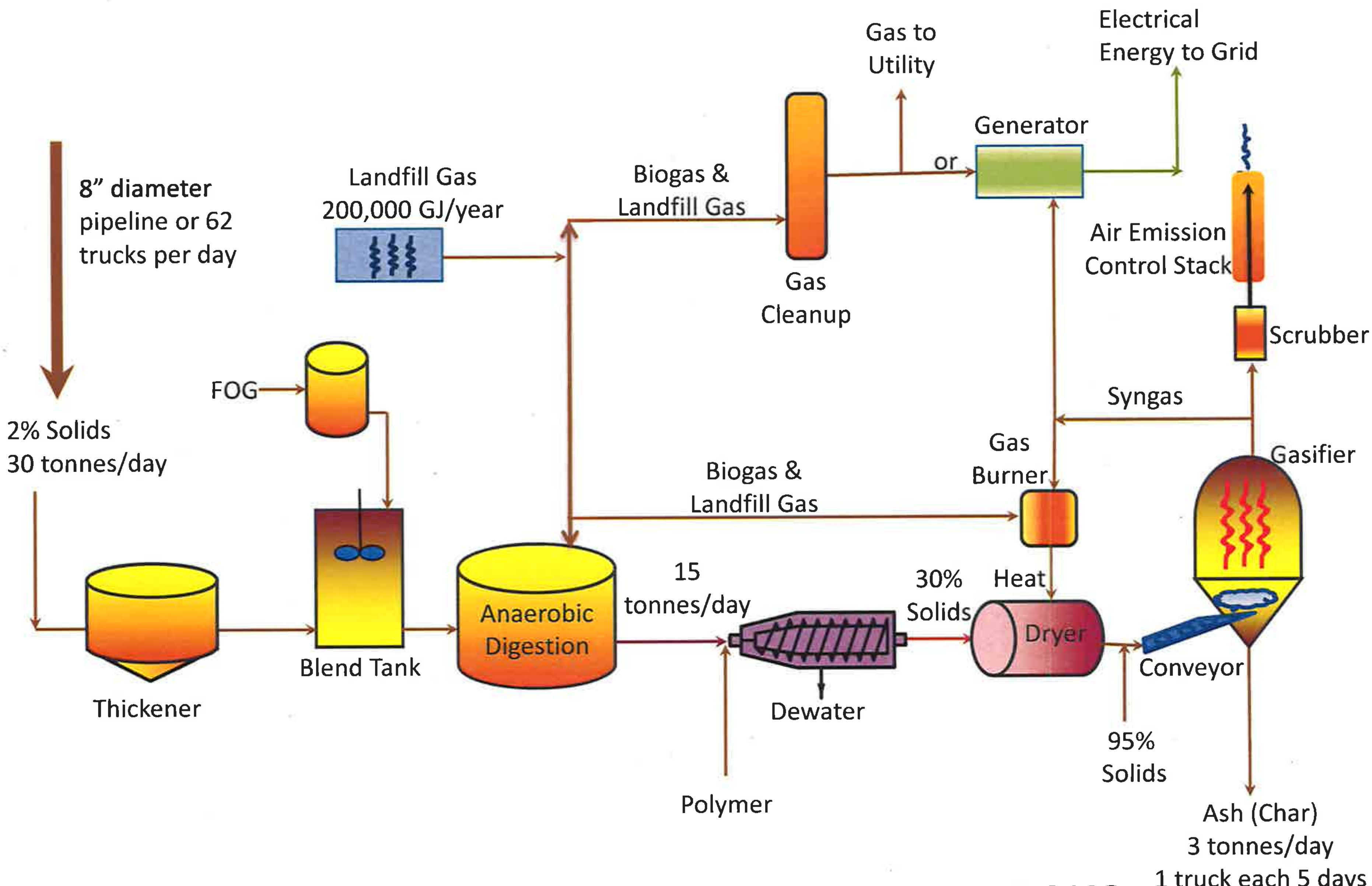
RESIDUAL SOLIDS MANAGEMENT OPTIONS

GASIFICATION OF RESIDUAL SOLIDS 108MLD



RESIDUAL SOLIDS MANAGEMENT OPTIONS

ANAEROBIC DIGESTION WITH GASIFICATION 108MLD



RESIDUAL SOLIDS MANAGEMENT OPTIONS

Reference: Review of Gasification for CRD Sludge/Bio Solids Processing

To:	Tony Brcic, P.Eng.	From:	Charlie Alix, PE
		Reviewed by:	Reno Fiorante, P.Eng., PE Bob Dawson, PhD, P. Eng., Stan Spencer, P. Eng.
	Capital Regional District		Surrey
File:	111700431	Date:	February 13, 2015

Note: This is an updated version of an earlier memo issued December 5, 2013 to Tony Brcic

Reference: Review of Gasification for CRD Sludge/Bio Solids Processing

PURPOSE

The McLoughlin Point WWTP will produce approximately 30 dry tonnes per day of raw sludge at the average dry weather flow (ADWF) design condition of 108 MLD. A variety of technologies are available for processing solids from the wastewater treatment plant. Many of these technologies are well-established at existing sewage treatment plants and others are less well-developed. The solids processing is an important aspect of an overall treatment plant as it must be able to reliably accept solids at all times from the liquid train treatment process.

This Technical Memorandum (TM) examines the potential of sludge/biosolids gasification for CRD. It reviews the history of biosolids gasification and the potential for its use by the CRD. In this TM, solids are referred to as either sludge or undigested biosolids (solids that have not been anaerobically digested prior to gasification) or biosolids (solids that have been digested prior to gasification).

BACKGROUND

The technology of gasification first saw large scale use in the 19th Century converting coal into synthetic gas burned in lamps for light. The technology is still used to gasify coal as well as wood, agricultural waste, and other dry high energy value materials. Gasification of alternative feedstocks, such as biosolids, is a more recent development that has presented mixed results and operational challenges. Gasification is a **complex thermo-chemical process** that breaks down compounds in the feedstock and reforms the elements into combustible gases and char. Non-volatile components of the feedstock will be left over at the end of the gasification process and are removed as ash.

In general, the gasification process can be broken down into three stages:

1. **Heating or Combustion (Oxidation)** – Typically heat is supplied by combustion of a portion of the feedstock material, but it can also be accomplished by using an external heat source such as an induction heater or a plasma torch. Combustion is achieved by supplying oxygen to the reactor. Oxygen is commonly supplied via air at approximately 20-30 percent of the amount required for complete feedstock combustion.

Reference: **Review of Gasification for CRD Sludge/Bio Solids Processing**

2. **Pyrolysis (Volatilization)** – In this stage, volatile compounds are broken down to carbon solids. The pyrolysis reactions are highly endothermic and require a large heat input in order to proceed. These reactions occur between 400°C and 700°C and proceed in the absence of oxygen, in contrast to Step 1.Gasification (Reduction) – Elements are reformed into synthetic gas (syngas). This generally occurs between 850°C and 1,200°C. The type of gasifier used and the feedstock composition (e.g., digested or undigested solids) will impact the energy value of the syngas produced. Typical air-blown gasifiers will produce a relatively low energy syngas.

There are a wide variety of gasification reactors available and these can be divided into general gasifier types. **Table 1** lists the various general types of gasifiers and some of their characteristics. One type of gasifier that is not included in this list is the rotating drum gasifier with induction heating as manufactured in Germany by Pyromex.

Reference: **Review of Gasification for CRD Sludge/Bio Solids Processing**

Table 1: Common Gasifier Types[1]

Gasifier Type	Scale	Fuel Requirements		Efficiency	Gas Characteristics	Other Notes
		Moisture	Flexibility			
Downdraft Fixed Bed	5 kW_{th} to 2 MW_{th}	<20%	· Less tolerant of fuel switching · Requires uniform particle size · large particles	Very Good	· Very low tar · Moderate Particulates	· Small scale · Easy to control · Produces biochar at low temperatures · Low throughput · Higher maintenance costs
Updraft Fixed Bed	<10 MW_{th}	up to 50% - 55%	· More tolerant of fuel switching than downdraft	Excellent	·Very high tar (10% to 20%) ·Low particulates ·High methane	· Small and medium scale · Easy to control · Can handle high moisture content · Low throughput
Bubbling Fluidized Bed	<25 MW_{th}	<15%	· Very fuel flexible · Can tolerate high ash feedstocks · Requires small particle size	Good	·Moderate tar ·Very high in particulates	· Medium scale · Higher throughput · Reduced char · Ash does not melt · Simpler than circulating bed
Circulating Fluidized Bed	A few MW_{th} up to 100 MW_{th}	<15%	· Very fuel flexible · Can tolerate high ash feedstocks · Requires small particle size	Very Good	·Low tar ·Very high in particulates	· Medium to large scale · Higher throughput · Reduced char · Ash does not melt · Excellent fuel flexibility · Smaller size than bubbling fluidized bed
Plasma	<30MW	any	· Greater feed flexibility without the need for extensive pretreatment · solid waste capability	Very Good	· Lowest in trace contaminants; no tar, char, residual carbon, only producing a glassy slag	· Large scale · Easy to control · Process is costly · High temperature (5000°-7000°F)
Liquid Metal	<7MW	<5%	· Generally requires low moisture due to the possibility of steam explosion	Very Good	·Low trace contaminants; virtually no tar, char, residual carbon	· High syngas quality
Supercritical Water	UNK	70 - 95%	· Suitable for the conversion of wet organic materials	Good	· Suppressed formation of tar and char	· Short reaction time · High energy conversion efficiency by avoiding the process of drying step · Selectivity of syngas with temperature control and catalysts

1. Roos, C., 2008. Clean Heat and Power Using Biomass Gasification for Industrial and Agricultural Projects. *U.S. DOE Clean Energy Application Center*. WSUEEP08-033, Rev. 5.

SLUDGE/BIOSOLIDS GASIFICATION EXPERIENCE

Of the gasifier types listed in **Table 1** and the Pyromex rotating-drum type, only the following have been used to gasify sewage sludge:

- Downdraft fixed bed
- Updraft fixed bed
- Fluidized bed
- Induction heated rotating reactor

Of these reactor types only the fluidized bed gasifier is still currently in operation for gasifying sludge/biosolids. There have only been a handful of commercial-size biosolids gasifiers and a few bench-scale pilots. **Table 2** summarizes sludge/biosolids gasification commercial and pilot operations and their associated gasifier type, capacity, and current operational status. Note that many of the listed facilities were only operating for a short period of time or only conducted intermittent trials with a small shipment of sludge/biosolids. Many of the gasifiers had to be shut down due to operational problems.

Table 2: Sludge/Biosolids Gasification History

Project Owner	Location	Gasifier Type	Capacity (Maximum)	Operations Status
Pilot-Scale and Demonstration Facilities				
Waste to Energy Ltd. (pilot)	Wellingborough, England	Downdraft Fixed Bed Gasifier	0.11 dry tonnes/hr	Started 2005, presumed to **no longer be in operation**
Tokyo Bureau of Sewerage (pilot)[4]	Kiyose, Japan	Circulating Fluidized Bed	0.56 dry tonnes/hr	Pilot started 2005, **ceased operation in 2006**
Nexterra Pilot Facility (trials for Metro Vancouver and Stamford, CT	Kamloops, BC company experimental development site	Updraft Fixed Bed	Various blends of wood waste and biosolids	Metro Vancouver: 2010 for 222 hours of various trials Stamford: trials in 2009 with 40 tons of dried biosolids
Pyromex (pilot)	Emmerich, Germany	Induction Heated Rotating Reactor	0.94 dry tonnes/hr	2000 to 2003
Pyromex	Neustadt, Germany	Induction Heated Rotating Reactor	0.94 dry tonnes/hr	2003 for 6 months
M2R/Pyromex	Emmerich, Germany	Induction Heated Rotating Reactor	0.04 dry tonnes/hr; fresh solids from M2R's MicroScreens	January and June of 2010
University of British Columbia[3]	Vancouver, BC	Bubbling Fluidized Bed	Bench top study various blends of wood and biosolids	2013

Reference: **Review of Gasification for CRD Sludge/Bio Solids Processing**

Project Owner	Location	Gasifier Type	Capacity (Maximum)	Operations Status
Full-Scale Installations				
EcoTech Gasification (private developer)	Philadelphia, PA	Downdraft Fixed Bed (Primenergy)	Approximately 1.8 dry tonnes/hr	Started June 2005, **currently not operating**
MaxWest Environmental Systems, Inc	Sanford, FL	Originally Updraft Fixed Bed, converted to fluidized bed in 2012	0.6 dry tonnes/hr	Fall 2009 began operations, in operation approx. 1 year with new gasifier design. **Ceased operation in late Fall, 2014**
MaxWest Environmental Systems, Inc	Plymouth, ME	Fluidized Bed	1.3 dry tonnes/hr	In development, **not currently operating**
Kopf (demonstration facility)[3]	Balingen, Germany	Bubbling fluidized bed	0.11 dry tonnes/hr Upgraded to 0.22 dry tonnes/hr in 2010	Started 2002, rebuilt in 2010, still in operation
Kopf (commercial installation)[2]	Mannheim , Germany	Bubbling fluidized bed	0.57 dry tonnes/hr to be expanded to 1.14 in the future	Began commissioning phase in 2010
Tokyo Bureau of Sewerage	Kiyose, Japan	Circulating Fluidized Bed	Approximately 0.75 dry tonnes/hr	Full scale started in July 2010, presumed to still be in operation
Dockside Green	Victoria, BC	Updraft Fixed Bed	Approximately 0.35 dry tonnes/hr	The gasification plant at Dockside Green is designed to process approximately 3000 tonnes/year of wood waste.[5]. Although, the original concept was to co-compost sewage sludge, the final design did not include sewage sludge. From the owner, the facility **has not been operated in the last 2 years** since the development is not fully built out and there is insufficient demand for the energy.[6]

2. Waste Management. 2012 Apr;32(4):719-23. doi: 10.1016/j.wasman.2011.12.023. Epub 2012 Jan 28.

3. Young, Ming Ming, Co-Gasification of Biosolids with Biomass in a Bubbling Fluidized Bed, April 2013

4. Takahashi, H. (2007). Study on sewage sludge gasification. Proceedings of the Water Environment Federation. 15-17. San Diego, CA.

5. BC Ministry of Community & Rural Development, Integrated Resource Recovery Case Study
6. Amalak Nijjar, Dockside Energy LLP, telephone conversation with Stan Spencer on Feb 13, 2015

As mentioned above, many of the listed in **Table 2** were short duration pilot studies investigating the feasibility of sludge/biosolids gasification. Only four installations were started as commercial ventures and of these only three are still in operation.

Assuming no anaerobic digestion prior to gasification, the CRD would require a facility that could process between 1.1 and 3.2 dry tonnes/hr. With anaerobic digestion, the CRD would require a facility with a capacity of approximately 0.5 to 1.6 dry tonnes/hr, although this would reduce the energy content of the biosolids prior to gasification and could make operation of the gasifier more difficult.

Facilities summarized in Table 2 have used both digested and undigested biosolids. Of the facilities constructed, none could meet the raw sludge production rate for CRD and only the EcoTech facility in Philadelphia (which is no longer in operation) was large enough to meet the digested sludge production rate. The two operating viable commercial operations are the Kopf facility in Manheim, Germany; and the Tokyo Bureau of Sewerage facility in Kiyose, Japan. A more in-depth review of these two operations is provided in the following sections, in addition to a description of the M2R/Pyromex gasifier.

EcoTech

The EcoTech facility was a private commercial venture to process wastewater treatment plant (WWTP) biosolids and water treatment residuals. The facility dried biosolids prior to sending them into the downdraft gasifier. Syngas from the process passed through a cyclone to remove particulate and was combusted. Heat from the combustion was used to run the dryer and generate steam for power generation. Waste steam generated was used back in the gasifier.

From discussions with personnel involved with operations of the facility the following issues led to the failure of the facility:

- The WWTP biosolids were digested and the energy value of the material quality fluctuated because of digestion and the addition of the water treatment residuals. The power generation is not known but it is suspected to be very low given the experience at other facilities and the typically low energy value of syngas from air blown gasifiers.

- Both the water and wastewater solids contained ferric chloride and this increased particulate and slag generation. Frequent slag generation in the heat exchanger caused the system to shut down for cleaning as often as every two weeks. Slag generation can occur when temperatures exceed the ash melting point of the feedstock (approximately 1,000-1,100°C), and careful operations control is required to maintain temperatures in an optimum range.

MaxWest (Sanford, FL)

Several modifications have been made to the Sanford facility since it first began operation. These include replacing the existing batch indirect rotary dryer with a continuous flow indirect dryer, replacing the fixed bed gasifier with a fluidized bed unit, and adding a cooling tower to the air exhaust stack. In the MaxWest process, undigested dried biosolids are gasified in the fluidized bed reactor and the syngas is passed through a cyclone to remove particulates. The gas is then combusted in a thermal oxidizer to heat oil for operation of the indirect dryer. The combustion of the syngas immediately downstream of the gasifier reduces the requirements for syngas cleaning, which would be required for use in an internal combustion engine. Exhaust from the thermal oxidizer passes through a cooling tower before going out the facility stack. The cooling tower is needed because the facility is in the flight path of a nearby airport and the uncooled exhaust had the potential to create turbulence. The original facility had no emissions controls, however, subsequent exhaust sampling has showed that NO_x and HCl concentrations are above allowable limits and reduction controls are needed.

It is worth noting that there is no power generation from the syngas at the Sanford facility. All of the energy generated in the form of heat is used in the dryer. In this type of system, the energy balance is highly dependent on the upstream sludge dewatering processes since it is more cost-effective to remove water mechanically (through thickening/dewatering) than through thermal drying. For example, the Sanford facility currently requires natural gas to supplement the energy needs of the dryer, though the system has the potential to become energy neutral during normal operations by dewatering to a higher solids concentration upstream of the dryer.

Note that the facility is no longer operating because the operators have filed for bankruptcy. The facility suffered from frequent process breakdowns and un reliability was a major factor in the facility shutting down.

Kopf

In both the Balingen and Mannheim, Germany facilities the drying operation occurs separately and the gas produced is used to produce electricity. This requires additional syngas cleaning steps relative to the use of a thermal oxidizer downstream of the gasifier, as in the MaxWest system. Although Kopf has a patented gas cooler step for tar removal, the overall technology for this type of gas cleaning is not considered fully developed. Kopf has also noted that the performance of their gasifier appears to be extremely sensitive to the type of dryer used and the subsequent characteristics of the dried sludge feedstock. The general process steps are described below.

The dried biosolids are gasified in a fluidized bed reactor. The syngas passes through a heat exchanger that warms air going into the gasifier. The gas is then cooled with a water quench that also preheats the biosolids going to the gasifier. The gas then passes through a baghouse and then to a condensate cooling/drying step. It is then burned in a combined heat and power (CHP) generator to produce electricity and recover heat. There is condensate generated in the cooling process that must be treated in the WWTP. The facility produces approximately 636 kW per dry tonne of biosolids processed. Approximately 21% of the power produced is used to run the process, excluding the dryer operation.

Tokyo Bureau of Sewerage (Full-Scale Facility)

The Tokyo Bureau of Sewerage operated a sewage sludge gasification pilot plant from 2005 to 2006 (approximately 3,400 hours of operation) at the Kiyose Water Reclamation Plant. Based on the results of this pilot study, the Tokyo Bureau of Sewerage has reported that a full-scale system was constructed which began operation in July 2010. At this time there is very little published information about the full-scale facility, though it is reported to be a scale-up of the pilot gasification facility discussed in Takahashi (2007). The system processes dried sludge using an internally circulating fluidized bed gasifier. The syngas is processed through a heat exchanger to heat the recycled preheating gas stream which is used for operation of the drying the sludge in the drying unit. Finally, the syngas is passed through a liquid scrubber and the syngas is burned in a gas engine. The syngas must be blended with a natural gas supplement (50/50 syngas to natural gas ratio reported for pilot operations) in order to successfully operate the gas engine generator (the energy content of the syngas by itself is relatively low). The full-scale facility is presumed to still be in operation.

M2R/Pyromex

Pyromex does not have a current commercial facility; however, it is worth examining their process because it is significantly different from the MaxWest and Kopf processes. The primary difference is that the system uses an induction heater to supply external energy to heat the feedstock (in lieu of combustion of a portion of the feedstock). In the Pyromex process, the biosolids are dried and then processed through their rotating induction heated gasifier. There is no combustion step in the gasification process, and a nitrogen gas purge is used to keep oxygen out of the system. This results in the production of a higher energy syngas because the syngas is not diluted with nitrogen gas from the air and the there is no loss of volatile solids to combustion. As a result, the system can achieve a slightly higher power output, but electrical energy is also required to operate the induction heater. After gasification the syngas is cleaned and cooled in a similar manner to the Kopf process before going to a CHP generator. The reported power generation is 880 kWh/dry tonne of biosolids. Of this the gasification process uses 33% and the drying process uses 52% resulting in only 15% of the power generated available for sale or other uses.

Process Lessons Learned

Although different gasifiers can tolerate higher moisture contents in the feedstock material, efficiency generally decreases with increasing moisture content. Usually the minimum target solids content of the biosolids going into the gasifier is about 85%, though some water is needed in the feedstock in order for the water gas shift reaction to occur in the gasifier. The high required solids content means there must be a drying step prior to gasification of sewage sludge, which has a comparatively higher moisture content even after upstream thickening/dewatering processes. The ability to generate electricity from the syngas hinges on whether the drying step is heated by the syngas or by another fuel such as natural gas or digester gas, and also depends on the solids concentration of the sludge entering the dryer (as noted above).

If the dryer is dependent on syngas generation, there will not be enough electrical power generation capacity to warrant the cost of gas conditioning equipment and the system mainly becomes a disposal system that can power itself. This is often referred to a as a close-coupled (closed loop) gasification system and is similar to the MaxWest system described above.

The ash melting point of the feedstock materials is also crucial. If the gasifier runs above the ash melting temperature, slag can be generated and this will significantly increase cost of operation and decrease the productivity of the system.

The exhaust from combustion of the syngas requires treatment for NO_x and possibly for HCl. NO_x can be treated using either selective catalytic or non-catalytic reduction. The HCl can be treated with a wet to dry lime slurry scrubber.

The metals content of the ash will determine if it can be beneficially used or if it will have to go to disposal. The ash can potentially be used for building products such as cement or other industrial uses for carbon solids. Phosphorus recovery from the ash is also possible but the technology is still in the development stages.

Reference: **Review of Gasification for CRD Sludge/Bio Solids Processing**

A major factor to consider for CRD is that all Thermal Destruction technology will take a very long time for regulatory approval and can take up to 5 years of environmental and social impact evaluation and public information exercises to obtain on Operating Permit.

Major cost factors in gasification is the provision of good dewatering and drying facilities to achieve at least 80% solids concentration . Dewatering and drying as well as materials handling costs more than the gasifier and emission control facilities.

Gasification at the CRD

The CRD has been examining several options for biosolids treatment and beneficial reuse. Of these options there are two that are compatible with adding gasification: the first is digesting and drying the sludge, the second is drying the raw sludge without anaerobic digestion. **Figures 1 and 2** show the rudimentary process flow for each of these options with gasification added. It should be noted many process details and refinements are not shown.

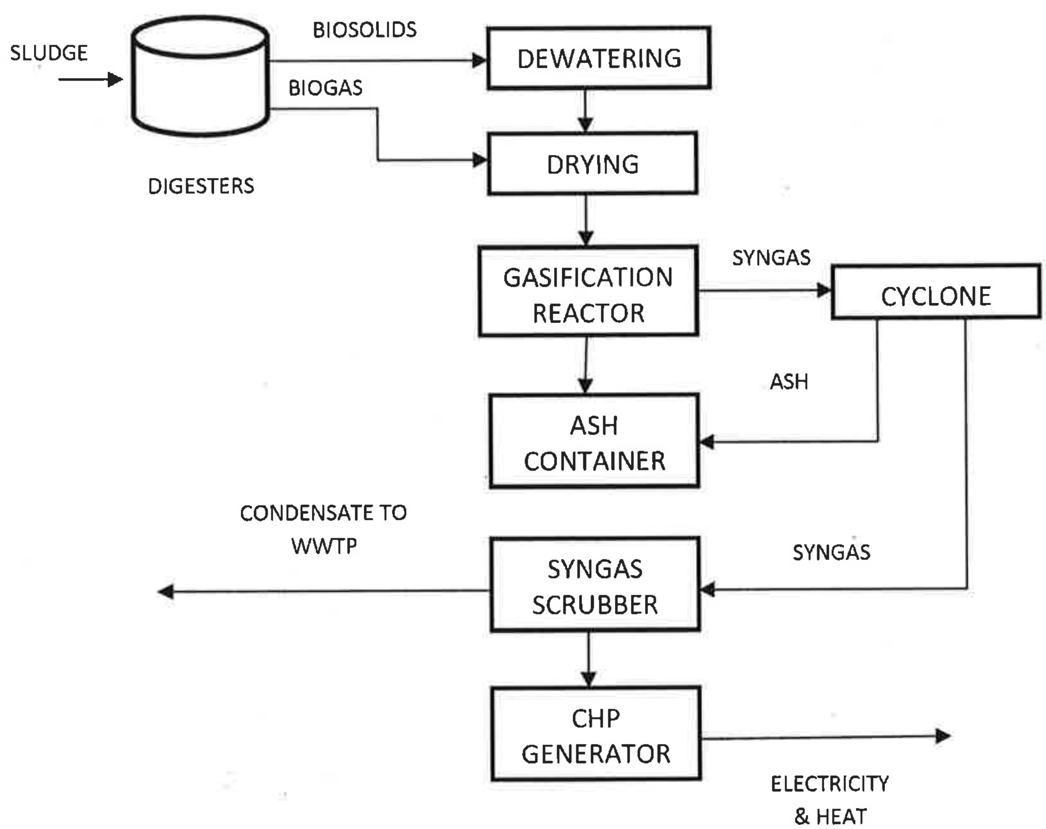


Figure 1: Simplified process flow for gasification of digested biosolids

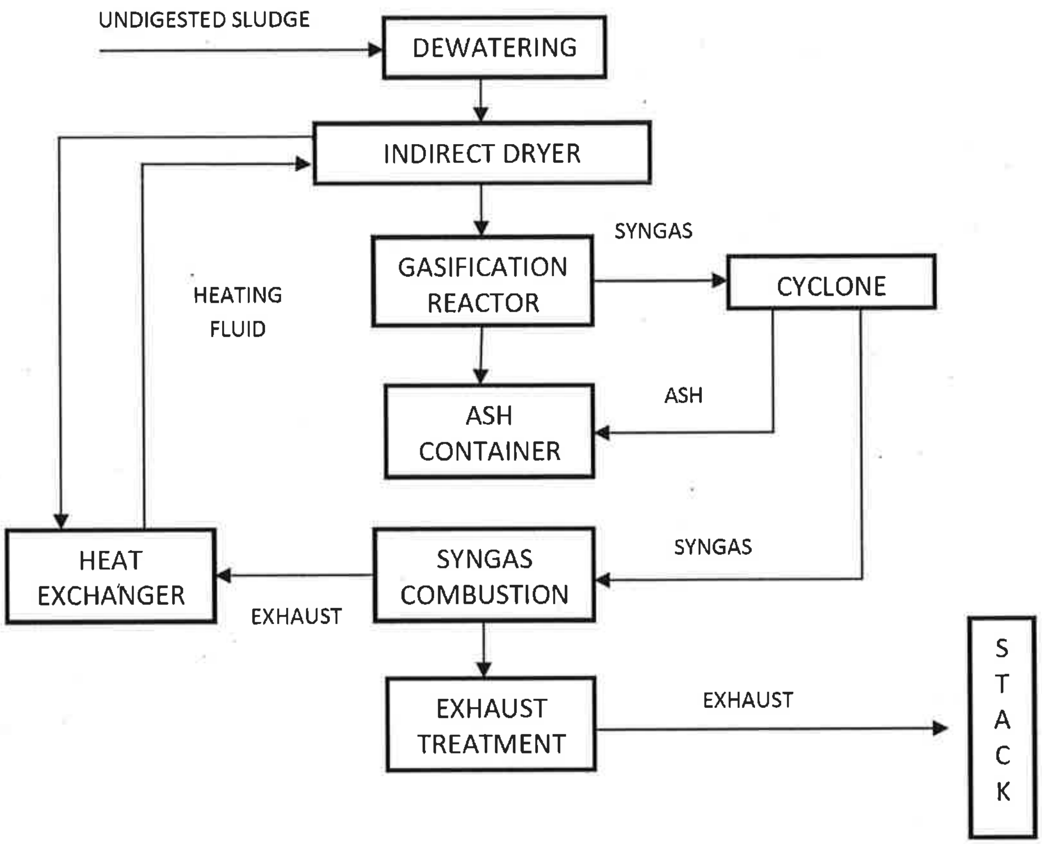


Figure 2: Simplified process flow for gasification of undigested biosolids

If the sludge is digested, biogas produced by the digesters would be used to provide heat for the dryers. The syngas from the gasification process could then be used to produce electricity. Without anaerobic digestion, the syngas is used to provide heat for the dryers, in addition to any natural gas supplemental fuel that may be required.

Economics

All of the full-scale gasification operations in North America have operated on a similar economic model, i.e. a developer or the equipment vendor owns and operates the facility and charges the City or Utility a fee for the gasification process. The original contract between MaxWest and the City of Sanford, Florida required the City to deliver dried biosolids to MaxWest at 85% to 92% solids at a minimum energy content of 4,225 Btu/pound [9.8 MJ/kg] delivered. MaxWest would return sufficient hot oil to run the indirect drier. Over time MaxWest took over operation of the dewatering and drying of the biosolids so that they would have full control over the condition of the feedstock going to the gasification process. The original cost in 2009 was $21,572/month with a 3% escalation each year. Sludge is processed from a 22 MLD plant or about 20% the size of CRD.

The Kopf model is similar however there is an option for the facility to be turned over to the City/Utility after five years of operation. Given the complexity of operating a gasification process and the specialized knowledge required, vendor operation of a system for at least some number of years is prudent.

Reference: **Review of Gasification for CRD Sludge/Bio Solids Processing**

Costs

Capital, operations and net present value costs have been prepared for the gasification option using digested and undigested sludge. These are compared with other options that have been considered as part of the Biosolids Management Plan.

Table 3: Cost Summary for Combustion and Landfill Options (all costs in millions of 2009 $)

	Off-Site Fuel (Dry)		On-Site Gasification (Dry)		On-Site Incineration (Dry)		Landfill (Dewatered)	
	Digest	Raw	Digest	Raw	Digest	Raw	Digest	Raw
Capital								
Biosolids Treatment	$254.9	$215.0	$254.9	$215.5	$251.0	$215.5	$219.8	$135.8
Incinerator	$0	$0	$0	$0	$46.9	$ 54.6	$0	$0
Gasification	$0	$0	$ 42.0	$ 84.0	$0	$0	$0	$0
Off-Site Costs	$5.0	$5.0	$0	$0	$0	$0	$0	$0
Total Capital Cost	**$259.9**	**$220.0**	**$296.9**	**$299.5**	**$297.9**	**$270.1**	**$219.8**	**$135.8**
Operation and Maintenance								
Biosolids Treatment								
Power	$2.1	$0.9	$2.1	$0.9	$1.6	$0.9	$1.6	$0.6
Chemical	$0.7	$1.5	$0.7	$1.5	$0.7	$1.5	$0.7	$1.5
Water	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1	$0.1
Labour	$0.7	$0.5	$0.7	$0.5	$0.7	$0.5	$0.5	$0.5
Maintenance	$2.8	$2.4	$2.8	$2.4	$2.8	$2.4	$2.4	$1.5
Incinerator								
Operation	$0	$0	$0	$0	$0.4	$1.0	$0	$0
Labour	$0	$0	$0	$0	$0.3	$0.5	$0	$0
Maintenance	$0	$0	$0	$0	$0.5	$0.6	$0	$0
Gasification								
Operation and Maintenance	$0	$0	$0.7	$1.9	$0	$0	$0	$0
Off-Site Costs								
Labour	$0.1	$0.2	$0	$0	$0	$0	$0	$0
Transportation	$0.4	$0.9	$0	$0	$0	$0	$0	$0
Tipping Fee	$0.4	$0.7	$0	$0	$0	$0	$2.3	$4.5
Total Annual O&M Cost	**$7.3**	**$7.1**	**$7.1**	**$7.2**	**$7.1**	**$7.4**	**$7.6**	**$8.6**
Revenue								
Biomethane	$1.4	$0	$1.2	$0	$1.3	$0	$1.4	$0
Gas Savings	$0	$0	$0	$0.2	$0	$0	$0	$0
FOG tipping fees	$0.9	$0	$0.9	$0	$0.9	$0	$0.9	$0
Power Savings	$0	$0	$0.2	$0	$0.2	$0.5	$0	$0
Total Annual Revenues (rounded)	**$2.2**	**$0**	**$2.2**	**$0.2**	**$2.4**	**$0.5**	**$2.2**	**$0**

Reference: **Review of Gasification for CRD Sludge/Bio Solids Processing**

Table 3: Cost Summary for Combustion and Landfill Options (all costs in millions of 2009 $)								
	Off-Site Fuel (Dry)		On-Site Gasification (Dry)		On-Site Incineration (Dry)		Landfill (Dewatered)	
	Digest	Raw	Digest	Raw	Digest	Raw	Digest	Raw
Net Present Value								
Capital (NPV)	$278.6	$239.0	$315.6	$318.2	$318.2	$288.9	$239.0	$147.5
O&M(NPV)	$261.1	$252.8	$252.8	$257.5	$252.8	$261.8	$270.3	$305.9
Revenue (NPV)	$126.2	$0	$137.6	$11.2	$129.5	$18.0	$126.2	$0
Total NPV	**$413.5**	**$491.8**	**$ 430.8**	**$564.5**	**$441.5**	**$532.7**	**$380.1**	**$453.40**

The current plan involving digestion and drying of biosolids, as proposed in the LWMP, still provides the lowest cost option for the CRD. There are also no significant operational risks as the technology is proven with a long track record at many installations across North America and globally.

Gasification and incineration without digestion require redundant units for back up and maintenance in the event that a unit must be taken off line for repairs or maintenance.

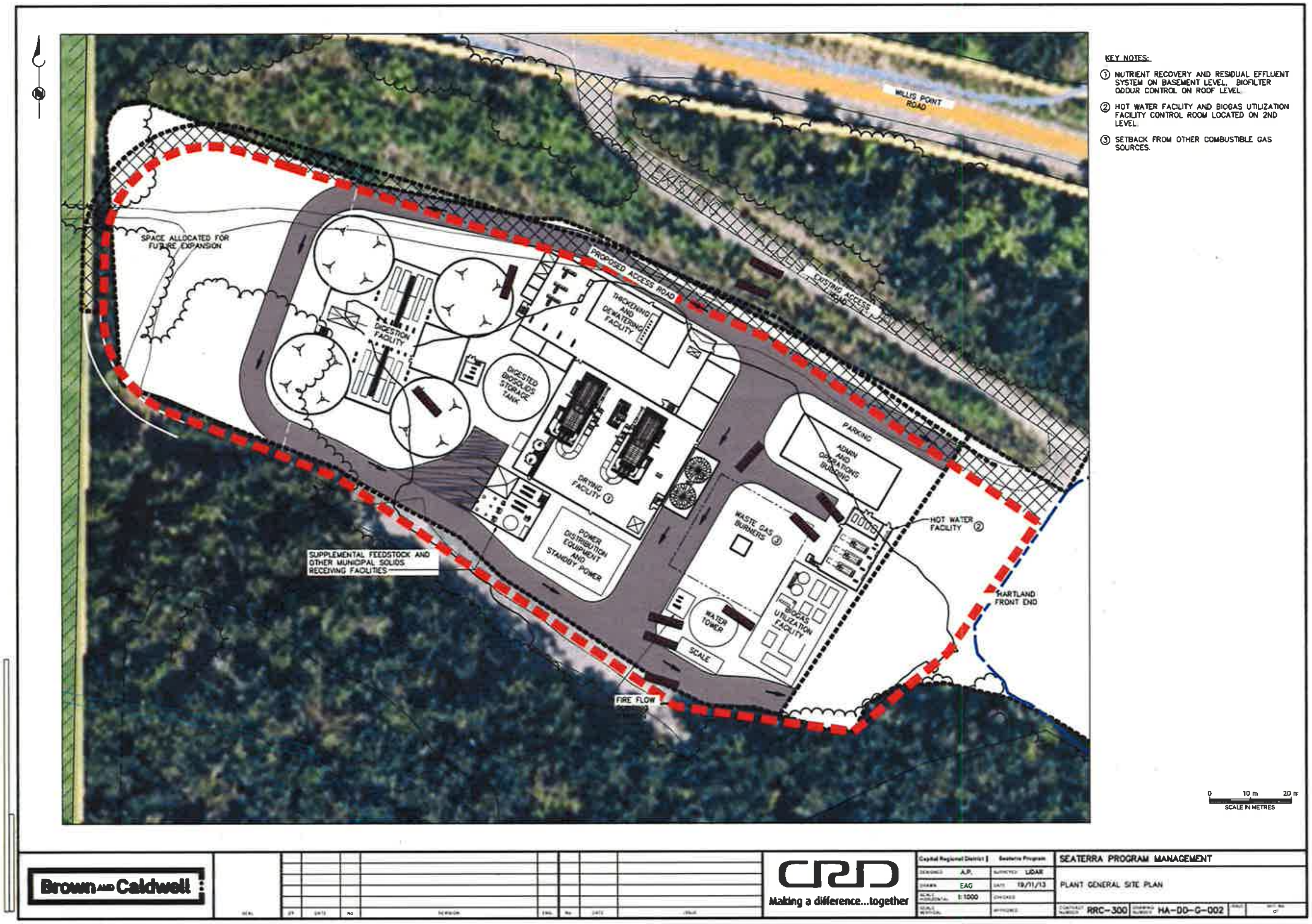
Conclusion

Successful use of gasification technologies for sludge/biosolids processing is limited at this time. The performance of gasification on biosolids applications has met with mixed results and many of the facilities have had operational difficulties and have been shut down. Other options such as incineration / waste to energy have a longer term operations track record and better reliability.

Gasification facilities are operationally complex. Although the technology shows promise, further refinement will be required to make it a viable and reliable option for long-term biosolids treatment. At this time we would recommend CRD not consider gasification as there is no long term proven track record for the technology at the scale required for the Resource Recovery Centre. Also given that the installations to date have met with mixed results, there is significant risk to the CRD by utilization of this technology.

The current plan which includes digestion and drying of biosolids provides the greatest flexibility and lowest net present cost to the CRD in comparison to other options.

APPENDIX C


KEY NOTES:
① NUTRIENT RECOVERY AND RESIDUAL EFFLUENT SYSTEM ON BASEMENT LEVEL, BIOFILTER ODOUR CONTROL ON ROOF LEVEL.
② HOT WATER FACILITY AND BIOGAS UTILIZATION FACILITY CONTROL ROOM LOCATED ON 2ND LEVEL.
③ SETBACK FROM OTHER COMBUSTIBLE GAS SOURCES.
WILLIS POINT ROAD
EXISTING ACCESS ROAD
PROPOSED ACCESS ROAD
SPACE ALLOCATED FOR FUTURE EXPANSION
DIGESTION FACILITY
THICKENING AND DEWATERING FACILITY
DIGESTED BIOSOLIDS STORAGE TANK
DRYING FACILITY ①
PARKING
ADMIN AND OPERATIONS BUILDING
HOT WATER FACILITY ②
WASTE GAS BURNERS ③
POWER DISTRIBUTION EQUIPMENT AND STANDBY POWER
SUPPLEMENTAL FEEDSTOCK AND OTHER MUNICIPAL SOLIDS RECEIVING FACILITIES
HARTLAND FRONT END
WATER TOWER
SCALE
BIOGAS UTILIZATION FACILITY
FIRE FLOW
0 10 m 20 m
SCALE IN METRES
Brown AND Caldwell
CRD
Making a difference...together
Capital Regional District | Seaterra Program
DESIGNED A.P.
SURVEYED LIDAR
DRAWN EAG
DATE 19/11/13
SCALE HORIZONTAL 1:1000
SEATERRA PROGRAM MANAGEMENT
PLANT GENERAL SITE PLAN
CONTRACT NUMBER RRC-300
DRAWING NUMBER HA-DD-G-002

Stantec | Brown and Caldwell

SEAL	BY	DATE	No.	REVISION	ENG.	No.	DATE	ISSUE

CRD — Making a difference...together

Capital Regional District | Environmental Services

DESIGNED	HN	SURVEYED	–
DRAWN	PRC	DATE	12/02/15
SCALE HORIZONTAL	1:500	CHECKED	PP
SCALE VERTICAL	–	APPROVED	RAF

CORE AREA WASTEWATER TREATMENT PROGRAM

HARTLAND LANDFILL SITE

COMPARISON OF CO-DIGESTION AND RAW SLUDGE WTE

CONTRACT NUMBER	DRAWING NUMBER	ISSUE	SHT. No. OF
–	SKETCH	–	– OF –

APPENDIX D

	WASTE TO ENERGY	GASIFICATION	ANAEROBIC DIGESTION
Approved in LWMP	No	No	Yes
Compliant with Funding Agreements	No	No	Yes
Capital Costs	$310 M (for 200,000 tonnes – CRD does not have retained)	$300M	$270M
Operating Costs	$7M - $8M	$7M – $10M	$6.1M
Revenue Potential	Low	$0.5M	$3.1M
Carbon Offsets	1,470 tonnes CO2e	-90 Tonnes CO2e	High 9,000 tonnes CO2e
Proven Technology	Yes	No	Yes (used at 80% of facilities)
Complexity To Operate	High	High	Low
Air Emissions	Yes – requires MOE permit	Yes – requires MOE permit	None
Timing	2023 +	2023 +	2020
End Product	Heat/Power	Heat/Syngas/Power/Fly Ash	Heat/Biogas/Power/ Biosolids/Struvite
Integration with Solid Waste	Residual Solids/ Kitchen Scraps/ MSW	Residual Solids/ Kitchen Scraps/MSW (not commercially proven)	Residual Solids/Kitchen Scraps/FOG
Health & Safety Risk	High	High	Low
Solid Waste Management Plan Implications	Need SWMP amendment/ consultation	Need SWMP amendment/ consultation	Approved in SWMP amendment 8.
Environmental Assessment Act Review needed?	Yes	Yes	No