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Memorandum

To:	Jay Heaman Manager, Strategic Initiatives	**From:**	Mark Sungaila, Ben Arnold SLR Consulting
Company:	Oxford County		
cc:		**Date:**	August 4, 2017
Subject:	**ASSESSMENT OF WASTE REDUCTION AND RECOVERY TECHNOLOGIES TECHNICAL MEMORANDUM 6: SUMMARY OF FINDINGS FROM TECHNICAL MEMORANDA 1 – 5**		

1.0 INTRODUCTION

Oxford County operates a very successful municipal solid waste management program having achieved a ranking of 6th out of 230 Ontario municipalities for diverting residential waste from landfill, as well as a ranking of 1st in diversion for municipalities within its grouping[1]. The County has also embarked on an ambitious program to achieve two significant long term Sustainability goals, being 1) achievement of 100% renewable energy by 2050[2], in accordance with the County's June 2015 resolution; and, 2) achievement of Zero Waste, as articulated in the September 2016 draft Zero Waste Plan[3]. Oxford County's renewable energy commitment provides a mechanism for linking the two goals outlined above and recognizes that residual waste can form a useful feedstock for generating energy from waste. As part of its program toward achieving Zero Waste and other related goals, OC has undertaken this ***Assessment of Waste Recovery and Reduction Technologies*** (the Project). The Project is being undertaken amidst the development of recent climate change and waste management legislation (and related policies, strategies, and emerging programs), intended to dramatically reduce waste generation and disposal, and intended to drive the 'Circular Economy'.

[1] Full Report County of Oxford Waste Management Strategy, Oxford County, August 2014.

[2] Draft 100% Renewable Energy Plan, Oxford County, June 22 2016.

[3] Draft Zero Waste Plan, Oxford County, September 22, 2016.

The County has retained the consulting team of SLR Consulting (Canada) Ltd., in association with Love Environment to assist them in carrying out the Project, which will consist of five main tasks described in following **Sections 1.1** through **1.5.**

1.1 Task 1: Assessment of Existing Waste Recovery Technologies

Task 1 is a comprehensive review of existing approaches to the reduction of residual waste, leading to identification of technologies that are relevant to Oxford County. This will be undertaken in three stages:

- *Stage 1: Setting the Scene*: This is an analysis of the current waste management situation in Oxford County aimed at characterising the County's waste management situation in terms of scale, current approach, types of waste, barriers and opportunities.

- *Stage 2: Technology Options (Inclusive List).* Stage 2 is identification of a long list of technology suppliers under each material type and technology class. This long list would subsequently be screened against a set of criteria which would be agreed with the County.

- *Stage 3: In-depth Evaluation.* Stage 3 is a more in-depth analysis of the individual technologies using the County's Multi Criteria Analysis Tool (MCA).

1.2 Task 2: Case Studies of Implemented Technologies

Task 2 will result in the documentation of case studies of technologies implemented in other jurisdictions, as well as highlighting of those technologies which have been successfully implemented and which have highest likelihood of successful implementation in Oxford County.

1.3 Task 3: Review of New and Emerging Technologies

This task will be the documentation of new and emerging technologies as identified in Task 1, as supplemented by gathering of additional data as required and prepare meaningful commentary.

1.4 Task 4: Relationship of EPR and Resource Recovery with Current Waste Stream

Task 4 will examine and assess the impacts of recent climate change and waste management legislation, namely:

- Bill 151 – the *Waste Free Ontario Act* which includes both *Resource Recovery and Circular Economy Act* and the *Waste Diversion Transition Act;*
- The *Strategy for a Waste Free Ontario* (through which topics like the future of organics, disposal bans, new material designations and ICI diversion are prominent); and,
- The *Ontario Climate Change Action Plan* (and its potential impact on municipal waste operations).

This legislation will be examined in the context of several key questions, including the County's role in the delivery of waste management services in areas where producer responsibility is significantly changing, and the County's role in ensuring that expanded EPR programs that are implemented are well integrated with the overall waste management system.

1.5 Task 5: Economic Potential of Full Resource Recovery

This task will seek to identify the net economic benefits of implementing the preferred technology solutions identified in Task 1, considering the outline Capex and Opex costs of technologies, and accounting for the value within recovered materials, the potential sale of power and/or heat from certain categories of technology, and avoided costs of landfilling and long-term management of impacts.

1.6 Study Documentation

Documentation generated during this study will be presented in technical memoranda covering each task. Following review and agreement by the County, the technical memos will be combined into a final report with an overarching introduction and conclusion section.

2.0 DOCUMENT OBJECTIVES AND ORGANIZATION

2.1 Document Objectives

This document is **Technical Memorandum 6 (TM6)** which summarizes the main findings, conclusions, and recommendations from preceding TMs 1 through 5. For details around the summarized information provided herein, readers are directed to TMs 1 through 5.

2.2 Glossary

As an aid to the reader the following glossary is provided for terminology used in this memorandum:

%	Percent
AD	Anaerobic Digestion
APCr	Air pollution control residues
Biomethane	Methane derived from non-fossil fuel origins.
BtL	Biomass to liquid
CAPEX	Capital expense
CHP	Combined Heat and Power
CLO	Compost-like output

CO_2	Carbon dioxide
CV	Calorific Value
DS	Dry solids
ECA	Environmental compliance approval
EFW	Energy from Waste, also known as Waste to Energy WtE), is the conversion of waste into a useable form of energy, e.g., heat or electricity. A common conversion process is waste combustion.
EPC	Engineering, procurement, and construction
EPR	Extended Producer Responsibility
EU	European Union
GtL	Gas to liquids. A refinery process to convert natural gas or other gaseous hydrocarbons into longer-chain hydrocarbons
h	hour
HAZOP	Hazard and operations study
IC&I	Industrial, Commercial and Institutional
IVC	In-vessel Composting
kg/m^3	Kilograms per cubic meter
kpta	Kilo tonnes per annum
LBM	Liquid biomethane
MBT	Mechanical-biological treatment
MC	Moisture content
MCA	Oxford County's Multi Criteria Assessment tool, a framework for making decisions on the basis of criteria categorized as Community, Economic, Environmental, and Implementation
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
MW	Megawatts (10^6 W) is a unit of power equal to one million watts

NASM	Non-agricultural source material
NIR	Near infra red
NMA	Nutrient Management Act
NMP	Nutrient management plan
OC	Oxford County
OPEX	Operating expense
PE	Population equivalents
Pre Feed	Refers to the development of a pre-defined design package for a facility to evaluate technical and economic feasibility
PFI	Private finance initiative
RDF	Refuse-derived fuel
SRF	High grade solid-recovered fuel
tph	Tonnes per hour
US	United States
UK	United Kingdom
WWTP	Waste water treatment plant

3.0 SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

3.1 Task 1: Assessment of Existing Waste Recovery Technologies

OC's waste generation rate and composition was estimated based on various waste audit data including the County's 2014 Waste Management Strategy, the County's 2015 Waste Diversion Year End Report, and a 2012/2103 Curbside Audit prepared by AET for the Continuous Improvement Fund.

The generation rate and composition estimates were used to make projections of waste generation and composition over the period from 2020 to 2050. The overall waste generation rate was estimated to increase from about 41 ktpa to in 2020 to 46 ktpa in 2050, with the increase seen to be driven primarily by population growth. Two diversion scenarios were examined: A - if the diversion rate presently achieved stayed the same, and B – the capture rate for recyclables, food, and yard waste increased to 100% by 2050.

A broad range of waste treatment technologies which could manage OC's projected waste stream were reviewed. These can be classified into 4 broad classes: materials recovery (MRFs), mechanical biological treatment (MBT), biological treatment (composting or anaerobic digestion), and thermal treatment (conventional combustion or advanced treatment including gasification and pyrolysis).

Considerations of the technology classes that might be appropriate for OC can be summarized as follows:

- Conventional combustion Waste to Energy (WtE) is generally not viable at throughputs of less than 40 ktpa – 60 ktpa, and is therefore likely not viable for OC's waste stream on its own.

- Advanced thermal treatment technologies such as gasification/pyrolysis are generally not viable below a throughput of 5ktpa to 10ktpa, and may therefore be viable for OC's projected waste stream, depending upon the waste generation scenario considered.

- 'Complex' MRF technologies are not generally not viable below throughputs of 15kpta to 25ktpa etc., and may therefore be viable for OC's projected waste stream, depending upon the waste generation scenario considered.

- Ultimately the viability of any given technology class depends on jurisdiction-specific factors including land cost, energy prices, renewable tariffs, landfill prices, etc.

A list of potential providers for each technology type was compiled. All of the firms listed were known to have operations, manufacturing, or at least registered offices in North America (w/ some specific exceptions), and all had one or more operational reference facilities (although these may not be in North America.

Seven scenarios were developed, consisting of different types and combinations of technology that are considered appropriate for OC, as follows:

- **Scenario 1**: MRF recovering recyclables and organics, with the recovered organics to be bulked and transferred outside of OC for further processing at a wet anaerobic digestion (AD) plant, and the non-recyclable material to be disposed to landfill;

- **Scenario 2**: MRF recovering recyclables and producing refuse derived fuel (RDF) for thermal treatment outside of OC;

- **Scenario 3**: Mechanical Biological Treatment (MBT), i.e. Scenario 1 above plus a wet AD processing stage in OC;

- **Scenario 4**: MBT, i.e. Scenario 1 above plus a dry AD processing stage in OC;

- **Scenario 5**: MBT, i.e. Scenario 1 above plus an organics composting stage in OC;

- **Scenario 6**: Basic MRF to recovering inert construction and demolition material, and producing RDF for thermal treatment outside of OC; and

- **Scenario 7**: MRF recovering recyclables and producing RDF for gasification at a new facility in OC.

OC provided SLR with a template for the Multi-Criteria Assessment (MCA) tool to assist with the review and evaluation of the seven Scenarios. The MCA considers the sustainability of alternative options or actions in consideration of the goals and objectives of the Future Oxford Community Sustainability Plan. Four categories of evaluation criteria are in the MCA tool: Community, Economy, Environment, and Implementation.

The criteria in the MCA were adapted to make the tool relevant to assessing the technology scenarios. The criteria were weighted to ensure a balanced assessment between the scenarios while ensuring that the criteria of greatest importance to OC have a greater bearing on the final outcome.

The MCA assessment resulted in Scenarios 3, 2, and 4 being ranked 1st, 2nd, and 3rd, respectively.

3.2 Task 2: Case Studies of Implemented Technologies

Case study information was compiled for Scenarios 2, 3, and 4 as follows:

Scenario 2: FCC Environment, Wrexham UK, and Neath Port Talbot Recycling Ltd, Swansea UK;

Scenario 3: Biffa, West Sussex UK, and Waste Serv Malta, Sant'Antnin Malta; and

Scenario 4: Western Isles Council, Scotland UK, and Tri-Municipal Region, Alberta Canada.

A process description and operational comments were provided for each case history. It is noted that the Tri-Municipal Region example is still in the planning stage, and thus no operational commentary was possible.

A series of 'lessons learned' were derived from the case histories, as follows:

- It is important to characterise the waste stream accurately to serve as the facility design basis. An unexpected waste stream composition will lead to a poorly specified and designed facility.

- Consideration should be given to future potential changes in the waste streams – for example due to future revision of collection programs. It is recommended that facilities are future-proofed as far as reasonably possible to offer maximum flexibility.

- An awareness of the general direction of federal/provincial level legislation relating to waste treatment is also valuable as future changes to these may influence the process inputs or target outputs. This is also an element of future-proofing the facility.

- A competent Technical Advisor or Owner's Engineer should be appointed to represent the public sector organization, unless sufficient expertise resides in-house. Failure to carefully evaluate contractor's proposals with the appropriate technical expertise may also lead to a poorly specified facility.

3.3 Task 3: Review of New and Emerging Technologies

A summary was compiled of trends that SLR is seeing in the waste treatment technology industry. These include the following improvements:

- the speed and accuracy of methods used to segregate recyclable plastics in MRFs, such as near infra red detectors and air knives;
- options for management of air pollution control residues, including using fly ash using it in the production of an aggregate material which stabilizes and locks-up heavy metals and other contaminants; and
- increased efficiency of the AD digestion process and upgrading biogas to biomethane.

Another emerging practise is to use existing waste water treatment plant facilities to treat the organic fraction of MSW. Two case histories were presented and evaluated: the GENeco WWTP in Avonmouth, Bristol UK, and, the Fielding WWTP, Manawatu District Council, New Zealand.

An important aspect for any AD plant is where and how the digestate will be utilised. As a rule of thumb, for every 100 tonnes of input about 75-80 tonnes of digestate is produced. Key to the successful utilization of digestate is the regulations surrounding its application to land:

- In the EU:
  - digestate derived from source separated organics (household and post production) can be applied to land as a fertilizer and soil conditioner if it is processed appropriately by being pasteurised;
  - digestate derived from residual MSW organics cannot be applied to agricultural land and is termed ‘compost like output’ (CLO) that can be only used for landfill restoration or the remediation of contaminated land, or otherwise sent to a landfill for disposal;
  - mixing of non-source segregated organics with agricultural wastes and/or biosolids in an AD plant results in the digestate being deemed a CLO.

- In Canada:
  - regulations differ from that in the UK/EU. The *Compost Guidelines* generally follow similar lines to UK/EU regulations but with the important distinction that the pasteurisation of certain food wastes is not required;
  - the Guidelines enable composting of a broad range of materials and provide guidance on grading compost based on quality standards for metals, pathogens, foreign matter and maturity;
  - biosolids and residual MSW food waste can be mixed and used as compost (with restrictions), subject to meeting various metals content per the Guidelines, as well as sodium loading per the *Nutrient Act*.

While the regulations provide guidance, they are not explicit with regard to compost created from AD digestate or in respect of the acceptability of biological contaminants, and it is recommended that OC directly consult the MOECC to clarify requirements.

3.4 Task 4: Relationship of EPR and Resource Recovery with Current Waste Stream

The research carried out for Task 4 on waste diversion policies and program options was based on three key recent pieces of waste and environmental legislation, and their pending regulations:

- The Waste Free Ontario Act;
- the Strategy for a Waste Free Ontario; and
- the Ontario Climate Change Action Plan.

Five major action areas were identified to support Oxford County and the province of Ontario's move towards a zero waste future:

- transitioning existing waste diversion programs to a new producer responsibility framework;
- amend the 3 Rs regulations to increase resource recovery from all sources (including ICI);
- food and organics diversions actions;
- designating new materials for diversion; and
- implementing disposal bans to support these efforts.

Twelve specific "zero waste" actions are recommended for consideration by Oxford County. The top priority measures include:

- Oxford county should be actively engaged in the transition and expansion of existing and new extended producer responsibility programs for recyclable materials (in collaboration with other smaller, rural municipalities and with the Association of Ontario Municipalities);

- Oxford County needs to both be engaged in the development of the province's food and organics action plan and begin to implement its own food and organic waste reduction programs;

- The County should provide encouragement and assistance (especially to small and medium sized businesses) to help them reduce the amount of their waste sent to landfill;

- Oxford County facilities should serve as a model of best practice zero waste diversion measures; and

- The County should explore ways to improve the performance of recyclables and organics diversion from multi-family households.

3.5 Task 5: Economic Potential of Full Resource Recovery

Scenarios 3 and 2 were ranked 1st and 2nd, respectively, on the basis of the MCA analysis carried out in Task 1. In Task 5, high-level estimates were made of the potential quantity of materials produced by the two scenarios and the subsequent revenues and avoided costs, to allow a high-level economic comparison of the two scenarios.

The economic analysis was developed based on:

- the estimated waste composition and quantity from Task 1;
- outline CAPEX and OPEX costs assumed on the basis of typical costs for similar sized facilities (i.e.handling 20kta-30tpa waste);
- the facility would be developed on OC-owned lands;
- revenue streams from recovered materials, power and heat sales, and avoided landfill costs were included;
- various technical and financial assumptions.

Cost elements that were not included in the analysis were those relating to project approvals and permitting, design and procurement, and financing.

The economics of Scenario 2 (20ktpa MRF plant producing recyclables and RDF for thermal treatment outside OC) were estimated as follows

- CAPEX estimated as **CAN $6.6M - $6.9M**;
- OPEX estimated on the order of **$26 - $31/te**;
- Potential annual revenue of **$0.6M.**

The economics of Scenario 3 (20ktpa MBT plant using a wet AD to process generating electricity and hot water) were estimated as follows:

- CAPEX estimated as **CAN $7.7M - $9M**;
- OPEX estimated on the order of **$64 – $79/te**;
- Potential annual revenue of **$1.1M.**

A simple payback calculation based on the initial high level assessment suggests the following:

- Scenario 2: estimated OPEX $26 - $31/te and annual revenue of $0.598M gives a net income of **$(-)22k to $78k**.

- Scenario 3: estimated OPEX of $64 – $79/te and annual revenue of $1.104M gives a net income of **$(-)176k to $(-)476k**.

On this basis only Scenario 2 could provide a small positive net income and results in a simple payback period of approx. 80 years, which is clearly unacceptable financially. It is clear that the simple payback assessment is very sensitive to the CAPEX/OPEX and revenue assumptions and that modest changes in these values could have a significant impact on the final results. A more detailed assessment of the top two potential technology options and associated costs/revenues is needed to obtain a more accurate result.

It is important to use the high-level economic analysis primarily as an indicator of the potential relative difference between Scenarios 2 and 3, and not as absolute ‘project costs’.

The implementation of a waste treatment facility along the lines of those considered in this study would likely include the following elements:

- Conceptual design studies to refine facility elements, size, and costs.

- Integration of the facility into OC's waste management system now and in the future.
- Stakeholder consultation.
- Business case preparation, including consideration of financing and procurement processes.
- Securing of provincial and regulatory approvals.
- Procurement, construction, and commissioning.