SLR Consulting (Canada) Ltd.
300 Town Centre Blvd., Suite 200
Markham, ON L3R 5Z6

Tel: 905-415-7248
Fax: 905-415-1019

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 5: ECONOMIC POTENTIAL OF FULL RESOURCE RECOVERY**		

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 5 (TM5)** which summarizes considerations for the economic potential of full resource recovery. TM5 sets out the estimated range of possible revenues from the *two highest scoring* MCA technology options:

- Scenario 2 (MRF producing recyclables, and RDF for thermal treatment outside OC); and
- Scenario 3 (MBT i.e. Scenario 1 plus a wet AD organic processing stage in OC).

Scenarios 3 and 2 were ranked 1st and 2nd, respectively, on the basis of the MCA analysis presented in TM1C.

The remainder of TM5 presents high level estimates of the potential quantity of materials produced by the two scenarios and the subsequent revenues and avoided costs, to allow a high-level economic assessment of the two scenarios.

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
kWh/te	Kilowatt hours per tonne equivalent
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
MWe	Megawatt equivalents
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
te	Tonnes equivalent
tph	Tonnes per hour
US	United States
UK	United Kingdom
WWTP	Waste water treatment plant

3.0 SCOPE OF ECONOMIC ANALYSIS AND ASSUMPTIONS

3.1 Analysis Methodology

The economic analysis was developed according to the steps outlined below.

a. Waste composition and quantity were estimated based on work carried out in Task 1 and as documented in **TM1A**.

b. Outline CAPEX and OPEX costs were assumed for Scenarios 2 and 3 on the basis of the following:
   i. Zero land acquisition cost (e.g. assumed facility would be developed on lands owned by OC); and
   ii. Typical CAPEX/OPEX costs for similar sized facilities (i.e.handling 20kta-30tpa waste), were derived from a combination of published data and SLR experience, adjusted for currency exchange. For estimating purposes the plant was based on:
      - 10tph throughput;
      - operating on a single shift basis;
      - housed in an 80m x 40m x10m building;
      - eight operational staff employed.

c. Project approvals, permitting costs and financial costs were excluded at this stage based on the following rationale:
   i. Costs would be similar for both Scenarios 2 and 3; and
   ii. Permitting costs were assumed to be small relative to CAPEX and OPEX costs and were thus not estimated at this stage.

d. At this initial stage of the study, details of potential funding sources were not known and therefore potential financial costs could not be identified and thus were not included at this stage.

e. Potential revenue was considered from the following:
   i. recovered materials;
   ii. power sales;
   iii. heat sales; and
   iv. avoided landfill costs.

3.2 Specific Assumptions

The key assumptions used in the analysis are as follows:

a. Waste composition is based on 2017 survey results[4]:

Material	Composition (2017)
Non-acceptable materials	21%
Organics	31%
Glass	4%
Metals	4%
Plastics	13%
Paper Packaging	28%
Total	**100%**

b. Revenue and cost assumptions:

Revenue Type	Assumed Value	Source/Rationale
Electricity Sales	$0.08/kWh	Current pricing for electricity from York Durham Energy Centre
Hot Water Sales	$0.0081/kg	Reasoned to be similar to steam sale; rate from Peel Region Study[5]
Sale of Recyclables (prior to transport)	$120/te	Current OC average revenue per tonne
Avoided Landfill Cost	$38/te	Current OC cost per tonne for landfill operation

4 2017 Oxford County Waste Management Facility and Curbside Waste Composition Study Waste Composition Study Report. Prepared by AET Group, May 2017.

5 Peel Energy Recovery Centre Long Term Waste Disposal Study, April 2012.

c. Exchange rate assumed as CAN$ = £0.60.

d. Biogas production was assumed as an average of 100m^3/te organic feedstock, with 55% methane content. The value based on a conservative mixture of household food waste and some non-woody leaf and yard waste.

e. Gas engine generator conversion efficiency was taken as 40% of the input energy. Modern gas engines operating on biogas can achieve 42-43% conversion efficiency but at a larger output scale, typically 1MWe output. Smaller capacity gas engines are not as efficient and can be a low as 38% efficiency.

f. Efficiency of gas engine recoverable heat was assumed as 45% of the input biogas energy. The value is associated with 40% electrical conversion efficiency; the higher the electrical conversion efficiency the lower the percentage of recoverable heat.

g. Heat recovered is assumed to be as hot water at approximately 70-800 deg C. The engine exhaust heat can be recovered as low pressure steam but for a plant of this output the costs are not usually considered appropriate.

h. Parasitic electrical use for the MRF was assumed as 60kWh/te. The value of the parasitic electricity for an MRF varies with the design and plant capacity. A modest degree of electro-mechanical equipment has been assumed and the estimate of the parasitic electrical demand derived from a similar MRF reviewed by SLR.

i. Similar to the MRF above the estimated parasitic electrical load of the AD plant of 12% is based on the average value derived from a number of AD projects reviewed by SLR and assumes a typical AD plant design.

4.0 MCA SCENARIO 2

The CAPEX for a 20ktpa MRF plant producing recyclables and RDF (for thermal treatment outside OC) is estimated as **CAN $6.6M - $6.9M**.

The estimated OPEX for the plant is estimated on the order of **$26 - $31/te**.

The CAPEX and OPEX will vary depending on the complexity of the MRF plant, which in turn will impact on both the quantity and quality of the recyclates recovered.

For this initial, high level assessment, a conservative degree of plant complexity has been consumed, with a modest degree of manual sorting to enhance both a higher recovery rate and higher quality recyclate.

Based on the above assumptions the estimated revenue stream and avoided landfill costs are shown in **Table 4-1.**

Table 4-1: Potential Revenues Scenario 2

ANNUAL REVENUE	Available Quantity	CAN$
Electricity Sales (less 60kWh/te MRF parasitic load)	304,237kWh	24,339
Hot water sales	1,692,266kWh	13,538
Sale of recyclables (prior to transport) @ $120/te	1,320te	158,400
RDF price (assume avoided landfill cost) @$38/te	6,370te	242,060
Avoided landfill cost @$38/te	4,200te	159,600
Total Potential Annual Revenue		**$597,937**

5.0 MCA SCENARIO 3

The CAPEX for a 20ktpa MBT plant using a wet AD to process the approx. 7,400tpa recovered organic fraction and generating electricity and hot water at about 70 deg C, is estimated as **CAN $7.7M-$9M**.

The estimated OPEX for the plant is of the order **$64 – $79/te**.

The CAPEX and OPEX will vary depending on the complexity of the MRF plant, which in turn will impact on both the quantity and quality of the recyclates recovered.

For this initial, high level assessment, a low degree of plant complexity has been assumed, with minimal manual sorting, which enhances both a higher recovery rate and higher quality recyclate.

Based on the above assumptions the estimated revenue stream and avoided landfill costs are shown in **Table 5-1**.

Table 5-1: Potential Revenues Scenario 3

ANNUAL REVENUE	Available Quantity	CAN$
Electricity Sales (12% AD and 60kWh/te MRF parasitic load)	123,728kWh	9,898
Hot water sales (15% parasitic use)	1,438,426kWh	11,507
Sale of recyclables (prior to transport) @ $120/te	7,690te	922,800
Avoided landfill cost @$38/te	4,200te	159,600
Total Potential Annual Revenue		**$1,103,806**

6.0 CONCLUSIONS AND FURTHER CONSIDERATIONS

6.1 Conclusions

The results for the two highest scoring MCA Scenarios 2 and 3, as presented in **Sections 4** and **5** above, and these illustrate the sensitivity of the outputs to the key assumptions. Our specific conclusions are provided as follows:

Conclusion 1

Waste composition is the key parameter that determines both the quantity of organics available and the quantity of recyclates available for recovery.

Conclusion 2

The subsequent design of the MRF will impact on both the quality and quantity of recyclates recovered and available for sale, with high quality recyclates securing a higher price, especially for paper and plastics that can be easily contaminated and produce a lower value output.

Conclusion 3

Refinement of the waste composition to identify the different types of plastic (and thus the higher recyclate prices achievable) could result in some changes to the potential revenue. However this is most likely modest.

Conclusion 4

The assumed RDF price is taken as equal to the $38/te avoided landfill cost but subject to the distance needed to travel may result in a reduced price if Oxford County are liable for the transport costs.

Conclusion 5

The parasitic electrical demand for the AD plant in Scenario 3 reduces the electricity available for sale and similarly the quantity of surplus heat available for use. The heat recovered is assumed to be as hot water at approximately 70-80 deg C, which is suitable for space heating purposes.

Conclusion 6

It is possible to recover half the total engine heat from the engine exhaust as low pressure (LP) steam, with the balance recovered from the engine cooling water circuit. However the overall quantity of heat is modest and it is unlikely that recovering the exhaust heat as LP steam would be financially worthwhile.

Conclusion 7

The total quantity of recovered heat is considered to be suitable only for onsite space heating use.

Conclusion 8

A simple payback calculation based on this 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 if a more accurate result is required.

It must be noted that the assumed CAPEX and OPEX values are generalised, average values and should be viewed as being of the order +/- 20%. Together with the assumed mix of recyclates, price for recyclates, RDF price, and the avoided landfill cost, the above factors are sufficient to impact significantly on the high-level financial assessment above.

Due largely to the lower CAPEX involved, Scenario 2 would most likely have the lower simple payback period of the two technology scenarios considered.

6.2 Facility Development Considerations

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

- Selection of facility type and its main elements. This may include conceptual design studies to refine facility elements, size, and costs.

- Consideration of how such a facility would integrate with Oxford County's waste management system now and in the future. This would include identification of a planning horizon for facility implementation, changes that may be needed to waste services provided by Oxford County, and consideration of new regulations anticipated under the new Waste Free Ontario Act and related legislation.

- Consultation with the appropriate stakeholders including the public, First Nations, local businesses, and special interest groups.

- Preparation of a 'business case' for the project going forward. This would include a more detailed consideration of costs and revenues, as well as review and selection of a preferred financing and procurement process.

- Commencement of the regulatory approvals process with the MOECC.

- Obtaining relevant municipal approvals.

- Procurement, construction, and commissioning.