## 2.0 TASK 1: ASSESSMENT OF EXISTING WASTE RECOVERY TECHNOLOGIES

### 2.1 Task 1 - Stage 1: Setting the Scene

#### *2.1.1 Baseline Waste Generation*

The most recent Waste Management Strategy for Oxford County (OC) was issued in 2014 and has been provided to SLR for review[5]. The most comprehensive waste data within this document is the GAP waste flow analysis for 2010 and this has been used in conjunction with the County's latest available population projection data, to derive a figure for the waste generation per capita. The data is summarized in **Table 2-1.** As shown, in 2010 the County managed a total of 39.1kt of residential waste, equating to a generation rate of approximately 363kg per person[6]. 42.2% of this total was garbage with the remainder being comprised of a combination of source or depot-segregated organics, blue box and other recyclable materials. (In OC, organics comprise only yard, leaf and brush waste). For 2010, a diversion rate of 54.1% was achieved.

**Table 2-1:
Waste Collected and Processed in 2010**

| Material Category | | Tonnes Collected | | | Tonnes Processed | |
|---|---|---|---|---|---|---|
| | | **Curbside** | **Depot** | **Total** | **Diverted** | **Disposed*** |
| **Recyclables** | **Printed Paper & Packaging** | 7,370.44 | - | 7,370.44 | 6,927.14 | 443.30 |
| | **Wine and Spirits Containers** | - | 566.19 | 566.19 | 566.19 | - |
| **Other Recyclables** | **Textiles** | - | - | 0.00 | 3,529.32 | 863.18 |
| | **Bulky Goods** | - | - | 0.00 | | |
| | **Scrap Metal** | 34.14 | 473.71 | 507.85 | | |
| | **Dry Wall** | - | 203.67 | 203.67 | | |
| | **Wood** | - | 686.36 | 686.36 | | |
| | **Brick and Concrete** | - | 0.00 | 0.00 | | |
| | **Other C&D Recyclables** | 75.37 | 2,852.73 | 2,928.10 | | |
| | **Tires** | - | 66.52 | 66.52 | | |
| **Organics** | **Leaf and Yard Waste** | 8,275.32 | - | 8,275.32 | 8,193.01 | 82.31 |
| | **Grasscycling** | - | 372.39 | 372.39 | 372.39 | - |
| | **Backyard Composting** | - | 1,292.30 | 1,292.30 | 1,292.30 | - |
| **Other Diversion** | **MHSW** | 69.43 | 93.10 | 162.53 | 146.77 | 15.76 |
| | **WEEE** | - | 171.87 | 171.87 | 137.50 | 34.37 |
| **Garbage** | | 13,928.65 | 2,599.05 | 16,527.70 | - | 16,527.70 |
| **Total** | | 29,753.35 | 9,377.89 | 39,131.24 | 21,164.62 | 17,966.62 |

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

[6] Population in 2010 estimated to be approximately 107,860.

| Material Category | | Tonnes Collected | | | Tonnes Processed | |
|---|---|---|---|---|---|---|
| | | Curbside | Depot | Total | Diverted | Disposed* |
| | | | | Current Diversion Rate | | 54% |
| | | | | Material Disposed | | 46% |
| | | | | Recyclables Diverted | | 28% |
| | | | | Organics / Other Diverted | | 26% |

Further basic composition data are presented in the 2014 Waste Strategy and in the 2015 Waste Diversion Year End Report[7], but they do not provide the level of compositional detail presented in the 2010 GAP analysis.

It is noted that a detailed audit of OC's residual garbage composition was carried out by AET concurrently with SLR's Task 1 work. As the results of this audit were not available to SLR prior to the completion of Task 1, SLR based its projections on existing data on the assumption (in consultation with OC) that AET's 2017 work would not reveal any significant change in waste composition. AET's audit results were made available in May 2017[8], and showed that with minor exceptions, the noted assumption was confirmed as reasonable.

### *2.1.2 Forecasting Methodology*

Key factors determining future rates of generation of residential waste are:

- growth in the overall generation of residential waste due to increased population; and
- changes in rates of separation and segregation of waste materials for reuse, recycling and composting, due to changing behaviour and/or changing collection systems.

Projecting potential future behaviour change is very difficult, therefore for the purpose of this review, we have made the conservative assumption that levels of overall residential waste generation per resident in OC will remain relatively constant. Making this assumption, any increased tonnage of residential waste generated in Oxford will be driven by population growth. In projecting waste generation, population projections published in the Waste Management Strategy for 2014 are assumed. The population projections for OC equate to a compound annual growth rate of 0.5% between 2010 and 2041. We have assumed that in the absence of other guidance, the population remains static from 2041-50.

Materials separated for reuse, recycling and composting must be deducted from the total projected residential waste arising to establish the remaining quantity of residual waste (garbage and non-accepted recyclables) requiring treatment / disposal. As noted above, in 2010 Oxford County diverted 54.1% of the residential waste generated. The 2015 Waste Diversion Year End Report indicates that diversion has increased steadily to around 59% in 2015.

OC has embarked upon a programme of moving towards Zero Waste, although this does not yet have any specific targets set, against which to measure their achievement. This will include

[7] 2015 Blue Box Waste Management System Annual Report, Oxford County, March 23, 2016.

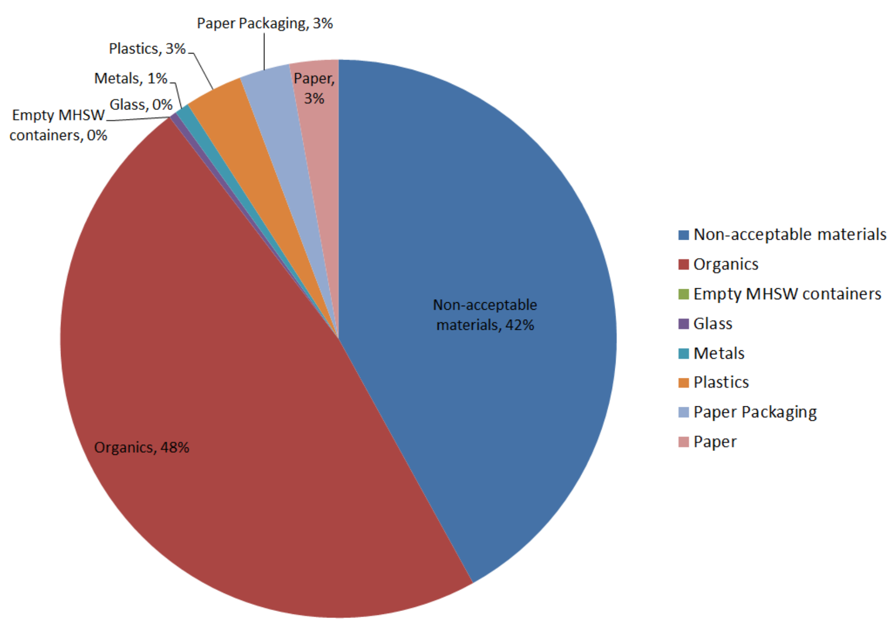
[8] 2017 Oxford County Waste Management Facility and Curbside Waste Composition Study, Waste Composition Study Report. AET Group Inc., May 5, 2017.

development of various new initiatives for the collection and processing of waste material. The potential impacts of these initiatives cannot be known at this time, but it is already clear that the County has already significantly exceeded the 2030 level of diversion recently proposed by the Ontario Ministry of Environment and Climate Change (MoECC).

In order to assess the potential shape and size of future waste and recycling we have sought other compositional information in the public domain. Although this is very limited, the CIF Ontario Single Family Curbside Audit report published in 2014 is useful. In discussion with the reports' authors, AET, it is considered that the Small Urban and Urban Regional municipalities could be reasonably comparable to OC (given that data for the two Rural Regional municipalities featured will be skewed by their relatively high proportion of seasonal dwellings in comparison to OC).

At the time the waste audits were conducted, the Urban Regional municipality had a green bin programme in place for the collection of curbside organic materials. As OC does not have such a programme in place, in drawing parallels from the waste study, it is assumed that the material presented in the green bins would otherwise be in the garbage for the case of Oxford. **Figure 2-1** presents a chart showing the derived composition, excluding blue box materials.

**Figure 2—1:**
**Indicative Waste Composition (excluding Blue Box)**




In **Figure 2-1**, "organics" are assumed to comprise yard wastes and "non-acceptable materials" are assumed to include all food wastes.

For the purpose of modelling, we have derived a high-level compositional breakdown for all waste and other materials in 2012/13, as follows:

- Dry Recyclables 40%;

- Yard organics 31%;
- Food waste 14%; and
- Non-recyclables 14%.

We have then derived a series of assumed capture rates from which overall future waste diversion figures are calculated. This has included the estimation of capture rates for 2010 and 2012/13 which would give the actual diversion rates achieved in OC, as shown in **Table 2-2**.

**Table 2-2:**
**Assumed Capture Rates**

| Material | Composition (2012/13) | Baseline (2010) | 2015 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|
| Dry recyclables | 40% | 72% | 85% | 85% | 85% | 93% | 100% |
| Yard organics | 31% | 80% | 80% | 80% | 80% | 90% | 100% |
| Food | 14% | 0% | 0% | 50% | 75% | 88% | 100% |
| Non-recyclables | 14% | 0% | 0% | 0% | 0% | 0% | 0% |
| **Total** | **100%** | | | | | | |
| **Combined diversion rate** | | **54.0%** | **59.2%** | **66.4%** | **69.9%** | **77.8%** | **85.8%** |

These assumed capture rates for each material type have then been applied to the modelled population growth estimates to derive projected tonnages of collected material streams at key dates.

In developing projections for waste generation and diversion, the following scenarios have been considered:

- Scenario A – no change; and
- Scenario B – gradual increase in capture rate of recyclables, food and yard organics to a capture rate of 100% in 2050.

### *2.1.3 Forecasted Recycling and Residual Waste*

Accounting for waste growth and recycling assumptions outlined above, **Table 2-3** illustrates the projected arising of residential waste collected in OC.

**Table 2-3:**
**Residential Waste Generation Summary**

| Scenario | | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| **A** | Total Waste Generated (tonnes) | 41,627 | 44,000 | 45,495 | 45,604 |
| | Dry recyclables diverted (tonnes) | 14,305 | 15,120 | 15,634 | 15,671 |
| | Yard organics diverted (tonnes) | 10,355 | 10,946 | 11,317 | 11,344 |
| | Food diverted (tonnes) | 0 | 0 | 0 | 0 |
| | Non-recyclables disposed (tonnes) | 16,967 | 17,934 | 18,543 | 18,588 |

| Scenario | | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| B | Total Waste Generated (tonnes) | 41,627 | 44,000 | 45,495 | 45,604 |
| | Dry recyclables diverted (tonnes) | 14,305 | 15,120 | 17,013 | 18,437 |
| | Yard organics diverted (tonnes) | 10,355 | 10,946 | 12,732 | 14,181 |
| | Food diverted (tonnes) | 2,963 | 4,699 | 5,668 | 6,493 |
| | Non-recyclables disposed (tonnes) | 14,004 | 13,236 | 10,081 | 6,493 |

As shown, with the introduction of as yet unspecified future reuse/recycling/composting initiatives, the expectation is for:

- a marginal increase in recyclables collected up to 2020, 2030 and 2050 to meet the diversion targets for both scenarios;
- an ongoing gradual increase in residential waste collected in line with population growth; and
- a significant decline in total waste going to landfill.

Over the period 2020 to 2050 for the scenarios considered:

- the overall annual residential waste (garbage and recycling combined) tonnage increases from 41.6kt, to 45.6ktpa; and
- The overall annual residential tonnage of diversion increased from 24.6ktpa to between 27.0ktpa and 39.0ktpa.

### *2.1.4 Additional Comments*

As part of the review of the data available, SLR has compared the total residential waste generation presented in the Oxford Waste Strategy Report against those presented in the Waste Diversion Year End Report for 2015. For 2011 through to 2013, the total residential waste that is reported to have been collected is considerably lower in the 2015 Year End Report than it is in the 2014 Waste Strategy Report. This difference could be explained by the fact that the C&D tonnages have not been included in the 2015 Year End Report as this material is collected at the C&D material depot and is recycled separately by the County's contractor.

It is reported that in 2015 the County diverted approximately 7,300 tonnes of C&D material from landfill. Assuming a comparable tonnage was also collected in the preceding years, this would bring the two reports to within +/-5% of each other for 2011 and 2013. The difference is greater for 2013; however, it is possible that more C&D material was collected in that particular year.

A further comparison was carried out to assess whether the figures presented in the 2015 Year End Report were aligned with the figures presented in SLR's high level projections. It is reported that approximately 43,510 tonnes of material were collected by the County in 2015 (inclusive of IC&I and C&D material). In contrast, SLR's high level forecast for the 'no change' scenario projected a tonnage of approximately 40,270 tonnes for the same period – a difference of approximately 8%. Again, this difference could be attributed to the annual variation in the generation of some material streams, such as C&D material which rather than being a function of population growth alone, may be linked to other factors such economic growth.

It should be noted that the ability of the County to capture further recyclable materials will be constrained by a number of issues including:

- The effectiveness of any communication campaign in influencing residents to improve the segregation of residential waste and recycling at source; and

- The ability of any new sorting/pre-treatment technology employed to achieve the capture rates required to enable the authority to meet its diversion targets.

Furthermore, as more recyclables are recovered from the garbage stream, the remaining proportion of recyclables will become increasingly difficult to recover.

#### *2.1.5 Initial Technology Considerations*

The projected changes in recycling targets and residual waste stream will impact on the selection of technology types and capacities, the size of facility and particularly the economic viability of MRF and WtE options. A broad description of waste treatment technologies is provided in **Appendix A**.

Based on the projections made herein and SLR's industry experience, the following initial technology class considerations are presented:

- Conventional combustion Waste to Energy (WtE) is generally not viable at throughputs of less than 40 kpta – 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.

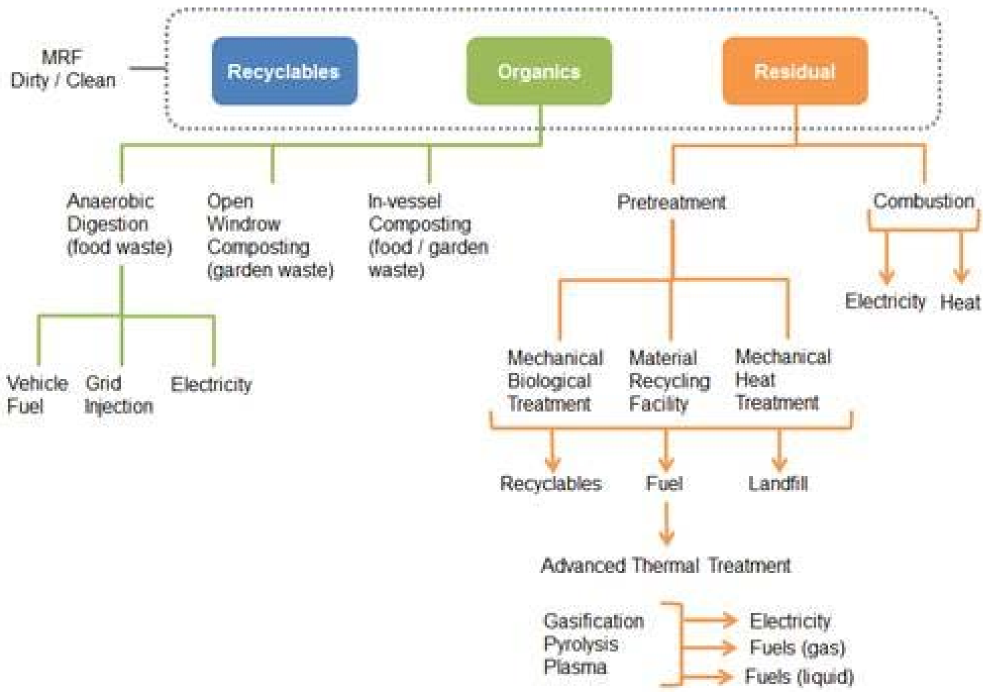
- 'Complex' MRF technologies are not generally not viable below throughputs of 15kpta to 25ktpa etc., and may therefore be viable for OC's projected waste stream, depending upon the waste generation scenario considered.

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

### 2.2 Task 1 - Stage 2: Technology Options

Waste treatment technologies comprise a wide range of largely mechanical and electrical equipment components configured to undertake particular processes, as shown in **Figure 2-2**

**Figure 2—2:**
**Waste Treatment Technology Schematic**




**Sections 2.2.1 through 2.2.4** provide a non-exhaustive list of potential providers for each of the main technology types, based on the use of mechanical, biological and thermal treatments. The identified firms have been selected on the basis of the following criteria:

- all of these providers are known or understood to have operations, manufacturing facilities or at least a registered office in North America, unless specifically stated; and
- all providers have one or more current operational reference facilities, although this/these may not be in North America.

### *2.2.1 Materials Recovery Facility (MRF)*

An MRF is a set of primarily electro/mechanical equipment used to separate the different materials in waste collected for recycling, either as materials or as a refuse derived fuel (RDF) or higher quality solid recovered fuel (SRF), for use in an energy production process. The individual equipment items are made by a number of providers but the design and construction of an MRF plant is typically undertaken by a company that manufactures a significant number of the key equipment items and undertakes to provide the MRF plant on an ‘engineer procure and construction’ i.e. EPC, contract basis. Other forms of contractual arrangement are also used and will be considered further in Task 5. **Table 2-4** provides a list of MRF technology providers.

**Table 2-4:**
**MRF Technology Providers**

| COMPANY | LOCATION |
|---|---|
| CP Group | CP Global, 6795 Calle de Linea, San Diego, CA 92154, USA |
| Eggersmann Anlagenbau | Max-Planck-Straße 15, 33428 Harsewinkel, Germany |
| Entsorga North America | ENTSORGA USA INC, 1904 Eastwood Road, Wilmington NC, 28403, USA |
| Greenstar North America | 3411 Richmond Avenue, Suite 700, Houston, TX 77046, USA |
| Machinex | Machinex Industries Inc, 2121, Olivier Street Plessisville, QC, G6L 3G9, Canada |
| Stadler | P.O. Box 910, Colfax, NC 27235, USA |
| Sutco Recycling Technik | Britanniahütte 14, 51469 Bergisch Gladbach, Germany |

### *2.2.2 Mechanical Biological Treatment (MBT)*

Similar to MRF, MBT is a hybrid process that uses a combination of electro/mechanical treatment processes to separate out the predominantly organic fraction of the waste from the recyclable material fractions, for use as a feedstock in an AD plant. In such circumstances, the AD technology provider usually takes on the main contractor role for the MBT plant. **Table 2-5** provides a list of MBT technology providers.

**Table 2-5:**
**MBT Technology Providers**

| COMPANY | LOCATION |
|---|---|
| Eggersman Anlagenbau | Max-Planck-Straße 15, 33428 Harsewinkel, Germany |
| Entsorga North America | ENTSORGA USA INC, 1904 Eastwood Road Wilmington NC, 28403, USA |
| Organic Waste Systems (OWS) | OWS Inc, 7155 Five Mile Road, Cincinnati, OH 45230, USA |
| Stadler | P.O. Box 910, Colfax, NC 27235, USA |

### *2.2.3 Biological Treatment*

#### 2.2.3.1 *Composting*

Both green wastes and food wastes can be composted. Green wastes are usually composted in static windrows but food wastes are typically composted in an 'enclosed' vessel (i.e. in-vessel composting, or IVC) or an enclosed building, to provide conditions to control vermin access, ensure sterilisation of the compost and to provide the ability to control odours. Windrow composting can also be undertaken using forced aeration (i.e. aerated static pile) and can also be undertaken within a container or a building.

**Table 2-6** provides a list of enclosed composting technology providers, as 'windrow' composting is not technology specific.

**Table 2-6:**
**Composting Technology Providers**

| COMPANY | LOCATION |
|---|---|
| Backhus Kompost-Technologie | Rothenschlatt 18, 26203 Wardenburg, Germany |
| BioSystem Solutions | 7 Ellery Lane, Westport, CT 06880, USA |
| Christiaens Group | Christiaens Group B.V, Witveldweg 104 - 106<br>5961ND Horst, The Netherlands |
| Engineered Compost Systems | 4220 24th Avenue West, Seattle, Washington 98199, USA |
| NaturTech® Composting System | Renewable Carbon Management, PO Box 7444<br>Saint Cloud, MN 56302, USA |
| Transform Compost Systems | 3911 Mt.Lehman Road, Abbotsford, BC, V4X 2N1, Canada |
| VCU Technology International Ltd | VCU Europa Ltd, 5a Harewood Yard, Harewood<br>Leeds, LS17 9LF, UK |

#### 2.2.3.2 *Anaerobic Digestion (AD)*

AD falls typically into 'wet' and 'dry' AD processes and in both technologies can be further divided into mesophilic (30-40°C) or thermophilic (50-60°C) regimes. Some manufacturers are able to provide either wet or dry AD systems. **Table 2-7** provides a list of AD technology providers.

**Table 2-7:**
**Anaerobic Digestion Technology Providers**

| COMPANY (DRY AD) | LOCATION |
|---|---|
| BEKON Energy Technologies | BEKON GmbH, Feringastrasse 9<br>85774 Unterfoehring, Germany |
| GICON Engineering North America | Representative: Main(e) International Consulting LLC<br>32 Blueberry Lane, Bremen ME 04551, USA |
| Hitachi Zosen Inova KOMPOGAS | Hitachi Zosen Inova U.S.A. LLC, 3740 Davinci Court, Suite 250, Norcross, GA 30092, USA |
| Organic Waste Systems (OWS) | OWS Inc, 7155 Five Mile Road<br>Cincinnati, OH 45230, USA |
| Viessmann Group & BIOFerm Energy Systems | Viessmann Manufacturing Company Inc, 750, McMurray Road, Waterloo, ON,  N2V 2G5, Canada |

| COMPANY (WET AD) | LOCATION |
|---|---|
| BIOFerm Energy Systems | BIOFerm TM Energy Systems, 440 Science Drive, Ste 300<br>Madison, WI 53711, USA |
| Doosan Enpure (formerly RosRoca) | 912 Chad Lane, Tampa, Florida 33619, USA |
| Eisenmann Corporation | Eisenmann Corporation, 150 E. Dartmoor Drive, Crystal Lake, IL 60014, USA |
| GICON Engineering North America | Representative: Main(e) International Consulting LLC<br>32 Blueberry Lane, Bremen ME 04551, USA |
| Organic Waste Systems | OWS Inc, 7155 Five Mile Road<br>Cincinnati, OH 45230, USA |

| COMPANY (WET AD) | LOCATION |
|---|---|
| PlanET Biogas USA Inc | PlanET Biogas Solutions Inc, 56-113 Cushman Road, St. Catharines, ON, L2M 6S9, Canada |
| Urbaser SA | 21550 Oxnard Street. 3rd floor, Woodland Hills, CA 91367, USA |

### *2.2.4 Thermal Treatment Technologies*

#### 2.2.4.1 *Combustion*

Conventional combustion forms the basis of the majority of the global incineration and Energy from Waste (EfW) processing capacity. **Table2-8** provides a list of Combustion technology providers.

**Table 2-8:**
**Combustion Technology Providers**

| COMPANY | LOCATION |
|---|---|
| B&W Volund | Babcock & Wilcox Enterprises, Inc, 13024 Ballantyne Corporate Place, Suite 700, Charlotte, NC 28277, USA |
| Doosan Lentjes | Doosan Power Systems SA (Atlanta), 1050 Crown Pointe Parkway, Suite 1200, Atlanta, GA 30339, USA |
| HZI Inova | Hitachi Zosen Inova U.S.A. LLC, 3740 Davinci Court, Suite 250, Norcross, GA 30092, USA |
| Keppel Seghers | Keppel Seghers UK Ltd, 1 Euston Square, 40 Melton Street London NW1 2FD, UK<br>Keppel Seghers Belgium NV, Hoofd 1, 2830 Willebroek Belgium |
| Martin Engineering | Martin Engineering World Headquarters, One Martin Place Neponset, IL 61345, USA |
| Steinmuller Babcock | Fabrikstraße 1, D-51643 Gummersbach, Germany |

#### 2.2.4.2 *Advanced Thermal Treatment – Pyrolysis and Gasification*

Advanced thermal treatment (ATT) has been in use in industrial processes for almost as long as combustion, but their application in waste management has until recently been relatively limited.

While some of the established combustion equipment manufacturers also offer advanced thermal process equipment, the sector is characterized by a much larger number of potential suppliers many of whom have however only progressed to pilot-scale operations. **Table 2-9** provides a list of ATT technology providers.

**Table 2-9:**
**ATT Technology Providers**

| COMPANY | LOCATION |
|---|---|
| Doosan Lentjes | Doosan Power Systems SA (Atlanta), 1050 Crown Pointe Parkway, Suite 1200, Atlanta, GA 30339, USA |

| COMPANY | LOCATION |
|---|---|
| Entech | Entech Technical Solutions Ltd, 111 Marlowes, Hamilton House, Hemel Hempstead,, Herts, HP1 1BB, UK |
| HZI Inova | Hitachi Zosen Inova U.S.A. LLC, 3740, Davinci Court, Suite 250, Norcross, GA 30092, USA |
| JFE Engineering | JFE Engineering America Inc. 301E. Ocean Blvd., Suite #1750 Long Beach, CA 90802, USA |
| Kobelco | Berliner Allee 55, 40212, Düsseldorf, Germany |
| Nippon Steel & Sumikin Engineering | NIPPON STEEL & SUMIKIN ENGINEERING USA INC. 2000, Alameda de las Pulgas, Suite 159 San Mateo, CA,94403, USA |
| Outotec | Outotec (Burlington), 1551 Corporate Drive, Burlington, Ontario L7L 6M3, Canada<br><br>Outotec (Vancouver), 955-789 West Pender Street. Suite 955, Vancouver BC, V6C 2X1, Canada |
| Steinmuller Babcock | Fabrikstraße 1, D-51643 Gummersbach, Germany |

## 2.3 Task 1 - Stage 3: Multi-Criteria Assessment

The purpose of the MCA tool developed by OC is to provide a transparent methodology for assessing the sustainability of alternative options or actions in consideration of the goals and objectives of the Future Oxford Community Sustainability Plan. For a given scenario, each of the criteria is assessed relative to that of the other potential scenarios with respect to how positive an impact it has on community sustainability. Each criterion is given a score of between 0 and 5, with zero being the worst and five being the best.

The criteria scores are also weighted to ensure a balanced assessment of the scenarios between the criteria groupings, while ensuring that the criteria of most importance to OC have a greater bearing on the final outcome.

Seven scenarios were developed, demonstrating the different types and combinations of technology that are available to OC for the treatment of garbage generated and collected within the county. The scenarios considered are 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 with the exception that organics are processed using a wet AD processing stage within OC;
- **Scenario 4**: MBT, i.e. Scenario 1 above with the exception that organics are processed using a dry AD processing stage within OC;

- **Scenario 5**: MBT, i.e. Scenario 1 above with the exception that organics are processed at a composting stage within OC;

- **Scenario 6**: Basic MRF to recover 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 within OC.

All scenarios involve at least some initial sorting of materials at a facility to be developed within the County. Scenarios 1, 2 and 6 involve second stage processing of remaining residual waste at a facility outside the County and assume that such facilities are already available with sufficient capacity to receive such materials. The remaining scenarios are based upon the development of new secondary processing capacity within the County and with any rejects from the secondary processing being landfilled at the Oxford Waste Management Facility (landfill).

### *2.3.1 Developing the MCA Tool*

The detailed evaluation of the seven scenarios included the consideration of their relative advantages and disadvantages as well as the ease with which the technologies could be rolled out in OC to meet the needs of the County. The detailed evaluation consisted of the application of criteria that fell into four broad categories – Community, Economy, Environment and Implementation. Each of these criteria is considered further in **Section 2.3.2**.

### *2.3.2 Defining the Criteria*

SLR carefully considered the range of criteria defined in the MCA tool and their appropriateness to this study. It was determined that the standard MCA provided on the Future Oxford website, referred to here on as the baseline MCA, would be of limited benefit in differentiating the various waste processing systems under consideration. As such, the criteria were adapted/interpreted in a manner to better serve the technology evaluation.

#### 2.3.2.1 *Community*

The Community-related questions do not lend themselves to differentiation of the relative merits of the identified waste processing system scenarios. All scenarios have therefore been given an equal score of zero, across the 3 Community questions, for the purpose of this exercise.

#### 2.3.2.2 *Economy*

##### 2.3.2.2.1 Q1. Improving Vibrancy of Green Economy

The extent to which each scenario results in recyclable materials remaining in OC for subsequent re-use, recovery or recycling, is used as a proxy for the improvement in the vibrancy of the OC economy. The logic for this is that export of recyclable or fuel-generating materials out of OC reduces the scope for a diverse economy and related employment opportunities.

##### 2.3.2.2.2 Q2. Enhancing Entrepreneurship Opportunities

Increasing the nature and extent of material segregation within OC increases the availability of opportunities to create new products & services relating to those materials. This approach will tend to favour MRF & MBT technologies, but may also have benefits for scenarios involving compost creation.

2.3.2.2.3 Q3. Advancing Local Food Production

This question is focussed on the relative merits of each scenario in respect of benefits to food production. Existing composting of leaf and yard waste is already supporting crop production in the County. Waste management systems which involve source-segregation (SSO) and composting of food wastes can also provide beneficial material for crop growing. However, given that OC has no current intention of implementing an SSO system, there does not appear to be any easily applicable way of differentiating the waste processing technologies under consideration. All scenarios have therefore been given an equal score of zero, for the purpose of this exercise.

2.3.2.2.4 Q4. Advancement of Green Economy

It was agreed with OC that we would seek to include consideration of the relative carbon impacts of the selected technology scenarios. While it would be possible to consider this issue under a number of the broadly defined criteria in the baseline MCA, we concluded that the green economy would be an appropriate criterion within which to examine carbon outcomes. In order to do this we considered a) the direct carbon impacts of each scenario and b) the relative quantity of material recycled resulting from each scenario. The next sections explain more detail about the basis of these assessments.

Q4 Carbon Element

In discussion with OC, carbon performance of the scenarios was selected as a proxy for advancement of the local green economy. A greenhouse gas assessment was completed for each of the scenarios to assess the carbon performance of each solution being considered. The greenhouse gas assessment provides a measure of the emissions of gases that contribute to global warming and hence, climate change. The primary gases of concern are carbon dioxide, methane and nitrous oxide; the measurement of greenhouse gas emissions, also referred to more generally as carbon emissions is units of carbon dioxide equivalents ($CO_2e$).

Climate change has become a major issue in contemporary society, and as a consequence governments and other organisations are making commitments to reduce their carbon emissions and the impacts on climate change. Waste management systems give rise to carbon emissions through a range of mechanisms, but equally sustainable management solutions offer the ability to reduce carbon emissions through utilisation of process outputs and generation of energy.

To aid with this assessment, the Greenhouse Gas Calculator for Municipal Waste[9] (GHG Calculator) has been used. The GHG Calculator was developed by SLR for use by the Greater London Authority, and facilitates the high level modelling of a range of municipal solid waste (MSW) treatment solutions while allowing the user to modify certain parameters such as waste composition and mass balances where required to reflect specific scenarios. The draft results of the detailed waste composition survey undertaken by AET, on behalf of OC, have been assumed to apply for modelling purposes (see **Appendix B-1**). While UK specific, SLR believes that the

[9] https://www.london.gov.uk/sites/default/files/glaghgcalcfinal.xls

GHG Calculator will provide a valid indication of the relative carbon performance of the seven scenarios in the context of OC.

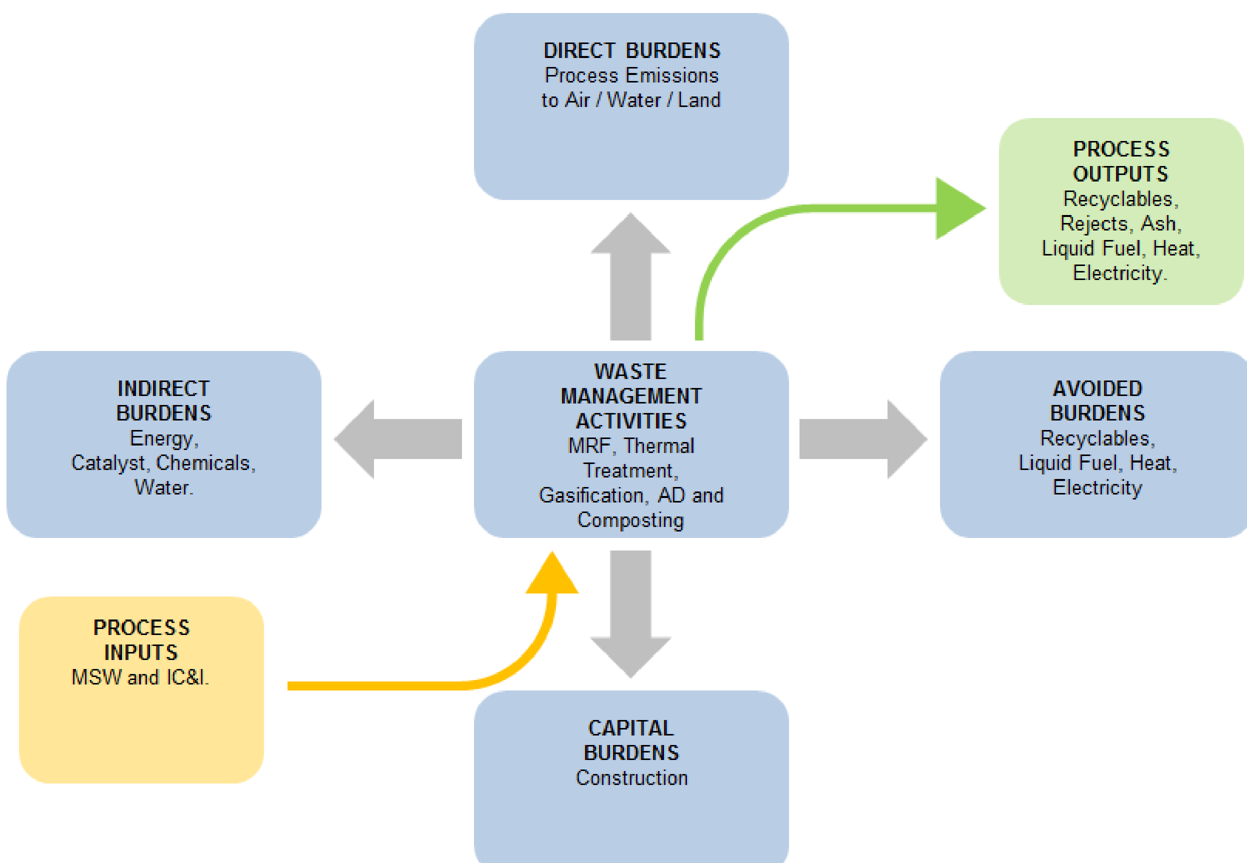
The GHG Calculator has been developed using Life Cycle Assessment (LCA) methodology. LCA considers the environmental aspects of an entire system (as defined by the system boundary) including activities that occur outside of the traditional framework of activities from the point of waste delivery through to final disposal.

An LCA considers not only the direct impacts of a given waste management process on the environment, but also takes account of:

- Capital burdens associated with the construction of infrastructure;
- Direct burdens associated with waste management processes (e.g. direct process emissions to air);
- Indirect burdens associated with supplying raw materials and energy to the system; and
- Avoided burdens (also referred to as environmental benefits) associated with the recovery of materials and energy and subsequent diversion of waste flows from conventional sources.

The concept of direct, indirect and avoided burdens is illustrated in **Figure 2-3**.

**Figure 2—3:**
**Life Cycle Assessment Concept**



The greenhouse gas assessment takes into consideration the various stages in the management of municipal waste – namely pre-treatment (MRF), AD or composting of organics, thermal treatment or gasification of RDF to produce electricity and disposal of process residues in landfill.

It should however be noted that the GHG Calculator is in practice relatively basic. For example, while the user is able to model the treatment of organics by AD, the model is unable to differentiate between wet and dry AD. Likewise with composting, the model is unable to differentiate between open windrow and in-vessel composting. From a carbon performance perspective, while there are some apparent limitations with the use of the GHG Calculator, SLR believes that its use is appropriate because:

a) Other criteria in the MCA will help to expose some differences between the scenarios where they exist, and

b) The GHG Calculator is a recognized tool, which has been used in decision making for a number of years.

Another point worthy of consideration is that the majority of scenarios (i.e. those with AD, gasification or thermal treatment) generate electricity which in turn offsets electricity from the grid. The actual benefit achieved will ultimately be dependent on a number of factors including:

- Mass flows & material recovery through the MRF (i.e. actual mass balance);
- The electrical efficiency of the AD, gasification or thermal treatment plant; and
- Energy mix assumptions (see **Appendix B-2**).

The summary results of the greenhouse gas assessment for each of the scenarios considered are presented in **Table 2-10.** The numbers given against each Scenario are an aggregation of all of the carbon impacts from the various stages of the specific process mix described, based upon the calculated impact of a unit of waste feedstock.

**Table 2-10:**
**Greenhouse Gas Assessment Summary**

| Scenario No. | Details | Carbon Impacts ($tCO_2e$ per tonne of waste managed) |
|---|---|---|
| 1 | MRF producing recyclables, and organics for processing outside OC | 0.044 |
| 2 | MRF producing recyclables, and RDF for thermal treatment outside OC | 0.045 |
| 3 | MBT, i.e. Scenario 1 above plus a wet AD organic processing stage in OC | 0.057 |
| 4 | MBT, i.e. 1 above plus a dry AD organic processing stage in OC | 0.057 |
| 5 | MBT, i.e. 1 above plus a composting organic processing stage in OC | 0.160 |
| 6 | MRF extracting inert material, and combustion of RDF at a thermal treatment facility outside OC | 0.180 |
| 7 | MRF producing recyclables and RDF for gasification at a new facility in OC | 0.045 |

Q4 Recycling Element

Further interrogation of the GHG Calculator, in particular the mass balances, enables the user to quantify the process outputs for a given technology scenario or combination of treatment technologies. For a given treatment process, the mass balance is able to present approximations for the following output streams where relevant:

- Recycling;
- Compost-like output (CLO) and/or digestate;
- RDF or solid recovered fuel (SRF);
- Bottom ash and air pollution control residues (APCr);
- Biogas output; and
- General process losses such as moisture loss, vaporisation of material, etc.

Recycling performance is important in helping to score this criterion. In this context recycling is assumed to comprise dry recyclates (paper, card, plastics, metals) recovered from the MRF or MBT process, as well as compost-like output (CLO), digestate and RDF, as all these materials are solid outputs that can be put to beneficial use. The results of the assessment of the recycling performance of each of the scenarios considered are presented in **Table 2-11**.

**Table 2-11:**
**Summary of Recycling Performance**

| Scenario No. | Scenario description | Material Recycled (tonnes of recyclates per tonne of waste managed)[10] |
|---|---|---|
| 1 | MRF producing recyclables, and organics for processing outside OC | 0.149 |
| 2 | MRF producing recyclables, and RDF for thermal treatment outside OC | 0.303 |
| 3 | MBT, i.e. Scenario 1 above plus a wet AD organic processing stage in OC | 0.110 |
| 4 | MBT, i.e. 1 above plus a dry AD organic processing stage in OC | 0.110 |
| 5 | MBT, i.e. 1 above plus a composting organic processing stage in OC | 0.119 |
| 6 | MRF extracting inert material, and combustion of RDF at a thermal treatment facility outside OC | 0.244 |
| 7 | MRF producing recyclables and RDF for gasification at a new facility in OC | 0.303 |

The scores from the carbon performance and the recycling performance were then combined to give an overall score for this criterion.

#### 2.3.2.3 *Environment*

##### 2.3.2.3.1 <u>Q1. Improve Oxford's Ecological Systems</u>

The introduction of improved waste diversion will have an overall benefit on the environment. However, each of the seven waste management technology scenarios may have some moderate impact on the environment in terms of emissions to air, water and land, with the potential extent of the impact(s) increasing with the complexity of the technology option. The effect of any emissions on the ecological system will depend on both the proximity and sensitivity of the adjacent ecosystem.

##### 2.3.2.3.2 <u>Q2. Reduce Fossil Fuel Use</u>

Each scenario uses electricity to process the feedstock but scenarios that subsequently generate electricity on site will displace electricity generated from fossil fuels. Thus in terms of the Oxford County environment, Scenarios 1, 2, 5 and 6 will be net users of fossil fuel generated electricity

[10] Inclusive of dry recyclates, compost-like output and/or digestate

and scenarios 3, 4 and 7 will be net producers of electricity generated using a non-fossil or renewable fuel source.

In addition, scenarios 3, 4 and 7 produce (surplus) heat as hot water or low pressure steam that is suitable for use on/off-site for heating buildings, thereby displacing fossil fuel-derived sources of heat. Options that are net producers of electricity and heat will therefore reduce overall fossil fuel use in Oxford County.

While all the technology scenarios will produce varying levels of $CO_2$, the $CO_2$ emissions per tonne of feedstock processed will be a combination of biogenic and non-biogenic in origin, depending on whether the scenario is a net user or producer of electricity. Biogenic derived $CO_2$ is considered overall less damaging than non-biogenic derived $CO_2$, as the subsequent production of the biogenic source of $CO_2$ involves the uptake of $CO_2$, providing overall a 'zero $CO_2$' balance, albeit with a time delay.

Options that generate electricity using gas engines or combustion based technologies i.e. scenarios 3, 4 and 7, will also produce emissions to air of other gases, including $NO_X$ and $SO_X$ and small amounts of other gases, with the quantities depending on the specific technology used. Depending on the location of the electricity generated from fossil fuel the impact of the emissions to air on the local Oxford County environment will vary accordingly.

2.3.2.3.3 Q3. Reduction of Solid Waste Disposal

To varying degrees, each technology scenario will reduce the demand for solid waste disposal in Oxford County as the primary purpose of introducing waste processing is to increase diversion of solid waste from landfill. For the purpose of this assignment, this criterion is based upon a subjective assessment of the relative diversion of waste from landfill, for each technology scenario.

2.3.2.3.4 Q4. Protection of Water

Potential emissions to water for all scenarios are limited, as the process technologies are essentially 'contained' units, with any liquids produced either collected for re-use or treated for subsequent discharge to water under the appropriate regulatory regime. Operations involving treatment of organic waste have greater risk of creating pollution of surface waters and of these, composting would typically present slightly more risk than AD, as the latter has liquids contained within purpose built tanks and pipework.

#### 2.3.2.4 *Implementation*

In order to provide good differentiation of the merits/disbenefits of each waste processing technology mix, SLR has divided Q1 in the baseline MCA into two parts and added a further three new directly relevant questions. Q1 regarding costs has now been split to address CAPEX costs in Q1 and OPEX costs in Q2. This refinement is needed because there is no direct relationship between the two parameters, i.e. a costly mix of technical solutions may have relatively modest operation and maintenance costs and vice versa.

Assessment of the six criteria, in terms of their implementation, is based on a combination of published data and SLR's experience of evaluating and implementing each technology option.

#### 2.3.2.4.1 Q1. Capital Costs

While a substantial amount of data is available on the capital cost of plants, both the quantity and quality of the data varies significantly with the technology. Thus a significant quantity of cost data for MRFs and wet AD plants are available, while for dry AD and gasification plants there are significantly less cost data available. In addition, the plant location and site specific aspects such as proximity to utility connections, ground conditions for construction works and local planning requirements that could lead to constraints on building heights and plant layout etc., will impact on the final capital cost of a specific facility.

#### 2.3.2.4.2 Q2. Operating Costs

Data on operating costs is generally available but not always in a form that shows the cost breakdown i.e. operation and maintenance (O&M), professional fees, rates/utilities, financial costs etc. Many stated operating costs exclude financial costs and essentially are only O&M costs, which while useful create uncertainties when seeking to assess different projects on a 'like for like' comparison basis.

#### 2.3.2.4.3 Q3. Timeframe to Plan & Implement

The overall time taken to implement a facility, post-achieving financial close, is dependent primarily on aspects such as regulatory matters, determining the contractual details, site investigation results, detailed design, delivery of long lead time items and the weather. The time required for undertaking the engineering elements is generally similar worldwide, as are the site investigation and detailed design phases. Specific aspects that can cause delays are regulatory matters and the weather, especially the latter if the planned start date is delayed due to contractual or regulatory issues.

For the purpose of this assignment, SLR has used its practical experience of developing each technology system to develop a relative score from each of the following time-influencing factors:

- Typical average time to carry out feasibility and develop a conceptual design;
- Typical average time to achieve the necessary regulatory approvals; and
- Typical average time to construct and commission the facility.

#### 2.3.2.4.4 Q4. Technology Readiness

An understanding of the level of readiness of each technology for commercial operation in North America is an important element in determining its suitability for implementation by OC. Our assessment was based on a combination of published information in trade magazines, information available on a selection of the technology provider's websites and our professional judgement.

#### 2.3.2.4.5 Q5. Capability of Modular Implementation

The capability of a technology to be implemented in modular form was a particular concern of OC and our assessment was based on technical information available from the equipment providers. Facilities such as MRFs are most easily scalable as modular units, including small-scale modules. Similarly the front-end preparation equipment for most other technology options is available as modular units to varying degrees.

While all technology options are 'modular' it is the scale of the module that varies. Thus wet/dry AD plants are modular by nature but the size of the 'module' i.e. digesters, tends traditionally to be relatively large, in the order of say 30-50% of the total plant capacity. There is no technical reason for not having a smaller digester but the cost effectiveness becomes the issue.

Gasification and combustion facilities can similarly be considered 'modular' but the modules are usually of the order 5-10tph for gasification plants and+45-60ktpa for combustion plants using RDF due to the cost effectiveness of installing an additional 'module' and the associated cost of upgrading the pollution control equipment etc.

2.3.2.4.6 Q6. Extent of Amenity Impacts

The extent of potential amenity impacts such as noise, dust, odours etc. produced by a technology is not directly addressed by the criteria discussed above under the Environment grouping and such impacts vary widely. This is therefore the basis for introducing this additional criterion.

With the exception of the digesters in a wet AD plant, the other technology options are usually contained wholly within a building, which if appropriately designed and operated, should mitigate any issues associated with noise, dust, odours etc. One key factor influencing the effectiveness of any mitigation measure is the location of the plant and its proximity relative to any sensitive receptors, which is a site specific issue.

The visual impacts of different technologies can also be quite significant, typically with a MRF in an industrial building being the least intrusive, followed by the tanks serving AD units and with chimney stacks of thermal treatment facilities being the most intrusive. However, stacks for conventional incineration plants are usually required to be significantly taller than for plants based on gasification/pyrolysis technologies, and buildings housing the latter are normally smaller than for an EfW plant.

### *2.3.3 Weightings*

Changing the weightings of criteria either within or between the criteria groupings does have the potential to change the outcome of the evaluation process. In discussion with OC, we felt that it would be important to maintain the balance of weightings in the baseline MCA Tool when applied to the four defined criteria groupings (i.e Community, Economy, Environment and Implementation). Thus, although the range of specific issues to be considered under Implementation had been expanded and a number of other criteria had been identified as being neutral in respect of differentiating waste technologies, the overall balance of 25% of the score applying to each criteria grouping was retained.

Following the principles in the baseline MCA Tool, and in discussion with OC, weightings were distributed equally across all of the expanded range of Implementation criteria.

Options evaluation through MCA in respect of multiple scenarios can be enhanced by more detailed consideration of the relative distribution of weightings between criteria. However, this can be quite time consuming, adding cost, and it can often be difficult to achieve a consensus amongst the stakeholder group being consulted. In our view, the even distribution of weightings is appropriate at this stage of the evaluation process and it is doubtful whether much additional benefit could be gained from a greater focus on this issue.

### *2.3.4 Scoring*

**Sections 2.3.1 through 2.3.3** set out the key factors that will impact on each technology scenario under the headings of *Economy, Environment* and *Implementation* and highlights the assessment basis that would be used for subsequently scoring a technology scenario for the questions under each of those headings.

The basis of the scoring assessment is founded on a combination of factual technical data and professional judgement, varying between the specific criteria. Thus, scoring of the *Environment* criterion is based more on professional judgement than purely technical data, as much will depend on the nature of the specific environmental ecosystem. In contrast scoring of the *Implementation* criterion is mostly based on factual technical data, with some professional judgement used for questions 3 and 6.

As discussed above, no scores have been given against the *Community* evaluation criteria or Q3 of the *Economy* evaluation criteria, as they are focussed on general issues which are not easily applicable to the differentiation of waste processing technologies.

### *2.3.5 Results*

The results of the MCA process, using the adjusted criteria and weightings described above, are set out in **Table 2-12**.

The scorings for each Scenario/Criterion are a combination of calculated objective scores for some criteria and more subjective scores, based upon professional judgement, for other criteria. Final scores are the outcome of the relative weighting applied to each criterion as determined largely by the County's baseline MCA, supplemented where appropriate by SLR's refinement of these weightings where new or modified criteria were introduced to enhance the applicability of the MCA process to the technology evaluation.

**Table 2-12:**
**Summary of Multi-Criteria Assessment Scores**

| | Weighted Score for Scenario | | | | | | |
|---|---|---|---|---|---|---|---|
| Evaluation Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Community | | | | | | | |
| 1. Will the action lead to an Oxford that is accessible for all citizens? | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. Will the action improve its citizenry's access to information and/or equity? | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Will the action advance Oxford's creative arts, culture, or recreation? | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Economy | | | | | | | |
| 1. Will the action improve the vibrancy of the Oxford Economy? | 10 | 10 | 25 | 25 | 25 | 5 | 20 |
| 2. Will the action enhance entrepreneurship opportunities in Oxford? | 10 | 10 | 25 | 25 | 20 | 5 | 15 |
| 3. Will the action advance local food production? | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4. Will the action advance Oxford's green economy? | 20 | 25 | 15 | 15 | 7.5 | 12.5 | 25 |
| Environment | | | | | | | |
| 1. Will the action improve Oxford's ecological systems? | 17.5 | 12.5 | 20 | 20 | 12.5 | 10 | 12.5 |
| 2. Will the action reduce fossil fuel use in Oxford? | 5 | 15 | 5 | 5 | 0 | 15 | 25 |
| 3. Will the action reduce solid waste disposal demand in Oxford? | 5 | 25 | 5 | 5 | 5 | 25 | 25 |
| 4. Will the action protect Oxford's water? | 25 | 5 | 25 | 25 | 25 | 5 | 10 |
| Implementation | | | | | | | |
| 1. What is the typical average amortised Capital Cost to implement the action? | 16.7 | 13.3 | 13.3 | 10 | 6.7 | 16.7 | 3.3 |
| 2. What are the typical average Operating Costs of implementing the action? | 16.7 | 16.7 | 13.3 | 10 | 16.7 | 10 | 6.7 |
| 3. How long will it take to plan and implement the action? | 13.3 | 13.3 | 10 | 10 | 13.3 | 16.7 | 6.7 |
| 4. What is the level of technology readiness in N. America | 16.7 | 16.7 | 16.7 | 13.3 | 13.3 | 16.7 | 10 |
| 5. To what extent is the technology capable of being implemented in modular format | 13.3 | 13.3 | 10 | 10 | 10 | 13.3 | 10 |
| 6. What is the extent of amenity impacts (noise, dust, odours) from the technology | 16.7 | 16.7 | 13.3 | 13.3 | 10 | 13.3 | 10 |
| ΣWEIGHTED CRITERIA SCORES = TOTAL SCORE<br>(Score of 400 = Maximum positive impact on community sustainability) | 185.8 | 192.5 | 196.7 | 186.7 | 165 | 164.2 | 179.2 |
| RANKING | 4 | 2 | 1 | 3 | 6 | 7 | 5 |

### 2.3.6 Discussion

The results of the MCA indicate that the top three preferred scenarios, in order, are::

- **Scenario 3:** Mechanical Biological Treatment (MBT), i.e. Scenario 1 plus a wet AD processing stage in OC;
- **Scenario 2:** MRF recovering recyclables and producing refuse derived fuel (RDF) for thermal treatment outside of OC; and
- **Scenario 4:** MBT, i.e. Scenario 1 plus a dry AD processing stage in OC.

These scenarios were used to inform the selection of Case Studies considered in **Section 3** and more detailed costing for two top ranked scenarios is presented in **Section 6**.

#### 2.3.6.1 *Interpretation of Results*

The separation between the lowest and highest ranked scenarios represents only 8% of the potential total points available. This indicates that the range of performance of the scenarios under consideration is relatively limited and, although there are significant differences between scoring for certain criteria groupings for some scenarios, there are not substantial overall differences between them.

It can also be seen that there is no one specific scenario aspect which is clearly visible in the lower or higher ranked scenarios. For example scenarios involving some treatment outside OC are ranked between $2^{nd}$ and $7^{th}$, while scenarios involving thermal treatment display the same broad range.

#### 2.3.6.2 *Limitations of the Evaluation*

There are inherent limits to the rigour with which the scenarios can be evaluated in an exercise of this nature. These can be summarized as follows:

- The evaluation of scoring for some of the criteria is based upon subjective opinion, albeit this is based upon professional judgement from a team with broad experience of the technologies under consideration;
- It is difficult to get hold of full data sets regarding costs for all technology types in directly comparable formats;
- The GHG Calculator tool uses certain assumptions about the average performance of different technologies which may not fully reflect the range of performance achieved by some technology categories; and
- As discussed below, alternative criteria weightings may give different results in terms of the rankings of the scenarios.

#### 2.3.6.3 *Influence of Weightings*

As stated herein the weightings applied to the scores have the potential to influence the outcome of the comparative evaluation. As things stand, the weighting applied to the cost-related criteria represents only 8.25% of the overall points allocation. It could be argued that this underplays the importance of financial issues in the evaluation process and in other evaluations that we have undertaken, costs generally feature more heavily, representing up to 33% of the overall points allocation. However, in accordance with OC's stated wishes, we were keen to maintain as much similarity as possible between the MCA applied to this technology comparison and the baseline MCA approach.

If considered helpful, it would be possible to test the sensitivity of the costs criteria in determining the preferred technology mix, by running the MCA using a range of different cost criteria weightings.