Green Lane Eco Park - Carbon Assessment

1. Introduction

This document presents a preliminary greenhouse gas assessment of the proposed Green Lane Eco Park. The information available is supplemented by assumptions drawn from experience of completing similar assessments.

2. Context

Waste management is one of the key issues faced by municipal authorities throughout the UK. The extensive suite of legislation limiting and controlling the options for waste disposal has been growing over recent years. A key driver in forcing regions to consider their strategic waste management systems has been the Landfill Directive, which limits the quantities of waste that can be disposed of within landfills.

One of the key purposes of the Landfill Directive is to help limit and control the volumes of methane (CH_4, a powerful greenhouse gas) that are released to the atmosphere as biodegradable wastes break down under anaerobic conditions in the landfill site.

The challenge with managing waste is therefore not only to provide reliable and effective waste management but also to limit, as far as possible, the amount of greenhouse gases arising from the disposal of the waste.

2.1 Proposed Development

A materials recycling facility (MRF), gasification-based energy from waste plant (EfW) and anaerobic digester (AD) with heat and power recovery have been proposed at Green Lane as part of the integrated waste management system in Greater Manchester. The MRF will take bulked dry recyclables from the local area, the EfW facility will take commercial and industrial waste and the AD will take a biodegradable waste fraction. Each of these processes in combination and separately have a carbon balance that improves the assumed current disposal route of landfilling of this waste.

2.1.1 Energy from Waste Facility

A gasification approach to energy from waste has a two stage waste conversion process where first the waste is heated under particular conditions to produce a syngas that can be combusted with energy recovered either in the form of electricity, heat or both. The process proposed has been set out in the project description in the Environmental Statement.

During the processing and recovery of this energy some energy the carbon in the waste is oxidised as it is combusted producing both short- and long-cycle CO_2.

2.1.2 Anaerobic Digestion Facility

Anaerobic digestion involves the biological decomposition of the biodegradable waste in air-tight containers to produce a methane rich biogas. The process requires the control of temperature, pH and moisture to optimise the gas production. Normally the gas is collected and combusted with energy recovered in the form of heat and/or electricity. Source separated waste is essential if the solid residue (the digestate) is to have value in agricultural or horticultural application as opposed to disposal in landfill sites.

The incoming waste is pumped into the air-tight digester vessel where it is held for 2-3 weeks. Inside the digester the material is mixed and biogas formed, taken off and burnt for energy (typical methane content 55-65%). The solid waste digestate is extracted, de-watered and disposed of. Control of temperature is very important in the formation of the biogas and must be maintained above 30°C for the gas production to occur at reasonable levels.

The anaerobic digestion process is assumed to process biodegradable waste fractions derived from source separated putrescible waste.

2.2 Assessment Approach

2.2.1 Relevant Terminology

Unless otherwise specified all units of greenhouse gas emissions are expressed in tonnes of carbon dioxide equivalent applying global warming potential emissions factors as set out in the Defra Greenhouse Gas Reporting Emissions Factors update 2009.

Essentially there are two types of carbon that are considered within greenhouse gas footprint assessments; the so-called biogenic (short-cycle) carbon and the non-biogenic (fossil) carbon. The biogenic sources feed the short-term carbon cycle, which assumes such carbon was taken up recently by biomass when it grew, and if such materials are grown in a sustainable manner equilibrium is reached between carbon taken up from, and that released to, the atmosphere.

Conversely, non-biogenic (fossil) sources feed the long-term carbon cycle, which prior to combustion was stored underground for a long time and hence is regarded as a net addition to the atmosphere.

Intergovernmental Panel on Climate Change (IPCC) guidelines on greenhouse gas assessment and reporting stipulate that biogenic emissions of carbon should not be included in the assessment of emissions from waste. Biogenic emissions are considered to be from biomass sources and are therefore treated, like biomass renewables, as having a zero carbon emissions factor.

2.2.2 Data Gathering

The data underpinning this assessment has been drawn from the initial designs and engineering work supplemented with robust assumptions and a transparent calculation approach. All assumptions are noted in this document.

2.2.3 Proposed Scope of Assessment

The majority of potential greenhouse gas emissions arise through the operational phase of the proposed development and therefore for the purposes of this assessment attention has been focused on the operational phase only. In assessing greenhouse gas emissions it is necessary to establish both the boundaries and the constituent elements of the assessment, which have been defined as follows (any exceptions are outlined under each option):

- **Transportation** - collection of the waste and direct delivery or delivery from transfer stations. Delivery of waste to the waste transfer station. Collection and disposal of residuals to landfill or the market, as appropriate. The delivery of waste via the public in private vehicles and the greenhouse gases emitted during the creation of the waste are considered to be outside the scope of this assessment;
- **Process emissions -** these are the greenhouse gas emissions from the processing of the waste. This may be through, for example, combustion in the energy recovery facility or through the release of methane from biodegradable wastes degrading in landfill sites. In addition this category includes any energy consumed in the process, such as auxiliary fuels, heat or electricity;
- **Avoided emissions -** these are the emissions that are avoided by the production or recovery of useful products from the waste which displace the need to consume virgin resources, thereby releasing emissions to the atmosphere. For example, heat and electricity recovered from an energy recovery facility can avoid the need to consume fossil fuels directly in the production of this energy at power stations or in the home. Another example is recycling where the materials recovered from the waste can avoid the need to consume resources in the replacement of such materials;
- **Disposal** - these are the emissions associated with the disposal of the residues from the treatment process. For example, residuals containing biodegradable waste can be disposed of in landfill where they continue to degrade and can result in the release of methane emissions.

Transportation

The transportation emissions have been assessed based on mileage estimates applying emissions factors set out by Defra in the Guidelines for Reporting Greenhouse Gas Emissions 2009.

As detailed work has not yet been completed detailing the specific locations and routes of waste from source through the system to recycling and disposal all transport emissions have been based on the same set of assumptions, as follows:

- Total movements are based on the ability of the facility(s) to process the following:
  - EfW - 80 000 tonnes commercial and industrial waste;
  - AD - 60 000 tonnes biodegradable waste;
  - MRF - 100 000 tonnes of dry recyclates.
- The following distances and vehicles have been assumed:
  - Delivery of waste - refuse collection vehicles (worst case) with an average one way journey of 25 km;
  - Removal of residues and rejects - articulated lorry with an average one way journey of 25 km;
  - Removal of recyclates - articulated lorry with an average one way journey of 50 km;

- Delivery of consumables (lime, activated carbon) - articulated lorry with an average one way journey of 50 km.

- The following emission factors and payloads have been assumed: 1178 gCO_2/km for refuse collection vehicles and 1135 gCO_2/km for larger lorries[1].

Type of Waste

This study assesses the greenhouse gas footprint of the proposed facilities, which offer the ability to process a wide variety of waste types making up the residuals of commercial and industrial waste along with municipal solid waste. The components of these potential waste streams vary considerably from area to area and it is difficult to obtain precise estimates of the current make up of the waste stream. It is even more difficult to estimate the content of the waste once the future (currently undefined) integrated waste management measures are taken into account.

The composition of the three waste streams are provided in Table 1 with the greenhouse gas characteristics assumed for this assessment is provided in Table 2.

Table 1 Assumed Composition of Waste

Materials Composition	C&I Content (%)a	Biodegradable Municipal Waste (BMW) Content (%)b	Dry Recyclates (%)b
Paper	18.0%	-	25.0%
Cardboard	0.0%	-	25.0%
Plastic film	2.0%	-	10.0%
Dense plastics	1.9%	-	10.0%
Textiles	0.6%	-	-
Miscellaneous non-combustibles (including soil)	10.1%	-	-
Glass	2.2%	-	20.0%
Putrescibles (including garden and kitchen waste)	14.1%	100.0%	-
Ferrous metal	9.1%	-	5.0%
Non-ferrous metals (cans)	5.6%	-	5.0%
Miscellaneous combustibles (including furniture, nappies and fines)	36.3%	-	-

a Source: Estimated for this study based on third party data.
b Source: Estimated for this study.

[1] Adapted from Defra 2009, Guidelines for Company Reporting on Greenhouse Gas Emissions.

Table 2 Waste Component Greenhouse Gas Properties

Materials Composition	Total Carbon Content % Dry Waste a	Fossil Carbon Fraction % of Total Carbon (%)b	Proportion of Total Carbon Degradable (%)b	Dissimilable Degradable Organic Carbon, DDOC (%)c
Paper	39.1	1	100	14
Cardboard	39.1	1	100	14
Plastic film	47.8	100	0	0
Dense plastics	54.8	100	0	0
Textiles	39.8	50	50	6
Miscellaneous non-combustibles (including soil)	n/a	n/a	n/a	n/a
Glass	n/a	n/a	0	n/a
Putrescibles (including garden and kitchen waste)	18.7	0	100	12
Ferrous metal	n/a	n/a	0	n/a
Non-ferrous metals (cans)	n/a	n/a	0	n/a
Miscellaneous combustibles (including furniture, nappies and fines)	38.4	50	75	10

a Source: Adapted from Environment Agency 1994 and Defra 2006[2]
b Source: Adapted from IPCC 2006[3]
c Source: Fraction of DOC that mineralises to methane and or carbon dioxide - Calculated.

Landfill

Landfilling involves the managed disposal of waste on land and since October 2007 all waste must be treated before it is disposed at a landfill site. In a modern landfill site the decaying wastes use up the available oxygen, creating anaerobic conditions. Under such conditions the waste continues to degrade producing landfill gas which contains roughly 60% methane (CH_4) and 40% carbon dioxide (CO_2). The CO_2 is assumed to be short-cycle as only the biogenic materials will degrade.

Greenhouse gas emissions associated with disposal have been estimated using the default greenhouse gas IPCC methodology. This method treats greenhouse gas emissions as if they have been produced instantaneously after the waste has been landfilled. This is a reasonable approximation for the purposes of this study.

[2] Environment Agency 1994, National Household Waste Analysis Project.

[3] IPCC 2006, Intergovernmental Panel on Climate Change, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste.

Key parameters are:

- Degradable organic carbon content (DOC) - fraction of waste that is biodegradable carbon;
- Dissimilable DOC - fraction of DOC that mineralises to CO_2 and or CH_4. The remainder is assumed not to degrade to gaseous products under the landfill conditions; and
- CH_4 content of the landfill gas (the rest is assumed to be carbon dioxide).

For this estimate we have assumed the following:

- 60% of landfill gas is CH_4 (the remainder is short-cycle CO_2);
- CH_4 usable capture rate at landfill is 50% of the methane after accounting for oxidisation;
- CH_4 oxidisation to CO_2 by microbes is not assumed in this assessment; and
- Landfill gas engine efficiency is 30% and only electricity is recovered.

The only assumed avoided emissions in landfill are as a result of the generation of electricity from the landfill gas via onsite landfill gas engines.

As waste can be preserved in the anaerobic conditions that exist within the structure of a landfill site, a proportion of the short-cycle CO_2 that would have been released as biodegradable waste degrades is locked up. In assessing the carbon emissions from a landfilled process we have included the avoidance of the release of such carbon as a credit to the carbon footprint. The logic for this step is that such carbon is prevented from re-entering the natural carbon cycle for at least 100 years and therefore results in a net reduction within the 100-year time horizon. This is calculated as the difference between the DOC and DDOC. This potentially provides a reduced impact of disposal of waste in landfill, however this is considered to be appropriate for this study.

3. Baseline Overview

Given there are few details of the specific waste streams being disposed through these facilities the assumptions described above have been applied. It has been assumed that all the waste is currently disposed in landfill.

As a reminder the waste capacities of each facility are assumed as follows:

- Energy from waste (EfW) - 80 000 tonnes per annum commercial and industrial waste;
- Anaerobic digestion (AD) - 60 000 tonnes per annum biodegradable waste;
- Materials recycling facility (MRF) - 100 000 tonnes per annum of dry recyclates.

The approach to this study considers three scenarios:

- Scenario 1 - EfW + AD + MRF (240kt waste);
- Scenario 2 - EfW only (80kt waste);

- Scenario 3 - AD + MRF separately (160kt waste).

The emissions estimates for the baseline assume the combinations of technologies and waste assumptions above. Annual greenhouse gas emissions from landfill disposal are estimated as follows:

- Scenario 1 - 41 330 tCO_2 per annum;
- Scenario 2 - 6670 tCO_2 per annum;
- Scenario 3 - 34 660 tCO_2 per annum.

All of the proposed solutions would reduce emissions from the assumed existing landfill disposal of these wastes. The differences relate to the differences in types and quantities of waste being disposed under each scenario. It is not intended for these results to be compared.

4. Impact Assessment

4.1 Energy from Waste Facility

Due to the process of gasification it has been necessary to derive an estimate of the carbon content of the syngas. This has been assumed to be proportional to the carbon content of the input waste with 4% assumed to remain locked in the residual ash. The carbon contents have been estimated on the basis of the assumptions provided in Table 1 and Table 2. Biogenic emissions from the process have also been estimated although these are not reported which is consistent with international guidelines.

In addition to the CO_2 emissions there is a potential for nitrous oxide (N_2O) to be emitted. In practice there are a number of factors which affect this such as the type and nitrogen content of the waste and the fraction of excess air. As a worst case assumption the IPCC default value of 50 g N_2O/t waste has been assumed for this assessment although it is noted that typical operational emissions are likely to be at least 50% of this figure.

As noted previously it is possible for energy to be recovered in the form of heat and electricity. Two alternative scenarios have been considered namely:

- Electricity only - this assumes that electricity production is maximised and no additional heat is recovered. This assumes a net heat available for recovery of 31.96 MW with a 23.9% efficiency in electricity production providing 8-10 MWe output. This represents the proposed development at the current time although the plan will be designed to recover heat if suitable customers can be identified;
- Combined Heat and Power (CHP) - this assumes both heat and electricity are recovered. With the same available heat the efficiency of electrical recovery falls to an assumed 20% with heat recovery up at 45% (overall efficiency of the CHP assumed to be 65%).

It has been assumed that the energy from waste facility is assumed to operate 7800 hours per year.

It is also possible to avoid emissions through the sale of the process residues to the construction industry, again avoiding the need to consume resources in the production of virgin materials.

For this assessment it has been assumed that all suitable residues will be transported and utilised at a facility approximately 50 km from the site.

4.2 Materials Recovery Facility

It is assumed that 5% of the input waste is unsuitable for processing and that ferrous (3% of input) and non-ferrous (2% of input) metals are recovered. The emissions saved from this recovery are defined in Table 3.

Table 3 Emissions Avoided via Materials Recovery

Materials Composition	Avoided Emissions (t CO_2/t recycled)
Paper and card	0.45
Glass	0.253
Dense plastic	1.335
Plastic film	0.31
Textile	1.34
Wood	0.0479
Non-ferrous metals	12.7
Ferrous metals	0.705

Source adapted from: Defra 2006[4]

4.3 Anaerobic Digestion Facility

The energy balance of the AD facility has been estimated as part of detailed calculations completed for this project. 10% of the input waste is assumed to be unsuitable and treated as a reject fraction exported to landfill.

There are two elements to the AD process emissions: a) emissions associated with the consumption of power to heat and drive the reaction and b) emissions associated with the leakage of biogas before combustion. The power consumption is assumed to be parasitic load i.e. the generation of heat from the biogas provides the energy required to drive the process. Given this is a modern system minimal leakage is anticipated and therefore assumed to be zero for this study.

The energy recovered is summarised as follows:

- 16 080 MWh of electricity produced per annum;
- 12 560 MWh of heat used per annum;

[4] Defra 2006, Carbon balances and energy impacts of the management of UK wastes, R&D project completed for Defra by ERM and Golder Associates.

- 12 750 MWh of heat not used per annum.

As detailed above it is assumed that the biogas generated is combusted to produce electricity and heat that offsets the need for conventional electricity generation and heat production.

5. Summary of Impacts

The impact of the proposed development on carbon emissions from waste arisings in Greater Manchester, under each scenario, is summarised in Tables 4 and 5.

Table 4 Predicted CO2 Emissions from the Proposed Development (Tonnes per Annum)

	EfW, AD and MRF	EfW Alone	AD and MRF
Process emissions	30 618	26 365	4 253
Electricity recovery	-40 035	-30 187	-9 848
Combined Heat and Power recovery	-65 894	-56 046	-9 848
Recycling/Avoided emissions	-127 496	-22 013	-105 483
Transport	2 129	610	1 518
Alternative landfill emissions with 'short cycle' carbon	41 327	6 669	34 658

Table 5 Summary of Annual CO2 Savings (Tonnes per Annum)

Method	EfW, AD and MRF	EfW Alone	AD and MRF
Electricity recovery only - with Landfill Credits	-176 111	-31 894	-144 217
Electricity recovery only - without Landfill Credits	-134 784	-25 225	-109 560
CHP recovery - with Landfill Credits	-201 970	-57 753	-144 217
CHP recovery - without Landfill Credits	-160 644	-51 084	-109 560

6. Conclusions

Based on the assumptions set out in this document the various permutations considered for this development indicate overall greenhouse gas benefits for the project.

Depending on the scenario considered the magnitude of benefits alters. There are significant assumptions required to complete this assessment at this early stage of project design and as such the specific levels of savings could alter significantly as details become more certain. Despite this it is considered likely that overall benefits from the development can be achieved.

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