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BRUNNER MOND AND E.ON ENERGY FROM WASTE UK LIMITED

Lostock Sustainable Energy Plant

Carbon Assessment

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Contents

Figures and Appendices

Tables

Appendices

Summary

S.1 Security of power supply is a major concern to energy intensive industry. With conventional fossil fuel supplies in decline operators are seeking to secure future energy supply from alternative means through fuel diversification. The proposals for the Lostock Sustainable Energy Plant (SEP) are being developed for this very purpose. The burning of fuels comprising or derived from waste within the proposed facility will reduce reliance on power and heat supplied from the existing gas-fired plant.

S.2 In addition, the extensive suite of legislation limiting and controlling the options for waste disposal has been growing over recent years. A key driver 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 (a powerful greenhouse gas) that are released to the atmosphere as biodegradable wastes break down under anaerobic conditions in landfill.

S.3 The challenge with managing waste is therefore not only to provide reliable and effective waste management but also to limit, the amount of greenhouse gases arising from the disposal of the waste.

S.4 This report provides a greenhouse gas assessment for the proposed facility which compares the greenhouse effects of the current generating capacity with that should the SEP proposals become operational. The scope of the assessment in addition to considering the onsite emissions associated with burning the gas and/or waste fuel also includes greenhouse gas emissions associated with transportation of waste and other raw materials.

S.5 The results of the assessment are summarised in the table below:

Source of carbon emissions	**CURRENT OPERATION Tonnes of CO_2 per Annum**		**PROPOSED OPERATION Tonnes of CO_2 per Annum**	
TRANSPORT				
Waste Delivery	2,419		10,875	6,950
Other vehicle movements (road)	-		1,082	
Subtotal Transport	*2,419*		*11,957*	*8,032*
PROCESS				
Combustion of Gas in CHP	730,978	714,943	582,643	567,362
Combustion of Waste in SEP	-		211,218	
Emissions from Landfill	156,312	145,320	-	
Subtotal Process	*887,290*	*860,263*	*793,861*	*778,580*
AVOIDED				
Exported electricity	(271,254)	(321,309)	(338,831)	(415,197)
Onsite electricity and steam use (excluding power plant parasitic demand)	12,665	(22,897)	16,550	(22,204)
Use of bottom ash as aggregate	-		(327)	
Recovered metals	-		(4,345)	
Subtotal Avoided	*(258,589)*	*(344,206)*	*(326,953)*	*(442,073)*
TOTAL	**631,120**	**518,476**	**474,940**	**344,539**

Notes:
Figures in brackets represent a GHG saving; figures without brackets represent a GHG emission.
The range in results arises from a number of factors:

- Consideration of a range of years data for operation of the CHP plant
- Two transport scenarios have been considered; all waste by road; and 1/3 by road and 2/3 by rail.
- Use of different factors for calculating the avoided emission associated with electricity exported to the grid (see Box 2).

S.6 The assessment results demonstrates that the proposed SEP will provide a net greenhouse gas saving compared to current operations. These savings are achieved through:

- Reducing natural gas burned within the Winnington CHP.
- Exporting electricity from the SEP to the grid.
- Avoiding the generation of methane by diverting waste away from landfill to the SEP.
- Recycling of residues from the SEP avoiding the need for processing of virgin materials (e.g. aggregates and ferrous metals).

S.7 Based on the data in Table 3.1 greenhouse gas savings between 39,000 – 287,000 tCO_2 equivalent emissions per annum are predicted.

S.8 The above savings represent the maximum difference in greenhouse emissions between current and proposed operations. If the greenhouse gas performance is compared for corresponding years, i.e. current data and associated derived proposed data for each year considered, a narrower range of savings result. The net annual greenhouse gas emissions saving as indicated in Table 3.1 and calculated on this basis range from approximately

152,000 to 174,000 tCO_2 equivalent emissions per annum. This equates to annual emissions from approximately 25,000 - 29,000 homes or 61,000 - 70,000 cars.

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1 Overview

1.1 Security of power supply is a major concern to energy intensive industry. With conventional fossil fuel supplies in decline operators are seeking to secure future energy supply from alternative means through fuel diversification. The proposals for the Lostock Sustainable Energy Plant (SEP) are being developed for this very purpose. The burning of fuels comprising or derived from waste within the proposed facility will reduce reliance on power and heat supplied from the existing gas-fired plant.

1.2 In addition, the extensive suite of legislation limiting and controlling the options for waste disposal has been growing over recent years. A key driver has been the Landfill Directive, which limits the quantities of waste that can be disposed of within landfills. One of the main purposes of the Landfill Directive is to help limit and control the volumes of methane (a powerful greenhouse gas) that are released to the atmosphere as biodegradable wastes break down under anaerobic conditions in landfill.

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

1.4 The most effective management of greenhouse gas emissions from waste disposal is to limit the quantities of waste being disposed of in the first place. However, alongside waste stream management measures the strategic waste disposal system still requires the management and disposal of the residual waste stream and outputs from intermediate waste management facilities.

1.5 The proposed SEP facility will take waste and thermally treat it, dramatically reducing the waste volume, recovering the useful embodied energy within the materials and rendering the combustion residues inert in terms of greenhouse gas releases. The proposed SEP will therefore recover embodied energy from materials which would otherwise be predominantly lost to landfill under the current site power generation scenario.

1.6 This document provides a greenhouse gas assessment of the proposed SEP. This includes an estimate of the operational carbon footprint for the facility. For reference, a comparison with the carbon footprint associated with the current power generation plant is also provided.

2 Methodology and Assumptions

Introduction

2.1 Brunner Mond UK Limited operate two chemical manufacturing sites located near Northwich, Cheshire; Lostock and Winnington. The sites operate the ammonia soda process producing a range of products including soda ash, sodium bicarbonate and calcium chloride[1]. The processes used in the manufacture of these chemicals are energy intensive and require both heat, in the form of steam, and electricity. These energy requirements are currently provided by a gas-fired CHP unit located at the Winnington site. The Winnington CHP is designed to generate up to 140 MW of electricity and up to 600 tonnes of steam per hour (approximately 480 MW thermal).

2.2 Currently 160 tonnes per hour of intermediate pressure (IP) steam (@12.5 barg and 250°C is supplied to the Lostock site. Of this total 60 tonnes per hour is used directly within the process and 100 tonnes per hour passes through an alternator generating electricity and discharging the low pressure (LP) steam (@1.5 barg and 130°C).

2.3 This assessment provides an estimate of the greenhouse gas emissions from the inclusion of the proposed Sustainable Energy Plant (SEP), whilst also providing a comparison with the existing gas-fired Combined Heat and Power (CHP) power generating plant, to contextualise the emissions.

[1] http://www.brunnermond.com/about.aspx

2.4 The proposed SEP plant will be located at the Lostock site and will have a design capacity to produce up to 60 MW of electricity and will burn up to 600,000 tonnes per annum of waste fuels depending on fuel calorific value (CV). The SEP has designed for a wide variation in incoming waste fuel CV to provide operational flexibility with higher throughputs of waste fuel required for lower CV fuel and conversely lower fuel throughputs required for higher CV waste fuel for a given thermal input. The design envelop for the facility provides for a range of waste throughputs, which equate to between 360,000 – 577,600 tpa assuming 8,000 hours operation per annum. The SEP design also includes the flexibility to operate above 100% load and the design envelop has accommodated transient operation at up to 110% load with a maximum waste throughput of 39.7 tonnes per hour; the plant will not operate continuously at this rate. For the purpose of this assessment a throughput of 560,000 tonnes per annum has been assumed; but consideration of the potential effects of a 600,000tpa has also been discussed. The plant will comprise 2 no. 100MW thermal boilers and is assumed to generate approximately 100 tonnes per hour of IP steam (@12.5 barg and 250°C) and 37MW of electricity. Steam from the SEP would be provided to the Lostock site where the majority will be reduced to LP steam via an alternator also producing electricity. Electricity from the SEP would be exported to the grid or used on site.

2.5 The steam generated by the SEP will displace a portion of the steam currently being generated by the Winnington CHP. Consequently the Winnington CHP will operate at reduced load.

Approach to the assessment

2.6 The majority of potential greenhouse gas emissions arise through the operational phase of the project and therefore for the purposes of this assessment attention has been focused on the operational phase only.

2.7 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 wastes and delivery to site alongside transportation of other key reagents/chemicals required to support the operation of the facility. In this context, it is relevant to note that Brunner Mond is able to receive deliveries by rail and road. Thus facilitating more sustainable transport alternatives.

- **Process emissions** – these are the greenhouse gas emissions from the power generation processes or from landfilling of the wastes. This may be through, for example, combustion of waste or conventional fuels in the power plant 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 or electricity. The process releases associated from preparation of the Solid Recovered Fuel (SRF) have been excluded because it is assumed that these releases would occur irrespective of the proposals. This assumption has been made on the basis that the proposed facility will create a demand for SRF and drive the need for facilities diverting unprocessed Municipal Solid Waste (MSW) away from landfill to intermediate waste management facilities which will produce SRF.

- **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 resources, thereby releasing emissions to the atmosphere. For example, heat and electricity recovered from the SEP can avoid the need to consume fossil fuels directly in the production of this energy at power stations or in the home. Producing power and heat from the onsite CHP plant achieves much higher efficiency of power generation than the combined efficiency of power from the national grid. This is due to the efficiency benefits from cogeneration of both power and heat in the onsite CHP unit. Electricity from the grid includes facilities generating electricity only. Another example is recycling where re-use of the residues (for example bottom ash as an aggregate substitute) can avoid the need to consume resources in the production of such materials.

- **Disposal** – these are the emissions associated with the disposal of the residues from the treatment process. For example, where residuals containing biodegradable waste are disposed of in landfill they continue to degrade and result in the release of methane emissions.

2.8 The assessment of both the current and proposed power generation strategy at the Lostock site includes all of the above categories.

Power Generation Options

2.9 Two options for power and heat generation have been considered:

- Existing generation: Electricity and steam supply from the gas-fired CHP plant.

- Proposed operation: Reduced electricity and steam supply from the gas-fired CHP plant and power and steam supply from the proposed SEP.

2.10 These options are discussed in turn below. All key input data for both options is provided in Appendix A.

2.11 However to aid understanding of the assessment it is important to understand the distinction between shortcycle (or biogenic) carbon sources from those which are fossil (or non-biogenic) sources. Box 1 provides an overview of these terms.

Box 1: Short-cycle (biogenic) and fossil (non-biogenic) carbon

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 the biomass when it grew, and if such materials are grown sustainably an equilibrium is reached between carbon taken up from and that released to the atmosphere with a net addition of zero[2].

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 guidelines on greenhouse gas assessment and reporting stipulate that biogenic emissions of carbon should not be included in the assessment of emissions from waste:

'Consistent with the 1996 Guidelines (IPCC,1997), only CO_2 *resulting from oxidation during incineration and open burning of carbon in waste of fossil origin (e.g. plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national* CO_2 *emissions estimate. The* CO_2 *emissions from combustion of biomass materials (e.g. paper, food, and wood waste) contained in the waste are biogenic emissions and should not be included in national total emission estimates. However, if incineration of waste is used for energy purposes, both fossil and biogenic* CO_2 *should be estimated. Only fossil* CO_2 *should be included in national emissions under Energy Sector while biogenic* CO_2 *should be reported as an information item also in the Energy Sector.'*

Biogenic emissions are considered to be from biomass sources and are therefore treated, like biomass renewables, as having a zero carbon emissions factor but have been estimated and reported as an information item.

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2 In practice there will be some energy consumed in cultivating, harvesting, transport and processing, which will give rise to emissions. These are relatively very-small. Emissions associated with land use change are assumed to be zero for sustainable sources.

Current Power Generation Strategy

2.12 The existing heat and power generation on site is supplied by a gas-fired CHP plant. This is located on the Winnington site and supplies steam and electricity to both the Brunner Mond sites at Winnington and Lostock. Electricity from the CHP is also exported to other local users with the excess exported to the grid. Operational data for the existing gas fired CHP and Brunner Mond electrical and steam consumption has been provided by E.ON CHP and Brunner Mond. This data is included within Appendix A.

2.13 Emissions associated with energy consumption to deliver natural gas from the network to the site has been excluded. For the SRF, which will be burned within the proposed SEP, it is assumed that the material is currently landfilled and an average travel distance of 30 km from source to landfill site is assumed.

2.14 <u>Process Emissions.</u> Process releases from combustion of natural gas in the existing CHP plant are based on actual data (see Appendix A).

2.15 As indicated above for the waste streams which will be burned within the proposed SEP, it is assumed that this material is currently sent to landfill. Greenhouse gas emissions are released from a landfill site over time as the waste degrades. The emissions from waste landfilled have been estimated using the default greenhouse gas IPCC methodology[3]. This method treats greenhouse gas emissions as if they have been produced instantaneously after the waste has been landfilled. This approximation is reasonable for the purposes of this study, where the main focus is on the estimation of emissions from the energy recovery plant.

2.16 Key parameters are:

- Degradable organic carbon content (DOC) – fraction of waste that is biodegradable carbon (see Table 2.2).
- 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 (see Table 2.2).
- Methane content of the landfill gas (the rest is assumed to be carbon dioxide).

2.17 For this study we have assumed the following:

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

- 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.
- Landfill gas engine efficiency is 37.5%.
- While emissions occur over a long time period assessment has been completed assuming that all emissions arise today.

2.18 Avoided emissions. Avoided emissions from the onsite power plant are also considered (to account for variations in generating efficiency compared with similar energy supplied from the grid). Avoided emissions as a result of the generation of electricity from landfill gas via onsite landfill gas engines are also accounted for. This avoids the need to generate the equivalent electricity using conventional fossil fuel generation. The emissions factors applied are described in **Box 2.**

2.19 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.

Box 2: Electricity Displaced – Greenhouse Gas Emissions Factors

Energy can be recovered in usable forms via heat or electricity. If processes result in the production of heat or electricity for export and use, this can avoid the need to take electricity from the national grid or to combust fossil fuels to produce heat.

To enable a consistent assessment of the emissions avoided through the recovery of heat it was necessary to derive emissions factors that can be applied to every unit of heat or electricity captured and used.

Electricity

Electricity has been assumed to displace electricity drawn from the national grid. As the electricity in the grid comprises coal, oil, gas, nuclear and renewable origins it is necessary to account for all these sources in the emissions factors. Data from Table 5.6 of the Digest of UK Energy Statistics 2009 (DUKES) provides the total fuel used, and electricity generated and supplied in the UK. This was used to derive the total CO_2 for the year using the emissions factors related to fuel consumption from DEFRA 2009 as outlined in the table below. Finally the total CO_2 was divided by the total electricity supplied (including Nuclear and renewables) to provide the composite emissions factor:

Fuel type	GWh fuel used	tCO_2 released	GWh Energy supplied	Proportion of total generation	tCO_2 release/MWh generated	Generation weighted emissions factor (tCO_2/MWh)
	a	b = a x EF	c	d	e = b / (c x 1000)	e x d
Coal	336,621	104,369,341	115,093	35%	0.91	0.32
Oil	13,486	3,577,836	3,038	1%	1.18	0.01
Gas	344,184	63,185,299	158,802	49%	0.40	0.19
Total		171,132,476	326,972			**0.52**

Where: EF = emissions factors coal 0.31 $kgCO_2$/kWh; fuel oil 0.265 $kgCO_2$/kWh; and gas 0.18 $kgCO_2$/kWh. Note it was assumed for the purposes of this assessment that nuclear and renewables have greenhouse gas emissions factors of zero.

An emissions factor of 0.52 $kgCO_2$/kWh electricity supplied was obtained. As a sensitivity test the long-term projected emissions factor of 0.43 $kgCO_2$/kWh was also applied. The lower emissions factor is a 'worst-case' scenario for the GHG emissions savings from the displacement of grid electricity by EfW electricity. This factor forms the basis of a conservative assessment while the higher 0.52 derived factor is based on current UK data; results of savings from electricity generation are presented as a range with upper and lower bounds based on these factors.

2.20 Disposal. It is assumed that the SEP will produce inert residues (bottom ash and APC residues) that do not result in the production of methane when disposed of at the landfill site.

Proposed Energy Generation Strategy

2.21 The proposed location for the Sustainable Energy Plant (SEP) is within the Lostock site. The SEP would have a total gross maximum electrical capacity of approximately 60 MWe and would be capable of producing up to 100 tonnes of IP steam per hour consuming approximately 560,000 tonnes of pre-treated waste derived fuel per annum (tpa). The proposed plant would improve the overall sustainability of energy use at the Brunner Mond sites, therefore resulting in a significant reduction in the use of fossil fuel.

2.22 The SEP facility utilises SRF and other processed waste fuels, reducing the bulk of the waste to an inorganic ash residue which is recycled. Biogenic carbon compounds are oxidised to short-cycle CO_2 and water vapour which are discharged to the atmosphere. Fossil carbon compounds are also oxidised, however, these form non-biogenic CO_2 and other compounds which are discharged to the atmosphere.

2.23 Transport. Transport emissions have been incorporated for deliveries of key reagents (bicarbonate from the adjacent Brunner Mond works, activated carbon and ammonia), transport of recovered materials for recycling (ferrous and non-ferrous material) and residues (bottom ash and APC residues).

2.24 As a worst case scenario, for the low scenario all waste is assumed to be transported by road, however it is intended that the treated waste fuel is sent to the proposed SEP by a combination road and rail. The expected split of road and rail is approximately one-third of the material is transported by road and two-thirds by rail, this has been assumed for the high scenario. The average journey distance assumed by road is 120 km (75 miles). For rail a wider radius has been assumed at 400 km (250 miles).

2.25 In addition, the SEP would produce bottom ash and APC residues. The bottom ash is to be reused and a transport distance of 50 km is assumed, whilst for the APC residues it is assumed that these will be disposed of at a distance of 80 km from the site. Ferrous and non-ferrous metals are recovered and transported 50 km to a recovery site.

2.26 The SEP also requires reagent supply. Activated carbon is assumed to be sourced from a supplier in the Netherlands (700 km away). Ammonia is sourced within a distance of 15 km from the site and Briskarb™ will be supplied internally from an area of the site 0.3 km away.

2.27 Emission factors for calculating the greenhouse gas emissions from the various vehicle/transport types are provided in Appendix A.

2.28 Process emissions. Process emissions arise from the combustion of the natural gas, and SRF in the existing CHP and proposed SEP respectively. Emissions reported in the balance exclude biogenic releases although these have been calculated for information purposes in line with IPPC guidelines[1].

2.29 Avoided emissions. As noted above it is possible for energy to be recovered in the form of heat and electricity. Avoided emissions for the proposed scenario have been evaluated on a similar basis to those for the existing scenario. In addition, it is assumed that ferrous metals and non-ferrous metals are recovered as follows:

- 80% of the incoming ferrous metals are recovered.
- 35% of the incoming non-ferrous metals are recovered.

2.30 Further, the reuse of the treated bottom ash as aggregate avoids the need for virgin aggregate extraction with associated energy savings. It is assumed that 100% of the treated bottom ash is reused. The emissions saved from this recovery are defined in Table 2.1.

2.31 It is also possible to avoid emissions through the sale of the combustion residues to the construction industry, again avoiding the need to consume resources in the production of virgin materials. For this assessment given that ash processing plant is incorporated it has been assumed that all suitable residues will be re-used and a transport distance of 50 km has been assumed for this material.

2.32 Disposal. It is assumed that the SEP produces inert ash that does not result in the production of methane when disposed of at the landfill site.

Table 2.1: Emissions avoided via materials recovery

Materials Composition	Unit	Avoided Emissions
Aggregate	t CO_2 / t	0.0023
Ferrous metal	t CO_2 / t	1.487
Non-ferrous metal	t CO_2 / t	9.074

Source adapted from: AEAT 2001[4], Defra 2006[5]

Type of Fuel

2.33 The proposed SEP facility will primarily burn a combination of solid recovered fuel (SRF); commercial and industrial (C&I) waste and municipal solid waste (MSW). For the purpose of this assessment it is assumed that C&I wastes will have a similar composition to that for MSW.

2.34 The basis of the assessment assumes up to 560,000 tonnes per annum of input. For the purpose of the assessment the split of waste fractions is assumed to be as follows:

- 55% SRF
- 25% MSW having undergone some pre-treatment
- 20% C&I (pre-treated similar to MSW)

[4] AEAT 2001, Waste management options and climate change, Study for European Commission Environment DG.

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

2.35 Contracts are not in place for the treated waste materials to be accepted at the facility and therefore precise details of the processes treating the wastes are not available. In order to establish the waste composition the following assumptions have been made.

- In determining the composition for the SRF fraction, it has been assumed that the SRF will have been generated from intermediate waste management facilities providing mechanical and biological treatment (MBT) of residual MSWs. The composition of the feed SRF has been taken from other similar facilities and is detailed in Table 2.2.
- The MSW and C&I waste materials is assumed to have undergone simple pre-treatment comprising size grading, recovery of dense plastic and ferrous and non-ferrous metals recovery. The resulting composition assumed for the assessment is detailed in Table 2.2.

2.36 The greenhouse gas contribution of the intermediate waste facilities has not been included within this assessment. This would include both GHG emissions associated with the processing plants energy requirements and also the GHG savings associated with the recovery of materials for recycling.

Table 2.2: Assumed Composition of SRF

Materials Composition	MSW and C&I waste composition (%)[a]	SRF Composition (%)[b]	Combined (%)	Total carbon content % dry waste [c]	Fossil carbon fraction % of total carbon (%)[d]	Proportion of total carbon degradable (%)[e]	Dissimilable Degradable Organic Carbon, DDOC (%)[e]
Paper	10.9	17.5	14.5	39.1	1	100	13.7
Cardboard	10.9	17.5	14.5	39.1	1	100	13.7
Plastic film	5.6	4.5	5.0	47.8	100	0	0
Dense plastics	2.8	8.8	6.1	54.8	100	0	0
Textiles	3.4	3.2	3.3	39.8	50	50	6
Miscellaneous non-combustibles (including soil)	2.2	0.0	1.0	n/a	n/a	n/a	n/a
Glass	6.8	0.7	3.4	n/a	n/a	0	n/a
Putrescibles (including garden and kitchen waste)	46.4	29.7	37.2	18.7	0	100	12
Ferrous metal	0.5	0.1	0.3	n/a	n/a	0	n/a
Non-ferrous metals (cans)	0.3	0.0	0.1	n/a	n/a	0	n/a
Miscellaneous combustibles (inc. furniture, nappies and fines)	10.1	18.0	14.5	38.4	50	75	10.1

- a Assumes simple treatment (size grading, dense plastic recovery and ferrous and non ferrous metals recovery)
- b From operational plant
- c Source: Adapted from Environment Agency 1994 and Defra 2006[6]
- d Source: Adapted from IPCC 2006[7]
- e Source: Calculated

[6] Environment Agency 1994, National Household Waste Analysis Project
[7] IPCC 2006, Intergovernmental Panel on Climate Change, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste.

3 Results

3.1 This section summarises the results of the analysis.

Table 3.1: Summary of results (tCO_2 equivalent)

Source of carbon emissions	CURRENT OPERATION Tonnes of CO_2 per Annum		PROPOSED OPERATION Tonnes of CO_2 per Annum	
TRANSPORT				
Waste Delivery	2,419		10,875	6,950
Other vehicle movements (road)	-		1,082	
Subtotal Transport	*2,419*		*11,957*	*8,032*
PROCESS				
Combustion of Gas in CHP	730,978	714,943	582,643	567,362
Combustion of Waste in SEP	-		211,218	
Emissions from Landfill	156,312	145,320	-	
Subtotal Process	*887,290*	*860,263*	*793,861*	*778,580*
AVOIDED				
Exported electricity	(271,254)	(321,309)	(338,831)	(415,197)
Onsite electricity and steam use (excluding power plant parasitic demand)	12,665	(22,897)	16,550	(22,204)
Use of bottom ash as aggregate	-		(327)	
Recovered metals	-		(4,345)	
Subtotal Avoided	*(258,589)*	*(344,206)*	*(326,953)*	*(442,073)*
TOTAL	**631,120**	**518,476**	**474,940**	**344,539**

Notes:
Please refer to the assumptions underpinning this analysis as described in earlier sections of this report.
The tonnes equivalent are presented as ranges to encompass the different CO_2 intensities assumed for the provision/use of electricity and heat as set out earlier in the report (see Box 2).
Figures in brackets represent a GHG saving; figures without brackets represent a GHG emission.
Biogenic releases from burning of wastes for each of the two scenarios is as follows
Current Operation 0 tCO_2 equivalent per annum (as no burning of wastes)
Proposed Operation 444,173 tCO_2 equivalent per annum

3.2 The range in results arises from a number of factors:

- Consideration of a range of years data for operation of the CHP plant (2005-2008).
- Two transport scenarios have been considered; all waste by road; and 1/3 by road and 2/3 by rail.
- Use of different factors for calculating the avoided emission associated with electricity exported to the grid (see Box 2).

3.3 Both current and proposed options give rise to net greenhouse gas emissions from the production of energy and supply to the site. This would be expected given the inclusion of fossil carbon within the fuels burned. However, considering the potential annual emissions from the current and proposed scenarios it can be seen that there is a net saving in emissions from generating energy from the proposed SEP. Based on the data in Table 3.1 greenhouse gas savings between 39,000 – 287,000 tCO_2 equivalent emissions per annum are predicted.

3.4 The above savings represent the maximum difference in greenhouse emissions between current and proposed operations. If the greenhouse gas performance is compared for corresponding years, i.e. current data and associated derived proposed data for each year considered, a narrower range of savings result. The net annual greenhouse gas emissions saving as indicated in Table 3.1 and calculated on this basis range from approximately 152,000 to 174,000 tCO_2 equivalent emissions per annum.

3.5 The expected lifetime of the facility is 25 years and this amounts to savings of between approximately 3.8 and 4.3 million tonnes of CO_2 equivalent emissions over the lifetime of the project.

3.6 Although the proposals do not give rise to zero emissions of greenhouse gases, compared to the existing power generating plant substantial savings equivalent to the annual emissions of greenhouse gases from approximately 25,000 - 29,000 homes or 61,000 - 70,000 cars.

3.7 If the maximum throughput of 600,000tpa is assumed (and taking a conservative assumption that the calorific value of the waste remains unchanged) net greenhouse gas savings will still be achieved; although the magnitude of the savings would be marginally lower at approximately 149,000 – 161,000 tCO_2 equivalent emissions per annum.

4 Conclusions

4.1 The assessment of the potential carbon footprint for the existing and proposed energy generation options predicts that the proposed SEP facility performs well, providing reductions in the greenhouse gas emissions footprint compared with the current CHP.

4.2 The estimates within this study indicate that between approximately 152 and 174 thousand tonnes of CO_2 equivalent emissions per annum could be avoided through the installation of the facility (if all assumptions remain constant) and accounting for savings from avoided emissions from landfill.

4.3 Further, over the expected life time of the facility (assumed to be 25 years) this amounts to savings of approximately 3.8 to 4.3 million tonnes of CO_2 equivalent emissions.

4.4 In summary, operation of the proposed SEP is anticipated to have a positive impact on greenhouse gas emissions.

Appendices

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Appendix A

Data Inputs for the Model

Data Input for the Model

The key inputs required for the model are:

- characteristics of waste input to the SEP;
- the mode and distance to transport input materials and residues;
- the mode and distance to transport the SRF to landfill in the current scenario; and
- the combustion characteristics i.e. electricity and steam supply and Thermal inputs and outputs.

These data are summarised in the following tables.

Characteristics of Waste Input to the SEP

Waste Type	Assumed Annual Throughput (%)	Assumed Annual Throughput (tpa)
MSW	25	140,000
C&I	20	112,000
SRF	55	308,000
Total	100	560,000

Transport – Proposed Scenario

	Material	Distance to/from Site (km)	Amount (tpa)	Mode of Transport	Load Size (t)	CO_2 Factor kg CO_2/km[1]
Fuel[3]	SRF	120	102,667	Large lorry <33 t articulated	20	1.0342
	Treated MSW	120	46,667	Large lorry <33 t articulated	20	1.0342
	Treated C&I	120	37,333	Large lorry <33 t articulated	20	1.0342
	SRF	400	205,333	Rail	855	24.4 [2]
	Treated MSW	400	93,333	Rail	855	24.4 [2]
	Treated C&I	400	74,667	Rail	855	24.4 [2]
	SRF	*120*	308,000	*Large lorry <33 t articulated*	*20*	*1.0342*
	Treated MSW	*120*	112,000	*Large lorry <33 t articulated*	*20*	*1.0342*
	Treated C&I	*120*	140,000	*Large lorry <33 t articulated*	*20*	*1.0342*
Other Inputs	Briskarb™	0.3	25,000	Large lorry <33 t articulated	20	1.0342
	Activated Carbon	700	524	Medium lorry 1	15	1.0342
	Ammonia	15	3,579	Large lorry <33 t articulated	20	1.0342
Outputs	Bottom ash	50	142,365	Large lorry <33 t articulated	20	1.0342
	FGT residues	80	30,000	Medium lorry 2	15	1.0342
	Ferrous	50	1,161	Small Lorry 2	7	0.5973
	Non Ferrous	50	289	Small Lorry 2	7	0.5973

Notes: 1: CO_2 factors taken from DEFRA Greenhouse Gas Reporting Guidelines, 2009

2: Rail factors in (1) above are given in kg CO_2/tonne.km. Value above has taken DEFRA value for diesel trains (assumed worst case) given at 0.0285 kg CO_2/tonne.km multiplied by the train load (15 tonnes per container and 57 containers = 855 tonnes)

3. Figures in italics represent values used for all road scenario; plain type figure present road/rail split scenario

Transport – Current Scenario

Material	Distance to Landfill (km)	Amount (tpa)	Mode of Transport	Load Size (t)	CO_2 Factor kg CO_2/km[1]
MSW	30	448,000	Refuse Collection Vehicle	20	1.0342
MSW	30	140,000	Refuse Collection Vehicle	7.8	1.0342
C&I	30	112,000	Large lorry <33 t articulated	20	1.0342

Notes: 1: CO_2 factors taken from DEFRA Greenhouse Gas Reporting Guidelines, 2009

2: Assumes that treated wastes intended for combustion in SEP are landfilled. In this scenario the wastes would not be treated at intermediate facilities but would be sent direct to landfill. Model only accounts for those elements of the MSW which would have been burned at the SEP, i.e. greenhouse gas emissions from elements extracted for recycling etc. are not accounted for in the landfill scenario.

Combustion

Operating data for the CHP was modelled for the last full 5 years (2005-2009). The data reported in this assessment presents a high and low range of greenhouse gas savings which are based on the following data inputs:

High – 2005

Units (MWh)	**Proposed**		**Current**	
Exported Electricity	793,291		613,904	
Internal Electrical Supply*	214,225			
	CHP	**SEP**	**CHP**	**SEP**
Thermal Input	3,106,981	1,600,000	3,915,167	0
Steam	1,771,435	604,949	2,362,423	0
Electricity Generated	749,984	332,573	863,170	0
Total Output	2,521,418	937,522	3,225,593	0

*Internal demand includes electricity supply to Brunner Mond's Lostock and Winnington sites and other users but excludes parasitic loads for the CHP and SEP and.

Carbon releases associated with the current operation of the gas fired CHP are based on E.ON CHP Carbon returns for 2005 which were reported at 714,944 tonnes.

Low – 2006

Units (MWh)	Proposed		Current	
Exported Electricity	810,209		630,823	
Internal Electrical Supply*	197,639			
	CHP	SEP	CHP	SEP
Thermal Input	3,174,470	1,600,000	3,982,656	0
Steam	1,748,243	604,949	2,364,007	0
Electricity Generated	751,899	330,989	863,502	0
Total Output	2,500,142	935,939	3,227,509	0

*Internal demand includes electricity supply to Brunner Mond's Lostock and Winnington sites and other users but excludes parasitic loads for the CHP and SEP and.

Carbon releases associated with the current operation of the gas fired CHP are based on E.ON CHP Carbon returns for 2006 which were reported at 730,978 tonnes.

In both cases data for greenhouse gas emissions associated operation of the CHP under the proposed scenario are scaled from the corresponding years carbon returns.