FORD ENERGY RECOVERY FACILITY AND WASTE SORTING AND TRANSFER FACILITY, FORD CIRCULAR TECHNOLOGY PARK

ENVIRONMENTAL STATEMENT
TECHNICAL APPENDIX D:
CARBON ASSESSMENT

MARCH 2021

FICHTNER

Consulting Engineers Limited

Ford Energy Recovery Facility and Waste Sorting and Transfer Facility

Viridor Energy Limited

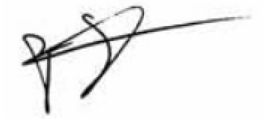
Grundon Waste Management Limited

Ford Energy from Waste Limited

Technical Appendix D1 – Carbon Assessment

ENGINEERING + CONSULTING

Document approval

	Name	Signature	Position	Date
Prepared by:	Katie Hampton		Environmental Scientist	08/02/2021
Checked by:	James Sturman		Lead Consultant	09/02/2021

Document revision record

Revision no	Date	Details of revisions	Prepared by	Checked by
00	15/04/2020	For Client	KLH	JRS
01	04/05/2020	Updated following Client comments	KLH	JRS
02	26/05/2020	Updated Applicant details	KLH	JRS
03	28/05/2020	Updated WSTF throughput	KLH	JRS
04	09/06/2020	Updated following Client team comments	KLH	JRS
05	10/02/2021	Updated for design changes	KLH	JRS
06	26/02/2021	Updated company name and conclusions	KLH	JRS

Contents

1 Introduction

1.1 Background

Viridor Energy Limited, Grundon Waste Management Limited and Ford Energy from Waste Limited (Viridor, Grundon and Ford EfW) are proposing to build an Energy Recovery Facility (ERF) facility (the ERF) to be located at the Ford Circular Technology Park (the former Tarmac blockworks site, which forms part of the former Ford Airfield) to the west of the village of Ford.

The ERF will be a two-stream design and will treat up to approximately 275,000 tonnes per annum of non-hazardous, residual waste material. The ERF will generate approximately 31.3 MWe at the nominal design capacity.

As part of the proposals for the proposed development, a new waste sorting and transfer facility (WSTF) is to be developed at the site. The existing waste transfer station (WTS) already present on-site will continue to operate during the construction of the northern section of the new WSTF before being demolished. The new WSTF will then operate during the construction of the ERF, taking mostly commercial and industrial waste from West Sussex and surrounding counties, delivered in RCVs.

The existing WTS handles approximately 20,000 – 25,000 tonnes per annum of waste from West Sussex and surrounding counties.

The new WSTF will have a throughput of approximately 20,000 tonnes per annum of waste. This throughput is slightly lower than the current throughput of the existing WTS, as a significant proportion of the material processed at the existing WTS will be delivered directly to the ERF instead.

1.2 Objective

The purpose of this Carbon Assessment is to determine the relative carbon impact of processing waste in the ERF, compared to disposal in a landfill, as this is the most likely alternative destination for the waste. The sensitivity of the results to changes in grid displacement factors and landfill gas recovery rates has also been assessed.

The carbon benefits associated with the operation of the WSTF is discussed further within section 3.4.

2 Conclusions

2.1 ERF

1. The carbon emissions have been calculated for the ERF. This takes account of:
   a. carbon dioxide released from the combustion of fossil-fuel derived carbon in the ERF;
   b. releases of other greenhouse gases from the combustion of waste;
   c. combustion of gas oil in auxiliary burners;
   d. carbon dioxide emissions from the transport of waste and residues; and
   e. emissions offset from the export of electricity from the ERF.
      i. The grid displacement factor used in the main assessment was obtained from the UK fuel mix table and reflects the marginal source of displaced electricity, which is currently gas-fired power stations. It is considered that the construction of the ERF would have little effect on how other renewable energy plants operate and that a gas-fired power station is a reasonable comparator for the purposes of this assessment – refer to section 3.1.3 for further justification.
2. These emissions have been compared with the carbon emissions from sending the same waste to landfill, taking account of:
   a. the release of methane in the fraction of landfill gas which is not captured; and
   b. emissions offset from the generation of electricity from landfill gas.
3. In the base case, the ERF is predicted to lead to a net reduction in greenhouse gas emissions of approximately 48,102 tonnes of CO_2-equivalent (CO_2e) per annum compared to the landfill counterfactual.
4. The sensitivity of this calculation to different grid displacement factors and different landfill gas recovery rates has also been considered. The lower figures used in the sensitivity analysis for grid displacement factor would only be relevant if the ERF were to displace other renewable sources of electricity. The results of the sensitivities for the base case provide a net reduction of greenhouse gas emissions within a range of 5,558 to 101,358 tonnes of CO_2e emissions per annum.
5. Some of the factors used within this assessment have been updated for the latest published data and latest plant design data.

2.2 WSTF

It is anticipated that there will be a carbon benefit associated with the development of the new WSTF when compared to the existing WTS. This will be primarily due to the reduction in transport emissions associated with the waste processed within the WSTF, alongside the recovery of recyclable materials from the incoming waste.

3 Calculations

3.1 Energy Recovery Facility

The combustion of waste generates direct emissions of carbon dioxide. It also produces emissions of nitrous oxide, which is a potent greenhouse gas. Methane may arise in minimal extents from decomposition of waste within the waste bunker; however, decomposition will be actively avoided and methane is not regarded to have relevant climate impacts in quantitative terms from the ERF.

Exporting energy to the grid offsets greenhouse gas emissions from the generation of power in other ways. In the case of the ERF, the displaced electricity will be the marginal source which is currently gas-fired power stations. It is considered that the construction of the ERF will not significantly affect how nuclear, wind or solar plants operate. Therefore, the use of a gas-fired power station is considered a reasonable comparator when assessing the grid offset of the ERF. This is discussed in further detail in section 3.1.3.

Sections 3.1.1 to 3.1.3 provide detail of the calculation of the carbon burdens and benefit associated with the ERF. Unless otherwise specified, all values presented are on an annual basis.

3.1.1 Waste Throughput and Composition

The ERF will be designed to process waste with a range of NCV's in accordance with the firing diagram. Therefore, the hourly throughput will vary in accordance with the NCV of waste that is processed. A lower NCV of waste is typically associated with a lower fossil carbon content, therefore each tonne processed will have lower associated carbon emissions.

This assessment has been undertaken based on the nominal NCV and nominal hourly processing capacity of the ERF, and assumes that it processes up to 275,000 tonnes of waste per year.

Table 1 presents the characteristics of the assumed waste composition which is relevant to this assessment.

Table 1: Waste characteristics

Carbon content (% mass)	Biocarbon (% carbon)	NCV (MJ/kg)	Waste throughput (tpa)
27.28	53.21	10.5	275,000

Waste composition data has been taken from different published sources to determine a composition which best reflects the design NCV of the ERF. This includes the following sources:

- WRAP: "National Municipal Waste Composition, England", 2017; and
- WRAP Cymru: "Compositional analysis of Commercial and Industrial waste in Wales", 2020.

3.1.2 Direct Emissions

The combustion of waste generates direct emissions of carbon dioxide, with the mass of emissions determined from the carbon content of the waste.

For the purposes of this assessment, only carbon dioxide emissions from fossil sources (e.g. plastics) need to be considered, as carbon from biogenic sources (e.g. paper and wood) has a neutral carbon burden. The biogenic material in the residual waste which is to be processed at the ERF is considered to be 'waste' material. This means that there is no requirement to consider, for example, any land use implications in producing the biogenic material as, unlike energy crops which are grown for combustion, biogenic waste already exists.

The UK Government's document "Energy from Waste: A Guide to the Debate" states, in paragraph 40, *"Considering the energy from waste route, if our black bag of waste were to go to a typical combustion-based energy from waste plant, nearly all of the carbon in the waste would be converted to carbon dioxide and be released immediately into the atmosphere. Conventionally the biogenic carbon dioxide released is ignored in this type of carbon comparison as it is considered 'short cycle', i.e. it was only relatively recently absorbed by growing matter. In contrast, the carbon dioxide released by fossil-carbon containing waste was absorbed millions of years ago and would be newly released into the atmosphere if combusted in an energy from waste plant."* For landfill, paragraph 42 states *"Burning landfill gas produces biogenic carbon dioxide which, as for energy from waste, is considered short cycle."* Therefore, this assessment is in line with government guidance for this type of assessment.

Volume 5 of the Intergovernmental Panel on Climate Change (IPCC) Guidelines for Greenhouse Gas Inventories assumes that waste incinerators have combustion efficiencies of close to 100%. Therefore, within this assessment, it has been assumed that all of the carbon in the waste fuel is converted to carbon dioxide in the combustion process. The mass of fossil derived carbon dioxide produced has been determined by multiplying the mass of fossil carbon in the fuel by the ratio of the molecular weights of carbon dioxide (44) and carbon (12) respectively as shown in the equation below:

$$Mass\ of\ CO_2\ out = Mass\ of\ C\ in\ \times \frac{Mr\ CO_2}{Mr\ C}$$

Where Mr = molecular weight.

The total fossil derived carbon emissions is presented in Table 2.

Table 2: Fossil CO_2 emissions

Item	Unit	ERF – Base case
Fossil carbon in input waste	t C	35,102
Fossil derived carbon dioxide emissions	**t CO_2**	**128,707**

The process of recovering energy from waste releases a small amount of nitrous oxide and methane, which contribute to climate change. The impact of these emissions is reported as CO_2e emissions and is calculated using the Global Warming Potential (GWP) multiplier. In this assessment the GWP for 100 years has been used.

Emissions of nitrous oxide and methane depend on combustion conditions. Nitrous oxide emissions are also influenced by flue gas treatment systems and the types of reagents used. These details are based on the final design of the ERF, which is not available at this stage. Therefore, default emission factors from the IPCC have been used to determine the emissions of these gases, refer to Table 3.

Table 3: N_2O and CH_4 assumptions

Item	Unit	Value	Source
N_2O default emissions factor	kg N_2O/tonne waste	0.04	IPCC Guidelines for Greenhouse Gas Inventories, Vol 2, Table 2.2 Default Emissions Factors for
CH_4 default emissions factor	kg CH_4/tonne waste	0.3	

Item	Unit	Value	Source
			Stationary Combustion in the Energy Industries, Municipal Wastes (non-biomass) and Other Primary Solid Biomass, using a NCV of 10 MJ/kg
GWP – N_2O to CO_2	kg CO_2e/kg N_2O	298	IPCC Fourth Assessment Report
GWP – CH_4 to CO_2	kg CO_2e/kg CH_4	25	

Nitrous oxide and methane emissions from both the biogenic and non-biogenic fractions are considered as a carbon burden. Both the biogenic and non-biogenic fractions of waste have the same default emissions factor. Table 4 presents the emissions of nitrous oxide and methane and the equivalent carbon dioxide emissions from the ERF.

Table 4: N_2O and CH_4 emissions

Item	Unit	ERF – Base case
N_2O emissions	t N_2O	11.6
Equivalent CO_2 emissions	**t CO_2e**	**3,442**
CH_4 emissions	t CH_4	86.6
Equivalent CO_2 emissions	**t CO_2e**	**2,166**

The ERF would be equipped with auxiliary burners which would burn gasoil and would have a thermal capacity of about 60% of the thermal capacity of the boiler; assumed to be approximately 56.88 MWth. These would only be used for start-up and shutdown operations. We have assumed that there would be 10 start-ups a year, which is a conservative assumption, and that the burners would operate for 18 hours total for start-up and shut down. Accordingly, the approximate total fuel consumption would be:

$$56.88 \times 10 \ \times 18 = 10{,}238 \ MWh$$

Each MWh of gasoil releases 0.25[1] tonnes of carbon dioxide. Therefore, the emissions associated with auxiliary firing would be 10,238 x 0.25 = 2,559 t CO_2e.

Table 5 presents the total direct equivalent carbon dioxide emissions from the combustion of waste in the ERF.

Table 5: Total equivalent CO_2 emissions from the combustion of waste

Item	Unit	ERF – Base case
CO_2 emissions	t CO_2	128,707
N_2O emissions	t CO_2e	3,442
CH_4 emissions	t CO_2e	2,166
Burner emissions	t CO_2e	2,559
Total emissions	**t CO_2e**	**136,874**

[1] DEFRA – Greenhouse gas reporting: Conversion factors 2019

3.1.3 Grid Offset

Exporting electricity to the grid offsets the carbon burden of producing electricity using other methods. In the case of an energy from waste plant, such as the ERF, the displaced electricity would be the marginal source which is currently gas-fired power stations, for which the displacement factor is 0.371 t CO_2e/MWh[2]. Electricity generated by the ERF would be exported to the National Grid. DEFRAs 'Energy from Waste – A Guide to the Debate 2014' (specifically, footnote 29 on page 21) states that "*A gas fired power station (Combined Cycle Gas Turbine – CCGT) is a reasonable comparator as this is the most likely technology if you wanted to build a new power station today*". Therefore, this assessment uses the current marginal technology as a comparator for calculating emissions which the ERF will offset from the grid.

It is considered that the construction of the ERF will have little or no effect on how nuclear, wind or solar plants operate when taking into account market realities (such as the phase-out of nuclear plants and the generous subsidies often associated with the development of wind and solar plants).

Current energy strategy uses nuclear power stations to operate as baseload stations run with relatively constant output over a daily and annual basis, with limited ability to ramp up and down in capacity to accommodate fluctuations in demand. Power supplied from existing nuclear power stations is relatively low in marginal cost and has the benefit of extremely low CO_2 emissions. Wind and solar plants also have very low marginal operating costs and are supported by subsidies in many cases. This means that they will run when there is sufficient wind or sun and that this will be unaffected by the operation of the ERF.

Combined cycle gas turbines (CCGTs) are the primary flexible electricity source. Since wind and solar are intermittent, with the electricity supplied varying from essentially zero (on still nights) to more than 16 GW (on windy or sunny days), CCGTs supply a variable amount of power. However, there are always some CCGTs running to provide power to the grid.

Gas engines, diesel engines and open cycle gas turbines also make a small contribution to the grid. These are mainly used to provide balancing services by balancing intermittent supplies. As they are more carbon intensive than CCGTs, it is more conservative to ignore these.

In addition, recent bidding of EfW plants into the capacity market mean that they are competing primarily with CCGTs, gas engines and diesel engines. It is therefore considered that CCGT is the appropriate comparator and may possibly be conservative.

It is acknowledged that the UK government has recently set a target which will require the UK to bring all greenhouse gas emissions to net zero by 2050. Taking this into consideration, in the future it is anticipated that the power which the ERF will generate will displace other forms of power generation, including renewable energy power stations. However, at this stage the mix of future generation capacity additions to the grid that might be displaced by the project is uncertain, and the emissions intensity of future displaced generation cannot be accurately quantified. Therefore, for the purposes of this assessment, it has been assumed that the ERF will displace a gas fired power station as this is considered a reasonable comparator.

A sensitivity analysis has been undertaken to consider the effect of changing the grid offset displacement factor, refer to section 4.2.

The amount of carbon dioxide offset by the electricity generated by the ERF is calculated by multiplying the net electricity generated by the grid displacement factor. The ERF will export different amounts of power depending on the NCV of the waste that is incinerated. For the purposes of this assessment, it is assumed that the ERF will have a gross electrical efficiency of

[2] DEFRA – Fuel Mix Disclosure Table – 01/04/2019 – 31/03/2020

33.02% and a net electrical efficiency of 29.75%. This is based on the design of the gross and net electrical output, and the thermal capacity of the boiler. If the ERF has a higher efficiency, a greater carbon benefit will result from displaced electricity.

The ERF will also be capable of exporting heat to local users, subject to technical and economic considerations. If heat is exported, the carbon benefits of the ERF will be significantly higher. However, this assessment does not cover the carbon benefits associated with heat export from the ERF, as at this stage of design there are currently no formal heat offtake agreements in place.

The carbon dioxide offset by electricity generation is counted as a carbon benefit and is presented in Table 6.

Table 6: ERF electricity offset

Item	Unit	ERF – Base case
Net electricity export	MW	28.2
Net electricity exported	MWh	238,614
Total CO_2 offset through export of electricity	**tCO_2e p.a.**	**88,526**

3.2 Landfill

When waste is disposed of in landfill, the biogenic carbon degrades and produces landfill gas (LFG). LFG is comprised of methane and carbon dioxide, so has a significant carbon burden. Some of the methane in the LFG can be recovered and combusted in a gas engine to produce electricity.

3.2.1 Emissions

The emissions associated with LFG can be split into:

1. carbon dioxide released in LFG;
2. methane released in LFG; and
3. methane captured and combusted in LFG engines and flares, producing carbon dioxide as a result of the combustion.

Since 1 and 3 result in the release of carbon dioxide derived from biogenic carbon in the waste, these can both be excluded from the assessment of carbon emissions associated with the operation of the ERF. Therefore, the focus of the calculations are based around the methane which is released to atmosphere. This is calculated as follows:

1. The biogenic carbon in the waste comes from the waste composition, discussed in Section 3.1.1 above.
2. 50% of the degraded biogenic carbon is released and converted into LFG. The released carbon is known as the degradable decomposable organic carbon (DDOC) content.
    a. This assumes a sequestration rate of 50%, which is considered to be a conservative assumption and is in accordance with DEFRAs 'Energy from Waste – A Guide to the Debate' (2014).
    b. There is considerable uncertainty in literature surrounding the amount of biogenic carbon that is sequestered in landfill. The high sequestration used in this assessment (i.e. 50%), combined with the use of high landfill gas capture rates (assumed 68% capture) is considered to be conservative. Therefore, it is not considered appropriate to give additional credit for sequestered carbon as this would result in an overly conservative assessment.

3. LFG is made up of 57% methane and 43% carbon dioxide, based on a detailed report carried out by Golder Associates for DEFRA[3].
4. Based on the same report, the analysis assumes 68% of the LFG is captured and that 10% of the remaining 32% is oxidised to carbon dioxide as it passes through the landfill cover layer. The unoxidized LFG is then released to atmosphere.
5. Based on the same guidance, 90.9% of the captured LFG is used in gas engines to generate electricity, although 1.5% of this captured LFG passes through uncombusted and is released to atmosphere. The remainder is combusted in a flare. We have assumed that the flares fully combust the methane.

Table 7 identifies assumptions relating to LFG, and Table 8 identifies the equivalent carbon emissions associated with landfill.

Table 7: LFG assumptions

Item	Value	Source
DDOC content	50%	DEFRA Review of Landfill Methane Emissions Modelling (WR1908) (2014)
CO_2 percentage of LFG	43%	
CH_4 percentage of LFG	57%	
LFG recovery efficiency	68%	
Molecular ratio of CH_4 to C	1.33	Standard Values
Molecular ratio of CO_2 to CH_4	2.75	
Molecular ratio of CO_2 to C	3.67	
Global Warming Potential – CH_4 to CO_2	25	United Nations Framework for Climate Change Global Warming Potentials

Table 8: LFG emissions

Item	Unit	ERF – Base case
Biogenic carbon	tonnes	39,918
Total DDOC content (biogenic carbon not sequestered – degradable)	tonnes p.a.	19,959
Methane in LFG, of which:	tonnes p.a.	15,169
- Methane captured	tonnes p.a.	10,315
- Methane oxidised in landfill cap (capping material)	tonnes p.a.	485
- Methane released to atmosphere directly	tonnes p.a.	4,369
Methane leakage through LFG engines	tonnes p.a.	141

[3] Review of Landfill Methane Emissions Modelling (WR1908), Golder Associates, November 2014

Item	Unit	ERF – Base case
Total methane released to atmosphere	tonnes p.a.	4,509
CO_2e released to atmosphere	**tCO_2e p.a.**	**112,732**

The value for biogenic carbon in Table 8 above is calculated by multiplying the annual tonnage of waste by the carbon content percentage of the waste, and then again by the percentage of that carbon which is derived from biogenic sources.

3.2.2 Grid Offset

The methane in the LFG that has been recovered can be used to produce electricity. This electricity will offset grid production, and results in a carbon benefit of sending waste to landfill as explained in section 3.1.3. The assumptions for the amount of LFG methane captured and used in a typical LFG engine are shown in Table 9.

Table 9: LFG grid offset assumptions

Item	Value	Source
Landfill gas recovery efficiency	68%	DEFRA Review of Landfill Methane Emissions Modelling (Nov 2014)
Methane captured used in LFG Engines	90.9%	
Methane leakage through LFG engines	1.5%	
LFG engine efficiency	36%	
Methane net calorific value	47 MJ/kg	Standard value

The power produced by the LFG engine is based on the amount of methane, the heat content of methane and the engine efficiency, as per the assumptions in Table 9. The power generated by the LFG engines and the carbon dioxide offset are shown in Table 10.

Table 10: LFG grid offset

Item	Unit	ERF – Base case
Methane captured, of which:	tonnes p.a.	10,315
- Methane flared	tonnes p.a.	938
- Methane leakage through LFG engines	tonnes p.a.	141
- Methane used in LFG engines	tonnes p.a.	9,236
Fuel input to LFG engines	GJ	434,114
Power generated	MWh	43,411
Total CO_2e offset through grid displacement	**t CO_2e p.a.**	**16,106**

3.3 Transport

There would be carbon emissions associated with the transport of waste and reagents to the ERF, and the transport of residues (i.e. Incinerator Bottom Ash (IBA) and Flue Gas Treatment Residues (FGT residues)) from the process to their respective waste treatment/disposal facilities. The assumptions for determining these emissions are presented in Table 11.

Table 11: Transport assumptions[4]

Parameter	Unit	Value	Source
Articulated lorry load size – waste to landfill	tonnes	18.2	Project-specific assumption. (65% by bulker, 35% by RCV)
Articulated lorry load size – waste to the ERF	tonnes	18.2	
Articulated lorry load size – Export of FGT residues	tonnes	27.1	Project-specific assumption
Articulated lorry load size – Export of IBA	tonnes	29	
Articulated lorry load size – Import of lime	tonnes	27.5	
Articulated lorry load size – Import of activated carbon	tonnes	21	
Articulated lorry load size – Import of ammonia	tonnes	10	
Articulated lorry load size – Import of fuel oil	tonnes	32	
Articulated lorry load size – Export of ferrous metals from the Proposed Development	tonnes	17	
Articulated lorry load size – Export of oversize bottom ash from the Proposed Development	tonnes	14	
Articulated lorry CO_2 factor - 100% loaded	kg CO_2/km	0.96235	BEIS "Greenhouse gas reporting: conversion factors 2020" HGV (all diesel) Articulated (>3.5- 33t)
Articulated lorry CO_2 factor - 0% loaded	kg CO_2/km	0.64607	
Waste distance to landfill (one way)	km	80	Distance from Ford to Biffa's Redhill Landfill in Surrey (closest active landfill).

[4] Reagents are currently assumed to be sourced from existing suppliers for the Lakeside Energy from Waste facility near Slough, which is also a Joint Venture between Grundon and Viridor. However, during the development of the ERF, the possibility of using suppliers closer to the site will be examined. Therefore, the current assessment is conservative with regards transport distances for reagents to the site.

Parameter	Unit	Value	Source
Waste distance to ERF (one way)	km	60	Average distance for current Lakeside deliveries[5]
IBA distance to recovery	km	110	Distance to Brentford
FGT residues distance to recovery	km	259	Distance to OCO, Suffolk
Ferrous metals distance to recovery	km	5	HD white
Lime distance to the Proposed Development	km	354	Lhoist, with distribution from Buxton
Activated carbon distance to the Proposed Development	km	306	CPL Activated Carbons, manufactured/distributed from James Durrans Group in Bilston
Ammonia distance to the Proposed Development	km	259	Brenntag, with distribution from Thetford
Fuel oil distance to the Proposed Development	km	50	General assumption
Mass of waste	tonnes	275,000	Planning application
Mass of IBA (including oversize)	tonnes	50,100	Approximately 18% of total waste
Mass of FGT residues	tonnes	11,400	Approximately 4% of total waste
Mass of recovered ferrous metals	tonnes	3,800	Project-specific assumption
Mass of lime	tonnes	5,700	
Mass of activated carbon	tonnes	74	
Mass of ammonia	tonnes	1,420	
Mass of fuel oil	tonnes	280	

The carbon burden of transporting the waste is determined by calculating the total number of loads required and multiplying it by the transport distance to generate an annual one-way vehicle distance. This is multiplied by the respective empty and full carbon dioxide factor for HGVs to determine the overall burden of transport. It is recognised that this is conservative, as it may be possible to coordinate HGV movements to reduce the number of trips. In addition, as explained in the footnotes to Table 11, the transport distances assumed within the assessment are conservative and may be shorter in reality.

[5] In the absence of project-specific data, the average distance for current deliveries from a reference plant of the Applicants has been assumed. It is expected that a proportion of the waste accepted at the ERF will be sourced closer than 60 km to the site. Therefore, the current assessment is conservative.

Table 12: Transport assumptions

Parameter	Unit	Waste to landfill	Waste to the ERF	IBA to disposal	FGT residues to disposal	Lime to the ERF	Carbon to the ERF	Ammonia to the ERF	Fuel oil to the ERF	Recovered metals off-site
Tonnage	tonnes p.a.	275,000	275,000	50,100	11,400	5,700	74	1,420	280	3,800
Number of loads required	p.a.	15,110	15,110	1,728	421	208	4	142	9	224
One-way distance	km	80	60	110	259	354	306	259	50	5
One-way total vehicle distance per year	Km	1,208,800	906,600	190,080	109,039	73,632	1,224	36,778	450	1,120
Total CO_2 emissions	**t CO_2**	**1,944.3**	**1,458.2**	**305.7**	**175.4**	**118.4**	**2.0**	**59.2**	**0.7**	**1.8**

3.4 Waste Transfer Station

Grundon Waste Management Limited currently operates an existing waste transfer station (WTS) at the site. The existing WTS handles approximately 20,000 – 25,000 tonnes per annum of waste from West Sussex and surrounding counties.

The waste, primarily from commercial and industrial (C&I) sources, is delivered to the existing WTS in RCVs. The waste is then bulked at the WTS before being loaded into articulated vehicles for transport off-site. Currently, there is no treatment of the waste (such as mechanical shredding) at the existing WTS, and it is bulked and then transferred to either the Lakeside Energy from Waste plant near Slough or the Brockhurst Wood Landfill in Horsham. A number of other facilities also receive waste from the existing WTS (albeit less frequently), including the Bishop's Cleeve landfill in Cheltenham, Sutton Courtenay Landfill near Didcot, the Riverside EfW facility and the Redhill Landfill in Surrey.

The new WSTF will have a throughput of approximately 20,000 tonnes per annum of waste. This throughput is slightly lower than the throughput of the existing WTS, as a significant proportion of the material processed at the existing WTS will be delivered directly to the ERF instead. Approximately one third of all incoming waste will subsequently be treated within the adjacent ERF after initial sorting and segregation of recyclable materials within the WSTF. The remaining waste will be composed primarily of recyclates such as metals, glass, aggregate material etc. This waste will be transferred off-site for recovery or recycling at a suitably licensed facility.

It is anticipated that there will be a carbon benefit associated with the development of the WSTF when compared to the existing WTS, due to the reduced transport and the recovery of recyclates from the incoming waste. The carbon emissions associated with the transport of waste to the Lakeside EfW, the Brockhurst Wood Landfill or other facilities will result in significantly higher carbon emissions compared to transport within the Proposed Development. Furthermore, the recovery of recyclates from the incoming waste will displace the extraction of primary resources and production of materials which would otherwise need to be produced. Finally, as recyclates will be recovered from the incoming waste, the WSTF will reduce the quantities of waste which would otherwise potentially be transferred for disposal.

4 Results

4.1 Energy Recovery Facility

The results of the assessment are shown below. It can be seen that there is a net carbon benefit of **48,102 carbon dioxide equivalent emissions per annum** for the ERF.

Table 13: Summary

Parameter	Units	ERF – Base case
Releases from LFG	t CO_2e	112,732
Transport of waste and outputs to landfill	t CO_2e	1,944
Offset of grid electricity from LFG engines	t CO_2e	-16,106
Total landfill emissions	**t CO_2e**	**98,571**
Transport of waste to and outputs from the ERF	t CO_2e	2,121
Offset of grid electricity with ERF generation	t CO_2e	-88,526
Emissions from the ERF	t CO_2e	136,874
Total ERF Emissions	**t CO_2e**	**50,469**
Net Benefit of the ERF	**t CO_2e**	**48,102**

Another way of expressing the benefit of the ERF is to consider the additional power generated by recovering energy rather than sending the waste to landfill and calculating the effective net carbon emissions per MWh of additional electricity exported.

The effective net carbon emissions per MWh of additional electricity exported for the ERF is calculated as follows:

1. Additional power exported = 238,614 – 43,411 = 195,203 MWh
2. Net Carbon released = (112,732 + 1,944) – (136,874 + 2,121) = -24,319 tCO_2e
3. Effective carbon intensity = -24,319 ÷ 195,203 = -0.125 t CO_2e/MWh

4.2 Sensitivities

The two key assumptions in the Carbon Assessment are the grid displacement factor for electricity and the LFG capture rate.

- There is some debate over the type of power which would be displaced and so we have considered the effect of using lower figures, which would only be relevant if the ERF were to displace other renewable sources of electricity.
- The Golders Associates report for DEFRA states that the collection efficiency for large, modern landfill sites was estimated to be 68% and the collection efficiency for the UK as a whole was estimated to be 52%. There have been suggestions in other guidance that a conservative figure of 75% should be used. The sensitivity of the results to this assumption has also been assessed below.

Table 14 below shows the estimated net benefit of the ERF, in tonnes of carbon dioxide equivalent emissions per annum, for different combinations of grid displacement factor and LFG capture rate.

It can be seen that there is a benefit for all LFG capture rate and grid displacement factor combinations.

Table 14: Sensitivity analysis

Grid Displacement Factor (t CO_2e/MWh)	LFG Capture Rate			
	75%	68%	60%	52%
0.371	22,915	48,102	76,887	105,672
0.35	18,910	44,003	72,680	101,358
0.32	13,187	38,147	66,671	95,196
0.28	5,558	30,338	58,659	86,979

4.3 Recovery of FGT Residues and Further Carbon Benefits

The FGT residues from the process would be sent to O.C.O. Technology Limited in Suffolk, where they would be treated and stabilised. The recovery process results in a sustainable construction product which can be described as a 'carbon negative aggregate'. The process has been granted EA 'End of Waste' approval, by the Environment Agency; therefore, the finished aggregate is classed as a product and not a waste.

The recovery process uses carbon dioxide in the treatment of the FGT residues. As many wastes are naturally able to react with carbon dioxide, an acceleration of the process results in the formation of manufactured limestone. The process is a genuine Carbon Capture and Utilisation (CCU) process and significant volumes of carbon dioxide are permanently captured as stable carbonates. As more carbon dioxide is captured than emitted in the manufacture of these aggregates, the aggregate is classed as 'carbon negative'.

The treatment of FGT residues to produce a carbon negative aggregate has not been qualitatively factored into this assessment. Therefore, if this was to be taken into consideration, it would result in an increased carbon benefit for the Proposed Development.

In addition to the treatment process for FGT residues outlined above, the use of carbon negative blocks will be examined during the construction phase of the ERF and WSTF. Should these be used, this will reduce the use of primary resources in the Proposed Development and introduce additional carbon savings during the construction phase. However, as outlined within the Carbon and Greenhouse Gas Emissions ES chapter, the carbon emissions associated with the construction stage of the development will be relatively minor when compared to the carbon impact over operational lifetime of the development. A detailed analysis of construction emissions has therefore not been included within the scope of this assessment.

ENGINEERING CONSULTING

FICHTNER
Consulting Engineers Limited

Kingsgate (Floor 3), Wellington Road North,
Stockport, Cheshire, SK4 1LW,
United Kingdom

t: +44 (0)161 476 0032
f: +44 (0)161 474 0618

www.fichtner.co.uk