Medworth Energy from Waste
Combined Heat and Power Facility

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Applicant's Response to ISH4 Action Point 7 Technical Note: Climate Additional Sensitivity Assessment

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Contents

1. Introduction

1.1 Background

1.1.1 This technical note has been prepared in response to a request from Cambridgeshire County Council (CCC) at Issue Specific Hearing 4 (ISH 4) on 17 May 2023, where it was considered that further details on the original sensitivity analysis for the Greenhouse Gas (GHG) assessment accompanying the Environmental Statement (ES) (**Appendix 14C (Volume 6.4) [APP-088]**) should be provided. See **ISH 4, action point No.7 [EV-059]**:

> *Submission of full sensitivity analysis for alternative scenarios to those provided in Appendix 14C of [APP-088] or signposting to existing submissions containing this information. At present in the sensitivity analysis both cases reduce plastics and food waste content and Cambridgeshire County Council wish to see these represented separately.*

1.1.2 The original sensitivity analysis for the ES (**Appendix 14C (Volume 6.4) [APP-088]**) sought to illustrate a range of scenarios in terms of the variables contributing to the assessment of greenhouse gas emissions, i.e. waste composition with increased recycling; offsets for UK energy supplies, including UK grid decarbonisation; and implementation of CHP for the EfW CHP Facility.

1.1.3 Following discussions with CCC on 20 October 2022 supplementary analysis was submitted in November 2022 (**Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**), providing a more detailed sensitivity analysis considering future UK grid decarbonisation applied to the scenario presented as the core case in the ES (ES Case) over the 40 year lifetime of the Proposed Development, and including construction, operational and decommissioning stages (i.e. rather than the net annual operational emissions for the years 2035 and 2050, selected as representative samples in the original ES sensitivity analysis).

1.1.4 The purpose of this additional GHG sensitivity analysis is to extend the variables considered for alternative scenarios, particularly with regard to waste composition scenarios proposed by CCC, and to address some of the main shortcomings identified by CCC in the original ES sensitivity analysis with respect to:

- Consideration of future UK grid decarbonisation across all the alternative scenarios, rather than just the ES Case.
- Presenting full 40-year lifetime emissions for each alternative scenario (including construction, operational and decommissioning stages, as per the main ES GHG assessment).
- Presenting gross emissions for the Proposed Development as well as net emissions.

1.1.5 Additionally, the extended GHG sensitivity analysis includes alternative scenarios that consider other issues raised by CCC during the course of the DCO examination, as well as those included in the original ES sensitivity analysis.

1.2 Methodology

1.2.1 The Applicant held a call with CCC's Carbon and Energy Manager on 07 June 2023 to agree the scope and methodology for the extended GHG sensitivity analysis, within the timescales of the DCO Examination. Following the discussion and additional correspondence with CCC by email on 20 June 2023 a methodology for the sensitivity analysis was agreed. This also considered the approach used by CCC in their own assessment of GHG emissions for the Proposed Development (**Deadline 1 Submission - Joint Local Impact Report with Cambridgeshire County Council (paras 9.4.9 to 9.4.10) [REP1-074]** and **Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**). The agreed methodology is documented in *Technical Meeting Note Climate Change v2.pdf* (see Appendix A).

1.2.2 In summary, the methodology for assessing GHG emissions for this sensitivity analysis is in line with **Section 14.8 of ES Chapter 14 Climate Change (Volume 6.2) [APP-041]**, but in addition to the approach used for the original ES sensitivity analysis (**Appendix 14C (Volume 6.4) [APP-088]**) and subsequent **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**, includes the following:

- Emissions for the construction, operation and decommissioning stages for each scenario (where relevant for the EfW CHP Facility, Landfill and infrastructure associated with Carbon Capture and Storage).
- Lifetime operational emissions for each scenario.
- Presentation of gross emissions for EfW and for Landfill, excluding the offset of emissions for electricity in each case.

1.2.3 The Applicant and CCC have acknowledged that, although there are expected to be discrepancies between the ES and CCC approaches, the agreed methodology and proposed alternative scenarios should ensure for a complete assessment of the lifetime net and gross emissions, and consistency for comparison with the GHG assessment reported in the ES.

1.2.4 In total, 31 scenarios are included in the extended GHG sensitivity analysis. These are described in Section 2, including the key assumptions for each scenario. CCC's view is that only those scenarios that consider future UK grid decarbonisation are relevant, which the Applicant has sought to address as a significant aspect in the sensitivity analysis.

1.2.5 The Applicant considers that Carbon Capture and Storage (CCS) technology will have a significant role in the future decarbonisation of energy supplies, including for EfW CHP facilities. Therefore, in addition to the 23 scenarios confirmed with CCC for the methodology (see **Appendix A**), the Applicant has included 8 additional scenarios that consider the adoption of CCS alongside future decarbonisation of the UK grid. The addition of scenarios for CCS was confirmed with CCC in a meeting on 05 July 2023.

1.2.6 This technical note sets out:

- The scenarios included in the sensitivity analysis, including the assumptions for inputs to be used for each scenario.
- Results and comment on the sensitivity analysis outputs, presenting gross and net GHG emissions determined for each scenario alongside the ES Case and compared to Landfill and, where relevant, presented for the EfW CHP Facility as a standalone entity.
- Summary discussion of the sensitivity analysis findings, including consideration of technology, regulations and developing policy.

2. Sensitivity Scenarios

2.1.1 The scenarios for the extended sensitivity analysis fall under the following broad categories:

- Waste composition.
- Electricity generation offsetting.
- Combined Heat and Power (CHP).
- Landfill Gas (LFG) capture rate.
- Adoption of CCS.

2.1.2 A key aspect for **ISH 4, action point No.7 [EV-059]** was to consider alternatives for waste composition. **Table 2.1** below provides a summary of the variation in waste composition for the agreed scenarios, including a breakdown of the waste categories, equivalent % carbon content, net calorific value (NCV) and annual waste throughput.

2.1.3 The original ES sensitivity analysis considered the maximum waste throughput of 625,600 tonnes/year as a worse case for each of the variations in waste composition. However, in response to consultation comments, the waste throughput for each waste composition scenario has been adjusted according to the NCV for the waste and capped at the maximum throughput of 625,600 tonnes/year. This results in a reduced waste throughput of 613,573 tonnes/year for the ES Case (applied to the EfW CHP Facility and Landfill). Where relevant, the operating hours and MWe output parameters for the EfW CHP Facility have also been adjusted for each waste composition scenario, which are also identified in **Table 2.1**.

2.1.4 The 31 scenarios are set out in **Table 2.2**, along with the key assumptions used for each scenario. General assumptions applicable to the scenarios are included in **Appendix B**.

Table 2.1 Residual waste composition scenarios and operational parameters

Waste Stream	ES Case	ES Case with reduced recyclables	ES Case with 90% food & plastic	CCC: current residual waste	CCC: 50% reduced plastics	CCC: 50% reduced organics
Recyclable Paper	5.9%	5.5%	8.5%			
Card	6.3%	5.9%	9.1%	12.4%[a]	23.1%[a]	26.1%[a]
Non-recyclable Paper	8.9%	10.4%	16.0%			
Dense Plastic	7.8%	7.3%	1.4%	13.2%[b]	8.0%[b]	19.8%[b]
Plastic film	8.2%	7.7%	1.5%			
Textiles	5.5%	5.1%	7.9%	3.9%	6.0%	6.8%
Misc. Combustible	9.3%	10.9%	16.7%	14.1%	10.2%	11.5%
Misc. Non-Combustible	3.6%	4.2%	6.5%	5.8%	3.9%	4.4%
Other Wastes	0.3%	0.4%	0.5%	-	0.9%	1.0%
Glass	2.6%	2.4%	3.7%			
Ferrous Metals	2.4%	2.2%	3.5%	5.0%[c]	6.7%[c]	7.5%[c]
Non-Ferrous Metals	1.1%	1.0%	1.6%			

Waste Stream	ES Case	ES Case with reduced recyclables	ES Case with 90% food & plastic	CCC: current residual waste	CCC: 50% reduced plastics	CCC: 50% reduced organics
Food Waste	27.0%	25.2%	4.9%			
Garden Waste	2.7%	2.5%	3.9%	41.4%[d]	35.0%[d]	16.0%[d]
Other Organic	2.3%	2.7%	4.1%			
Wood	2.3%	2.1%	3.3%	1.0%	2.5%	2.8%
WEEE	1.1%	1.3%	2.0%	3.3%	3.6%	4.1%
Hazardous	0.5%	0.6%	0.9%	-	-	-
Fines	2.2%	2.6%	4.0%	-	-	-
Operational Parameters						
Total Carbon (% by weight)	26.20%	26.21%	25.49%	24.87%	24.07%	29.91%
Biogenic Carbon (% of Total Carbon)	57.20%	58.35%	74.58%	55.92%	66.96%	50.26%
Non-Biogenic Carbon (% of Total Carbon)	42.80%	41.65%	25.42%	44.08%	33.04%	49.74%

Waste Stream	ES Case	ES Case with reduced recyclables	ES Case with 90% food & plastic	CCC: current residual waste	CCC: 50% reduced plastics	CCC: 50% reduced organics
Net Calorific Value (MJ/kg)	9.53	9.50	8.85	9.05	8.50	11.45
Total waste input (tonnes/yr)	613,573	615,668	625,600	625,600	625,600	503,804
EfW CHP Facility operations (hours/yr)	8,000	8,000	7,667	7,713	7,667	8,000
EfW CHP Facility electricity generation output (MWe)	55.00	55.00	54.08	55.00	51.94	55.00
Notes on EfW CHP operational parameters for variations in waste composition	100% design point with 55 MWe net power output and waste throughput <625,600 t/yr	100% design point with 55 MWe net power output and waste throughput <625,600 t/yr	Reduced boiler load and MWe output plus reduced operation hours not to exceed max. waste throughput of 625,600 t/yr	100% design point with 55 MWe net power output, but reduced operation hours not to exceed max. waste throughput of 625,600 t/yr	Reduced boiler load and MWe output plus reduced operation hours not to exceed max. waste throughput of 625,600 t/yr	100% design point with 55 MWe net power output and waste throughput <625,600 t/yr

[a] CCC waste composition – paper and card combined under one waste stream category

[b] CCC waste composition – all plastics combined under one waste stream category

[c] CCC waste composition – glass and metals combined under one waste stream category

[d] CCC waste composition – food, garden and other organic waste combined under one waste stream category

Table 2.2 Extended GHG sensitivity analysis scenarios

(* indicates scenarios considered as part of the original ES sensitivity analysis or technical note update)

Scenario	Description	Input Assumptions
1	The ES Case	Assumptions and inputs for the ES Case are as described in **Section 14.8 of ES Chapter 14 Climate Change (Volume 6.2) [APP-041]** (noting adjustment for ES Case waste throughput in Table 2.1). In summary: • Assessment of lifetime emissions and project lifecycle stages • Waste composition based on WRAP 2017 profile for England**Error! Bookmark not defined.** • Electricity generation offset based on emissions factor in ES for UK grid average[1] • Electricity export only for the EfW CHP Facility, no steam export • 68% landfill gas capture rate for modern, large UK landfill[2] • No carbon capture and storage • Operational parameters are as shown in Table 2.1
Waste Composition – variations with respect to the ES Case		
2*	ES Case with reduced recyclables (65% target) (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume waste composition as per ***'Reduced Recyclables'*** in **Table 14C.1** of **Appendix 14C (Volume 6.4) [APP-088].** This is as for Scenario 1 ES Case, with a further reduction in recyclables in residual waste, in-line with UK Government policy to achieve a recycling rate of 65% for municipal solid waste by 2035[3]. Operational parameters are as shown in Table 2.1 – noting adjustment for waste throughput compared to ES Case.

[1] BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021

[2] DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling

[3] HM Government (2018). England's National Waste Strategy. OUR WASTE, OUR RESOURCES: A STRATEGY FOR ENGLAND

Scenario	Description	Input Assumptions
3*	ES Case with 90% less food and plastics (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume waste composition as per '**Reduced Food & Plastic'** in **Table 14C.1** of **Appendix 14C (Volume 6.4) [APP-088]**. This is as for Scenario 1 ES Case, with a 90% reduction in food and plastics in residual waste, in addition to the 65% recycling rate for other recyclables. Operational parameters are as shown in Table 2.1 – noting adjustment for waste throughput (maximum), operating hours and net electricity generation compared to ES Case.
4	CCC: current residual waste	Assume waste composition as per the ***'Cambridgeshire Current Residual Waste Composition'*** scenario (provided by CCC **in Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**). Operational parameters are as shown in Table 2.1 – noting adjustment for waste throughput (maximum) and operating hours compared to ES Case.
5	CCC: 50% reduced plastics	Assume waste composition as per the ***'Reduced Plastics (50% Less than Baseline)'*** scenario (provided by CCC **in Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**). Operational parameters are as shown in Table 2.1 – noting adjustment for waste throughput, operating hours and net electricity generation compared to ES Case.
6	CCC: 50% reduced organics	Assume waste composition as per the ***'Reduced Food and Garden Waste (50% Less than Baseline)'*** scenario (provided by CCC **in Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**). Operational parameters are as shown in Table 2.1 – noting adjustment for waste throughput compared to ES Case.

Scenario	Description	Input Assumptions
Electricity generation offset – variations with respect to the ES Case		
7*	Gas-fired power stations (CCGT) (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume latest emissions factor for electricity generation from natural gas[4]
8*	UK grid decarbonisation – for ES Case (included as previous sensitivity scenarios for annual emissions comparison for 2035 and 2050 in **Appendix 14C (Volume 6.4) [APP-088]**, and 40 year emissions comparison in **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**)	Assume waste composition as per Scenario 1, and assume BEIS forecast emissions factors for UK grid electricity generation[5] over 40 years (for the period 2026 to 2065)
9	UK grid decarbonisation – with reduced recyclables	Assume waste composition as per Scenario 2, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065)
10	UK grid decarbonisation – with 90% less food and plastics	Assume waste composition as per Scenario 3, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065)
11	UK grid decarbonisation – CCC: current residual waste	Assume waste composition as per Scenario 4, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065)

[4] DESNZ (2023). Fuel Mix Disclosure Data Table 2021-2022

[5] BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)

Scenario	Description	Input Assumptions
12	UK grid decarbonisation – CCC: 50% reduced plastics	Assume waste composition as per Scenario 5, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065)
13	UK grid decarbonisation – CCC: 50% reduced food	Assume waste composition as per Scenario 6, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065)
Combined Heat and Power (CHP) – variations with respect to the ES Case		
14*	CHP, export of steam from the EfW CHP Facility (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume that the EfW CHP Facility would export 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam. Assume latest emissions factors for offsetting UK grid electricity generation**Error! Bookmark not defined.**. Assume latest emissions factor for offsetting the use of natural gas as fuel for heating[6].
15	CHP, export of steam from the EfW CHP Facility UK – including grid decarbonisation	Assume that the EfW CHP Facility would export 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam. Assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065). Assume latest emissions factor for offsetting the use of natural gas as fuel for heating**Error! Bookmark not defined.** up to 2035, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** as source for heating after 2035.
Landfill Gas (LFG) capture rate – variations with respect to the ES Case		

[6] UK Government (2023). Greenhouse gas reporting: conversion factors 2023

Scenario	Description	Input Assumptions
16	52% LFG capture rate	Assumption based on the LFG collection efficiency reported for older operational UK landfills (Type 3 in MELMod)[7].
17	52% LFG capture rate – including grid decarbonisation	Assume LFG capture rate as per Scenario 16, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065).
18	85% LFG capture rate	Assumption based on experts' assumptions for the upper instantaneous LFG capture rate for landfill once gas collection infrastructure is installed**Error! Bookmark not defined.**.
19	85% LFG capture rate – including grid decarbonisation	Assume LFG capture rate as per Scenario 18, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065).
Carbon Capture & Storage (CCS) – variations with respect to the ES Case		
20	2030 adoption of CCS by the EfW CHP Facility	Assume incorporation of carbon capture technology for the EfW CHP Facility from 2030 onwards The CCS scenario considers emissions related to: • carbon capture and CO_2 separation (use of steam and electricity, raw materials and catalysts) • compression (use of electricity) • transmission by pipeline (construction of pipeline (from the nearby power station only), use of electricity to drive further compression along the pipeline) • underground storage (use of electricity) • leakage factors

[7] DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling

Scenario	Description	Input Assumptions
21	2030 adoption of CCS by the EfW CHP Facility – including grid decarbonisation	Assume adoption of CCS as per Scenario 20, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065).
22	2040 adoption of CCS by the EfW CHP Facility	Assume incorporation of carbon capture technology for the EfW CHP Facility from 2040 onwards As for Scenario 20, the CCS scenario considers emissions related to: • carbon capture and CO_2 separation (use of steam and electricity, raw materials and catalysts) • compression (use of electricity) • transmission by pipeline (construction of pipeline (from the nearby power station only), use of electricity to drive further compression along the pipeline) • underground storage (use of electricity) • leakage factors
23	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation	Assume adoption of CCS as per Scenario 22, and assume BEIS forecast emissions factors for UK grid electricity generation**Error! Bookmark not defined.** over 40 years (for the period 2026 to 2065).
In-combination scenarios for UK grid decarbonisation and CCS		
24	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and reduced recyclables (65% target)	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume waste composition as per Scenario 2.
25	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and 90% less food and plastics	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume waste composition as per Scenario 3.
26	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: current residual waste	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume waste composition as per Scenario 4.

Scenario	Description	Input Assumptions
27	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% plastics	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume waste composition as per Scenario 5.
28	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% organics	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume waste composition as per Scenario 6.
29	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CHP, export of steam from the EfW CHP Facility	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23. As for Scenario 15, assume that the EfW CHP Facility would export 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam, and assume latest emissions factor for offsetting the use of natural gas as fuel for heating[Error! Bookmark not defined.] up to 2035, and assume BEIS forecast emissions factors for UK grid electricity generation[Error! Bookmark not defined.] as source for heating after 2035.
30	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation at 52% LFG capture rate	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume a 52% LFG capture rate for older operational UK landfills, as for Scenario 16.
31	2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation at 85% LFG capture rate	Assume adoption of CCS and factors for future UK grid electricity generation as per Scenario 23, and assume an upper limit of 85% LFG instantaneous capture rate for modern UK landfill, as for Scenario 18.

3. Sensitivity Analysis Results

3.1 Summary Results

3.1.1 Summary results for the sensitivity analysis for each scenario are provided in **Table 3.1** below, presenting lifetime gross GHG emissions (excluding emissions avoided for generation of energy by Landfill and the EfW CHP Facility) and lifetime net GHG emissions (including emissions avoided for generation of energy by Landfill and the EfW CHP Facility).

3.1.2 For the net emissions a comparison is also included showing the estimated change in emissions from the Proposed Development compared to the Landfill alternative: scenarios indicating a reduction in net GHG emissions from the EfW CHP Facility are highlighted in green in **Table 3.1**; scenarios indicating an increase in net GHG emissions from the EfW CHP Facility are highlighted in red in **Table 3.1**.

3.1.3 Observations on some of the key findings of the sensitivity analysis are provided in proceeding sub-sections, with additional graphical representation of the GHG emissions for the scenarios included in the following figures:

<u>Lifetime gross GHG emissions</u>

- **Figure 3.1**: EfW CHP Facility as a standalone entity for all scenarios.
- **Figure 3.2**: EfW CHP Facility and landfill for all scenarios.

<u>Lifetime net GHG emissions</u>

- **Figure 3.3**: EfW CHP Facility and landfill for all scenarios.
- **Figure 3.4**: EfW CHP Facility and landfill for waste composition scenarios (including UK grid decarbonisation and CCS scenarios).
- **Figure 3.5**: EfW CHP Facility and landfill for CCGT and grid decarbonisation scenarios for the ES Case.
- **Figure 3.6**: EfW CHP Facility and landfill for CHP scenarios (including UK grid decarbonisation and CCS scenarios).
- **Figure 3.7**: EfW CHP Facility and landfill for LFG capture scenarios (including UK grid decarbonisation and CCS scenarios).
- **Figure 3.8**: EfW CHP Facility and landfill for CCS scenarios.

Table 3.1 Summary of lifetime gross and net GHG emissions for each scenario

Scenario	Lifetime Gross GHG Emissions (ktCO2e)		Lifetime Net GHG Emissions (kttCO2e)		
	EfW CHP Facility	Landfill	EfW CHP Facility	Landfill	Net change from Proposed Development
1) ES Case	11,243	11,397	8,040	10,611	-2,572
Waste Composition – variations with respect to the ES Case					
2) ES Case with reduced recyclables	11,011	11,673	7,808	10,868	-3,060
3) ES Case with 90% less food and plastics	7,074	14,704	4,055	13,688	-9,632
4) CCC: current residual waste	11,197	10,792	8,109	10,048	-1,940
5) CCC: 50% reduced plastics	8,409	12,487	5,509	11,625	-6,116
6) CCC: 50% reduced organics	12,143	9,413	8,940	8,765	175
Electricity generation offset – variations with respect to the ES Case					
7) Gas-fired power stations (CCGT)	11,243	11,397	4,696	9,791	-5,095
8) UK grid decarbonisation – for ES Case	11,243	11,397	10,970	11,330	-361
9) UK grid decarbonisation – with reduced recyclables	11,011	11,673	10,738	11,604	-866
10) UK grid decarbonisation – with 90% less food and plastics	7,074	14,704	6,816	14,618	-7,801

Scenario	Lifetime Gross GHG Emissions (ktCO2e)		Lifetime Net GHG Emissions (kttCO2e)		
	EfW CHP Facility	Landfill	EfW CHP Facility	Landfill	Net change from Proposed Development
11) UK grid decarbonisation – CCC: current residual waste	11,197	10,792	10,934	10,729	205
12) UK grid decarbonisation – CCC: 50% reduced plastics	8,409	12,487	8,161	12,414	-4,253
13) UK grid decarbonisation – CCC: 50% reduced food	12,143	9,413	11,870	9,357	2,512
Combined Heat and Power (CHP) – variations with respect to the ES Case					
14) CHP, export of steam from the EfW CHP Facility	11,243	11,397	5,139	10,542	-5,404
15) CHP, export of steam from the EfW CHP Facility UK – including grid decarbonisation	11,243	11,397	10,138	11,330	-1,193
Landfill Gas (LFG) capture rate – variations with respect to the ES Case					
16) 52% LFG capture rate	11,243	17,032	8,040	16,431	-8,391
17) 52% LFG capture rate – including grid decarbonisation	11,243	17,032	10,970	16,980	-6,011
18) 85% LFG capture rate	11,243	5,411	8,040	4,428	3,611
19) 85% LFG capture rate – including grid decarbonisation	11,243	5,411	10,970	5,327	5,642
Carbon Capture & Storage (CCS) – variations with respect to the ES Case					
20) 2030 adoption of CCS by the EfW CHP Facility	11,285	11,397	1,185	10,611	-9,427

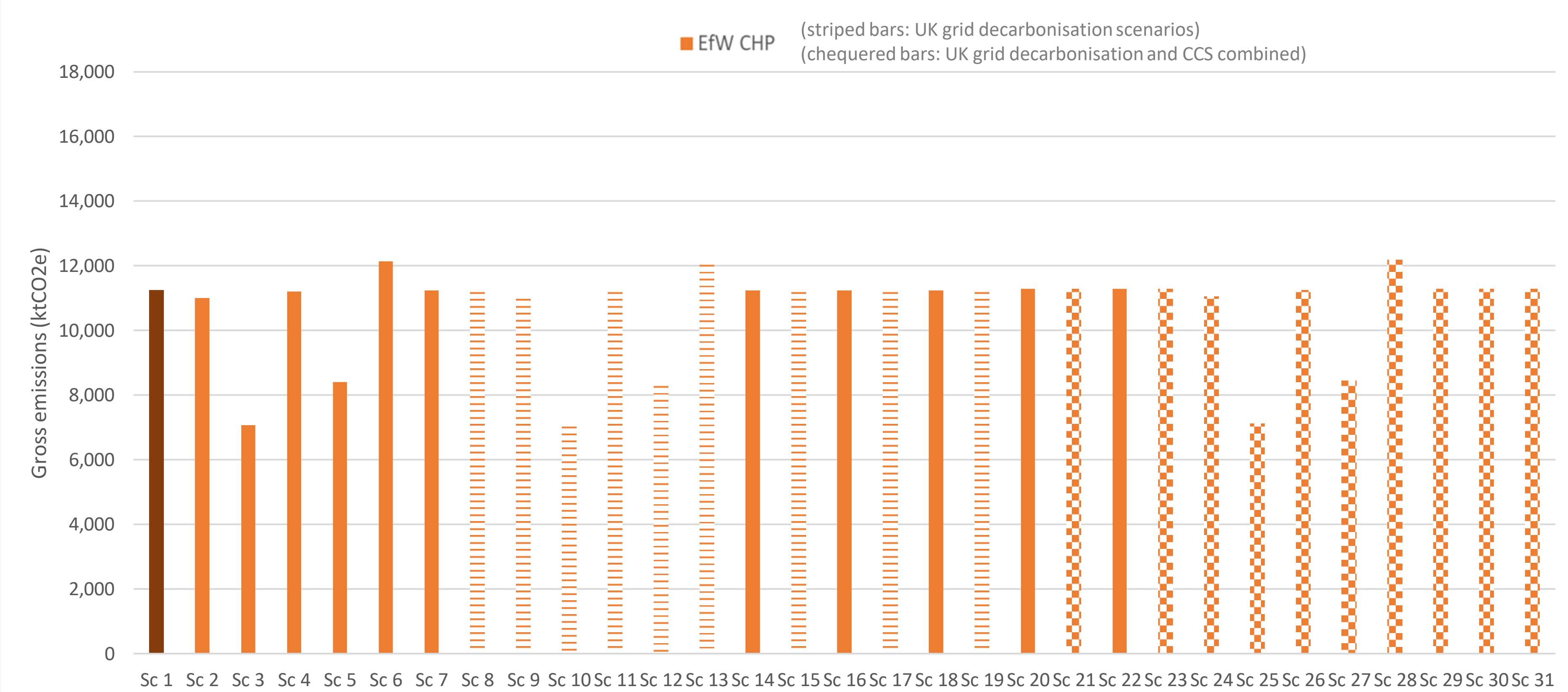
Scenario	Lifetime Gross GHG Emissions (ktCO2e)		Lifetime Net GHG Emissions (kttCO2e)		
	EfW CHP Facility	Landfill	EfW CHP Facility	Landfill	Net change from Proposed Development
21) 2030 adoption of CCS by the EfW CHP Facility – including grid decarbonisation	11,285	11,397	3,397	11,330	-7,933
22) 2040 adoption of CCS by the EfW CHP Facility	11,285	11,397	3,100	10,611	-7,511
23) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation	11,285	11,397	5,496	11,330	-5,834
In-combination scenarios for UK grid decarbonisation and CCS					
24) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and reduced recyclables (65% target)	11,053	11,673	5,392	11,604	-6,212
25) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and 90% less food and plastics	7,116	14,704	3,625	14,618	-10,992
26) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: current residual waste	11,239	10,792	5,478	10,729	-5,251
27) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% plastics	8,451	12,487	4,226	12,414	-8,187
28) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% organics	12,185	9,413	5,897	9,357	-3,460
29) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CHP, export of steam from the EfW CHP Facility	11,285	11,397	5,110	11,330	-6,221

Scenario	Lifetime Gross GHG Emissions (ktCO2e)		Lifetime Net GHG Emissions (kttCO2e)		
	EfW CHP Facility	Landfill	EfW CHP Facility	Landfill	Net change from Proposed Development
30) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and 52% LFG capture rate	11,285	17,032	5,496	16,980	-11,484
31) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and 85% LFG capture rate	11,285	5,411	5,496	5,327	169

3.2 Lifetime Gross Emissions

3.2.1 This section summarises the lifetime gross emissions for each sensitivity scenario, presenting emissions for the EfW CHP Facility as a standalone entity (**Figure 3.1**), and also in comparison to landfill (**Figure 3.2**).

Figure 3.1 <u>Gross Emissions:</u> EfW CHP Facility – ES Case vs all other scenarios



3.2.2 Lifetime gross GHG emissions for the ES Case are estimated to be 11,243 ktCO_2e (which as discussed in Section 2 takes account of the representative waste throughput of 613,573 tonnes/year for residual waste with an NCV of 9.53MJ/kg).

3.2.3 Gross emissions for the EfW CHP Facility are comparatively lower for the scenarios that consider a reduction in plastics alone (Scenarios 5,12 and 27, CCC: 50% less plastic), or a combined reduction in plastics and food (Scenarios 3, 10 and 25, ES Case with 90% reduced food and plastic), which is attributable to the relatively low non-biogenic carbon content of the residual waste for these scenarios (<40% of total carbon, see **Table 2.1**).

3.2.4 The maximum gross emissions of 12,143 to 12,185 ktCO_2e are estimated for Scenarios 6, 13 and 28, which consider a 50% reduction in organic material for the CCC waste profile. This is attributable to an increase in plastics in the residual waste and a related increase in sources of fossil (non-biogenic) carbon emissions for the EfW CHP Facility.

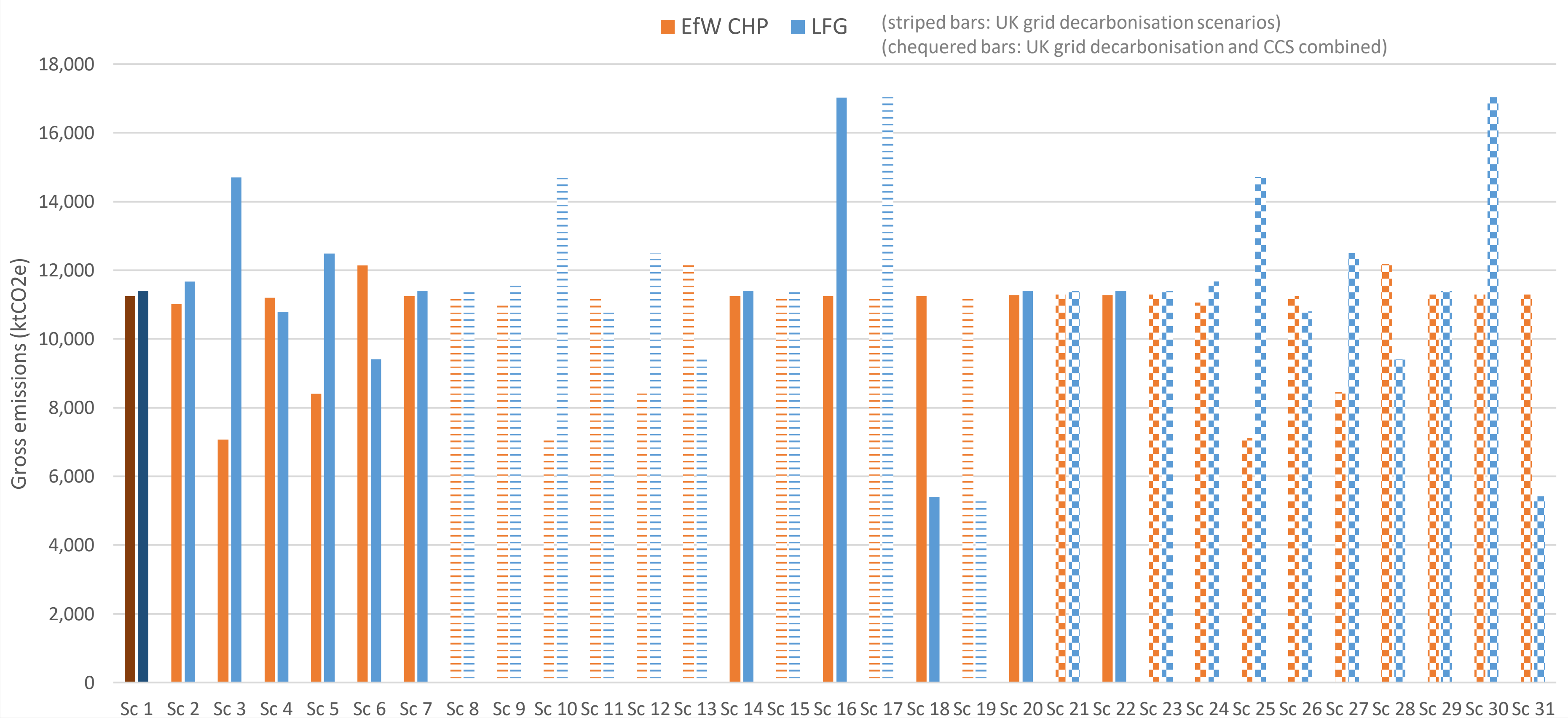
3.2.5 The other scenarios that indicate potential for a marginal increase in gross emissions compared to the ES Case are some of those that consider adoption of CCS (11,285 ktCO_2e estimated for Scenarios 20 to 23 and 29 to 31). This relates to the emissions included for the construction and decommissioning of CCS infrastructure (i.e. a connecting pipeline for the EfW CHP Facility).

3.2.6 For all of the other scenarios the gross emissions are the same as the ES Case (Scenarios 7, 8, 14, 15, 16, 17, 18, 19 and 26, where the waste composition is assumed to be the same as the ES Case), or there is a marginal decrease in gross emissions compared to the ES Core Case (Scenarios 2, 9 and 24, ES Core Case with reduced recyclables, and Scenarios 4, 11 and 26, CCC Current Case).

3.2.7 When considering lifetime gross emissions for the EfW CHP Facility and landfill (see Figure 3.2 below), the majority of scenarios indicate that gross emissions would be less with the EfW CHP Facility, with the greatest reduction in gross emissions estimated to be for Scenarios 3, 10 and 25 (ES Case with 90% reduced food & plastic). The exceptions to this, where gross emissions are higher for the EfW CHP Facility than landfill, are for Scenarios 4, 11 and 26 (CCC: current residual waste); Scenarios 6, 13 and 28 (CCC: 50% less organics); and Scenarios 18, 19 and 31 (85% LFG capture rate).

3.2.8 The scenarios for the 85% LFG capture rate represent the greatest difference in additional gross emissions for the EfW CHP Facility compared to landfill (at 5,832 to 5,874 ktCO_2e of additional gross emissions), which considers the highest estimate for instantaneous capture of LFG from landfill. Conversely, scenarios for the 52% LFG capture rate (included as the LFG collection efficiency reported for older operational UK landfills[7]) represents some of the greatest reductions in gross emissions for the EfW CHP Facility compared to landfill (5,747 to 5,789 ktCO_2e reduction in gross emissions).

Figure 3.2 <u>Gross Emissions:</u> EfW CHP Facility and Landfill (LFG) – ES Case vs all other scenarios



3.2.9 In terms of the waste composition scenarios that were considered by CCC in their own assessment of GHG emissions for the Proposed Development (**Deadline 1 Submission - Joint Local Impact Report with Cambridgeshire County Council (paras 9.4.9 to 9.4.10) [REP1-074]** and **Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**), there is alignment in this sensitivity analysis with the pattern identified in the CCC analysis with regard to the following waste composition scenarios (noting that a direct comparison is not possible as the scenarios in this sensitivity analysis now account for lifetime emissions rather than annual operational emissions):

- Scenario 3 (ES Case: 90% reduced food & plastic): gross emissions lower for the EfW CHP Facility than landfill.

- Scenario 4 (CCC: current residual waste): gross emissions higher for the EfW CHP Facility than landfill.
- Scenario 5 (CCC: 50% less plastics): gross emissions lower for the EfW CHP Facility than landfill.
- Scenario 6 (CCC: 50% less organics): gross emissions higher for the EfW CHP Facility than landfill.

3.2.10 This sensitivity analysis differs to the pattern identified in the CCC analysis with regard to Scenarios 1 and 2 (ES Case and ES Case with reduced recyclables), as the CCC analysis identifies that emissions for landfill would be marginally lower than the EfW CHP Facility (in the order of 2 to 5% lower for landfill), whereas for this sensitivity analysis the EfW CHP Facility has marginally lower emissions than landfill (in the order of 1 to 6% lower for the EfW CHP Facility). Aside from the indirect comparison of annual operational emissions and lifetime emissions, the difference between the patterns observed for Scenarios 1 and 2 may be attributable to the carbon content values assigned to the material sub-categories for waste in each sensitivity analysis (i.e. paper/card, plastics etc). This was identified as a potential source of discrepancy in the Technical Meeting Note for this sensitivity analysis (see Appendix A), where it was agreed to use the WRATE model[8] to derive carbon content values, as this was able to accommodate additional detail for material sub-categories in the waste composition.

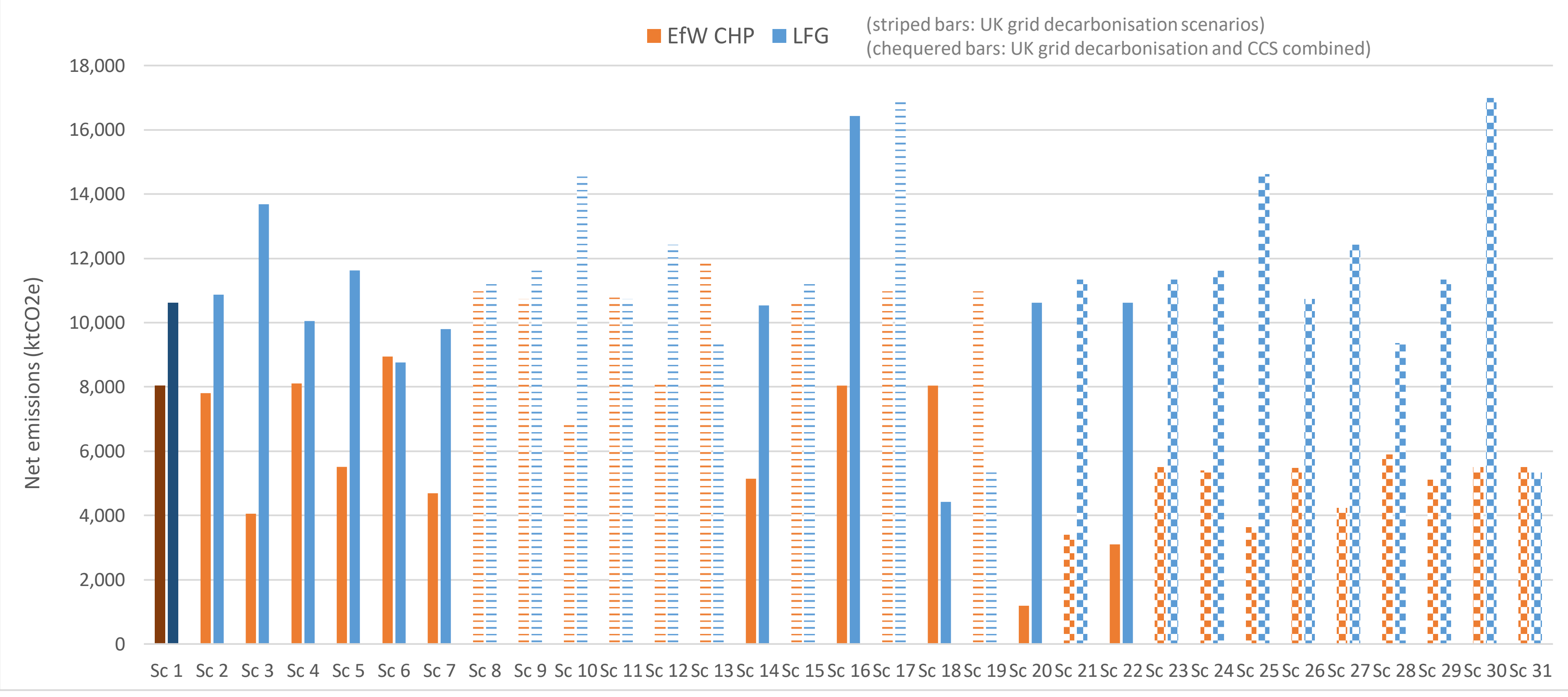
[8] WRATE (2011), Greenhouse Gas Calculator for Municipal Waste. WRATE v2

3.3 Lifetime Net Emissions

Net Emissions – all scenarios

3.3.1 This section summarises the lifetime net emissions for the sensitivity scenarios, presenting emissions for all of the scenarios in **Figure 3.3**.

Figure 3.3 <u>Net Emissions:</u> ES Case vs all other scenarios



3.3.2 The lifetime net emissions for each scenario includes consideration of avoided emissions for energy generation (and carbon capture and storage where relevant). The following general observations are made with respect to the lifetime net emissions estimated for the EfW CHP Facility and landfill:

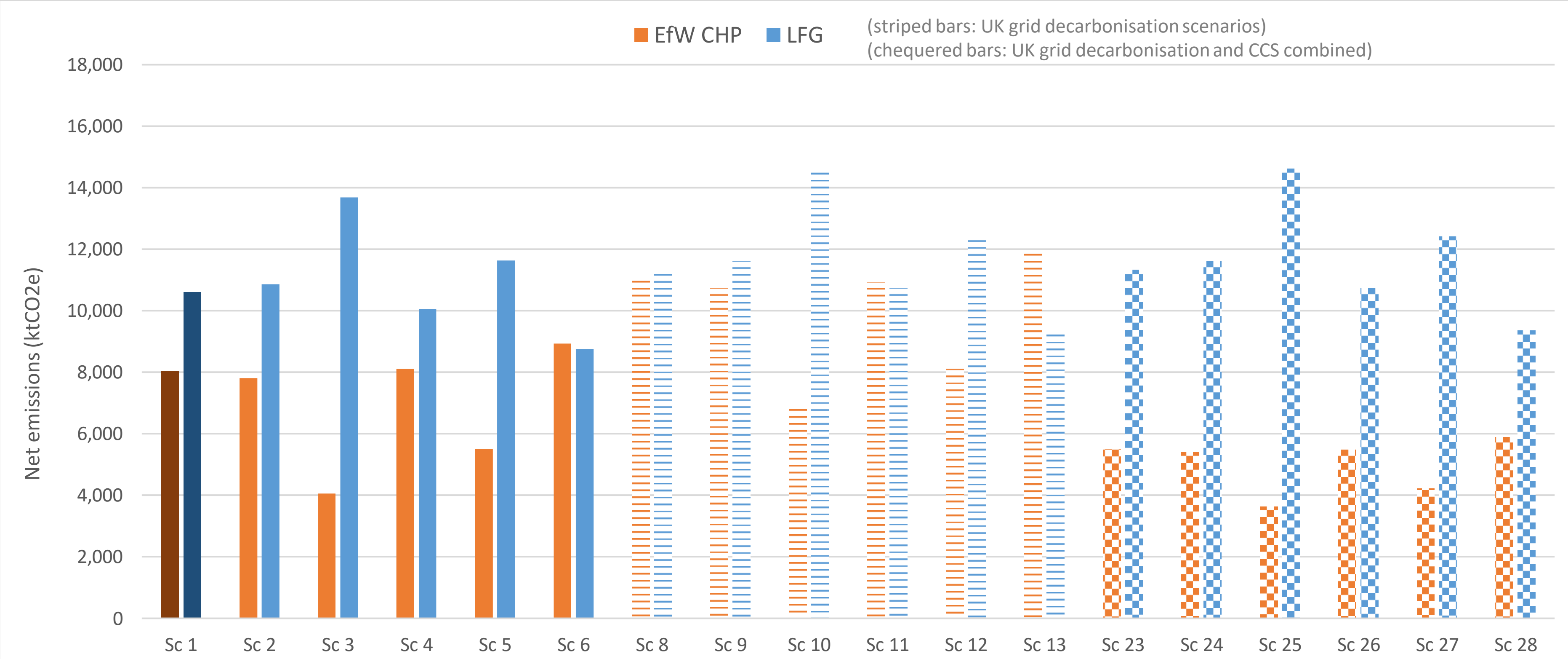
- As for the gross emissions the majority of scenarios indicate that net emissions would be less for the EfW CHP Facility compared to landfill. Again, among the scenarios with the greatest reduction in estimated net emissions compared to landfill is where there is a combined reduction in plastic and food in residual waste (Scenarios 3 and 25: ES Case with 90% reduced food & plastic); although the highest reduction in estimated net emissions is where decarbonisation and CCS are considered for a LFG capture rate of 52% (Scenario 30).
- The scenarios where lifetime net emissions are higher for the EfW CHP Facility than landfill are:
  - Scenario 11 (CCC: current residual waste – with UK grid decarbonisation).
  - Scenarios 6 and 13 (CCC: 50% less organics – for the current UK grid average and with UK grid decarbonisation).
  - Scenarios 18 and 19 (85% LFG capture rate – for the current UK grid average and with UK grid decarbonisation).
- Other than the scenarios referred to above, the scenarios with the greatest savings in net emissions compared to landfill (>70% reduction) are those that account for adoption of CCS, i.e. Scenarios 20 to 22 (adoption of CCS by 2030 – for the current UK grid average and with UK grid decarbonisation, and adoption of CCS by 2040 – for the current UK grid average).
- As expected, and as identified in the original ES sensitivity analysis, accounting for UK grid decarbonisation (without considering adoption of CCS) reduces the avoided emissions attributable to energy generated by both the EfW CHP Facility and landfill.

3.3.3 Key observations related to the main categories for the sensitivity analysis (waste composition, electricity generation offsetting, CHP, LFG capture and CCS) accompany the respective **Figures 3.4** to **3.8** below.

Net Emissions – waste composition scenarios

3.3.4 This section considers the lifetime net emissions for the waste composition scenarios, presenting emissions for the relevant scenarios (including for UK grid decarbonisation and adoption of CCS by 2040) in **Figure 3.4**.

Figure 3.4 <u>Net Emissions:</u> ES Case vs waste composition scenarios



3.3.5 With the exception of Scenario 6 (CCC: 50% reduced organics) the waste composition scenarios that consider current UK grid average emissions (Scenarios 1 to 6) all show a reduction in net lifetime missions for the EfW CHP Facility compared to landfill. In the case of Scenario 6, where organic material in residual waste is reduced but plastics are not, the higher net emissions for the EfW CHP Facility are attributable to an increase in plastics in the residual waste and a related increase in sources of fossil (non-biogenic) carbon emissions for the EfW CHP Facility. The greatest reduction in lifetime net emissions for the EfW CHP Facility for these scenarios is for Scenario 3 (ES Case with 90% reduced food & plastic) at 9,632 ktCO_2e, which is in line with the findings of the original ES sensitivity analysis. This is followed by Scenario 5 (CCC: 50% reduced plastics) at 6,116 ktCO_2e, although this scenario does not allow for an accompanying reduction in organic material in the residual waste.

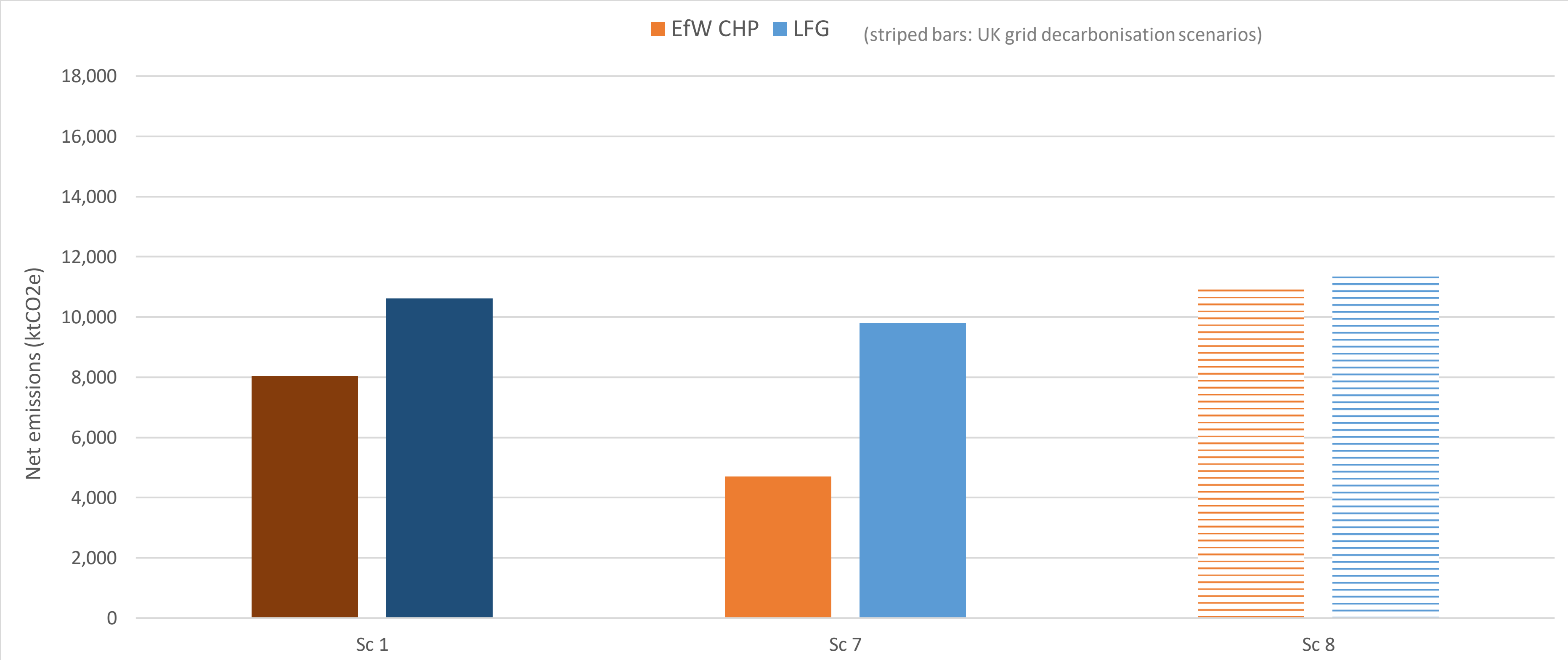
3.3.6 When UK grid decarbonisation (without the adoption of CCS) is considered for the waste composition scenarios there is an overall increase in the net emissions for the EfW CHP Facility and for landfill, and the savings attributable to the EfW CHP Facility are reduced; although for most scenarios the EfW CHP Facility would still provide net savings in emissions. However, a change is noted in the case of Scenario 11 (CCC: current residual waste – with UK grid decarbonisation), where the analysis indicates that the EfW CHP Facility would no longer provide emissions savings and would have marginally higher emissions than landfill (2% higher net emissions for the EfW CHP Facility for UK grid decarbonisation, compared to net savings of 19% for the EfW CHP Facility for the current UK grid average).

3.3.7 When adoption of CCS by the EfW CHP Facility is considered as part of future UK grid decarbonisation (Scenarios 23 to 28), the analysis indicates the Proposed Development would provide a reduction in net lifetime missions for all of the variations in waste composition, including for CCC: 50% reduced organics and CCC: current residual waste.

Net Emissions – alternative electricity generation scenarios

3.3.8 This section focusses on the lifetime net emissions for the ES Case considering sources of electricity generation that would be replaced by the EfW CHP Facility or landfill. Emissions for the relevant scenarios (CCGT and UK grid decarbonisation applied to the ES Case) are presented in **Figure 3.5**.

Figure 3.5 Net Emissions: ES Case vs replacing CCGT Power Plants and UK grid decarbonisation scenarios



3.3.9 Scenario 7 considers the case where electricity generated by both the EfW CHP Facility and landfill would replace electricity generated by gas-fired power stations (CCGT), which is in line with guidance from DEFRA[9] as the reasonable substitute for energy generated by EfW facilities (which was used at PEIR and has been used as a comparator in several development applications[10], see **Appendix C**). The analysis shows that for this electricity generation scenario there would be a further improvement in the net emissions savings for the EfW CHP Facility compared to landfill, from 24% (for the current UK grid average) to 52% (for CCGT electricity generation).

3.3.10 Scenario 8 considers the case for future decarbonisation of UK grid average electricity generation, which is a progression on the existing ES Case that considers that the EfW CHP Facility would replace current UK grid average electricity generation. The analysis shows that for this electricity generation scenario there would continue to be net savings for the EfW CHP Facility compared to landfill; however, the savings would be reduced from 24% (for the current UK grid average) to 3% (for UK grid decarbonisation). This is in line with the findings of **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**, submitted in November 2022.

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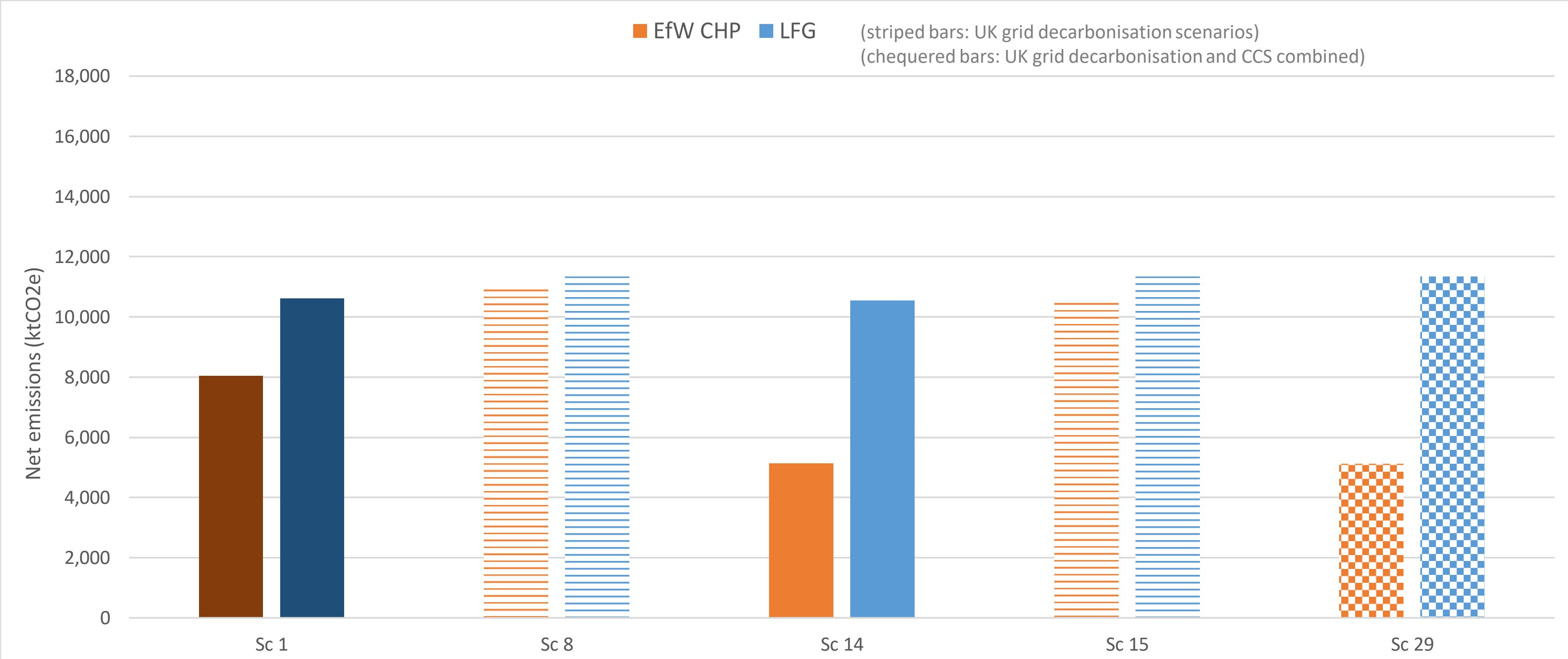
[9] DEFRA (2014). *Energy from waste. A guide to the debate.*

[10] Longfield Solar Farm: PINS Ref: EN010118; Wheelabrator Kemsley Generating Station (K3) and Wheelabrator Kemsley North (WKN) Waste to Energy Facility: PINS Ref: EN010083; Mallard Pass Solar Project: PINS Ref: EN010127; North Lincolnshire Green Energy Park: PINS Ref: EN010116; South Humber Bank Energy Centre: PINS Ref: EN010107.

Net Emissions – CHP scenarios

3.3.11 This section considers the lifetime net emissions for the CHP scenarios. **Figure 3.6** provides a comparison of net emissions for the ES Case (including with decarbonisation) with scenarios that include CHP for the EfW CHP Facility, with the export of steam for heating as well as the generation of electricity.

Figure 3.6 Net Emissions: ES Case vs CHP scenarios

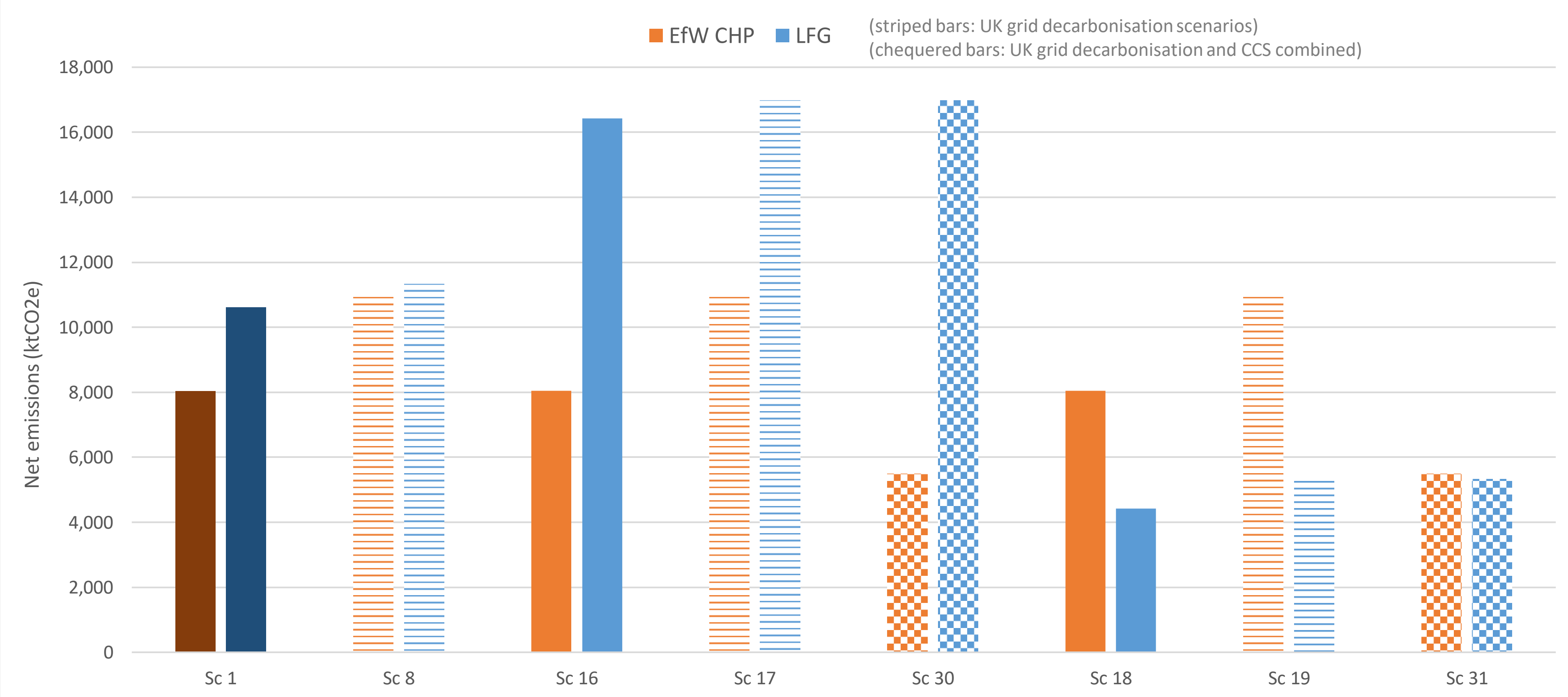


3.3.1 For each of the comparison scenarios the implementation of CHP for the EfW CHP Facility would continue to deliver net emissions savings compared to landfill. For Scenario 14 (CHP at the current UK grid average) the net emissions savings would increase to 51%; for Scenario 15 (CHP with UK grid decarbonisation) the net emissions savings would be the lowest at 6%; and for Scenario 29 (CHP with UK grid decarbonisation and adoption of CCS) the net emissions savings would be greatest at 55%.

Net Emissions – LFG capture rate scenarios

3.3.2 This section considers the lifetime net emissions for the LFG capture rate scenarios. **Figure 3.7** provides a comparison of net emissions for the ES Case with variations in LFG capture rates reported for landfills in the UK. For the ES Case a 68% LFG capture rate has been used, which is considered to be representative of the instantaneous capture rate for modern, large landfill operations in the UK[7].

Figure 3.7 <u>Net Emissions:</u> ES Case vs LFG capture rate scenarios



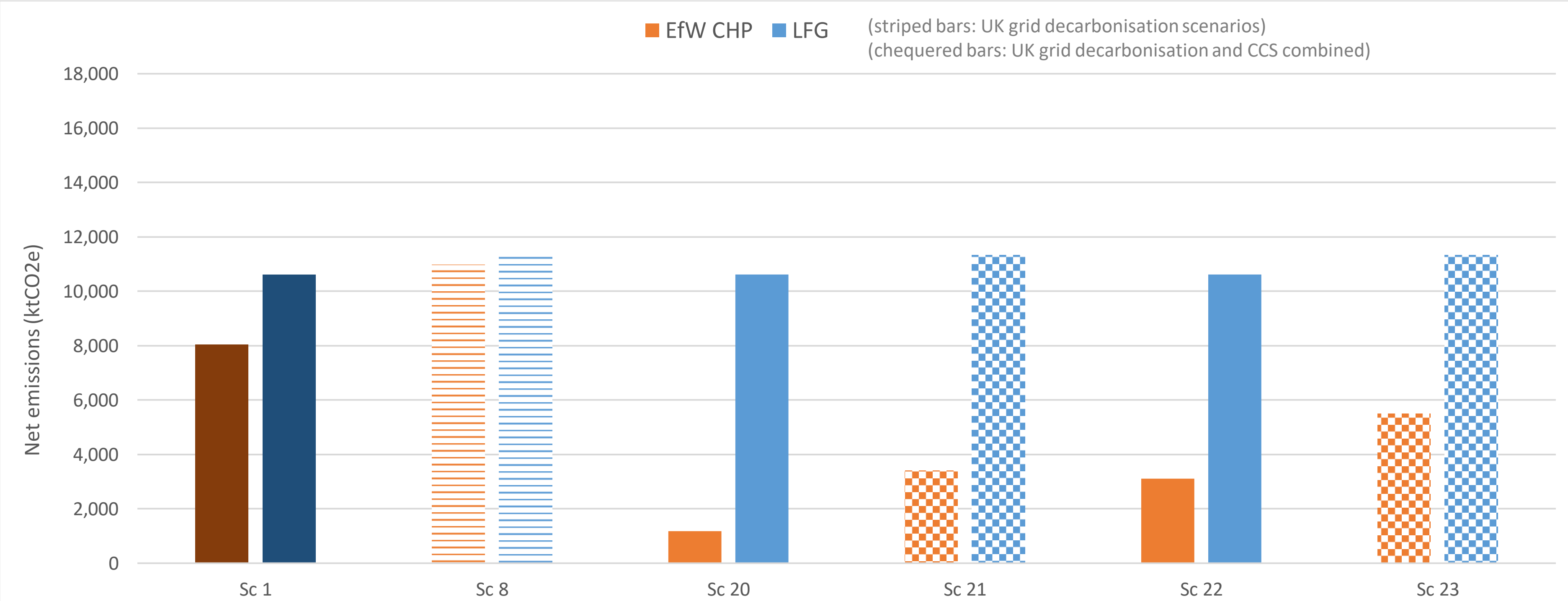
3.3.3 Scenarios 16, 17 and 30 assume an LFG capture rate reported for older operational UK landfills, at 52%[7]. For each of these scenarios there is an increase in the net emissions attributable to landfill compared to the ES Case as more methane is considered to escape to the atmosphere. Compared to the ES Case the net emissions savings for the EfW CHP Facility over landfill for these scenarios would increase to between 35% (with UK grid decarbonisation) and 67% (UK grid decarbonisation combined with adoption of CCS).

3.3.4 Conversely, Scenarios 18, 19 and 31 assume an instantaneous LFG capture rate of 85%, reported by experts as the upper bound capture rate once gas collection infrastructure has been installed[7]. For each of these scenarios there is a decrease in the net emissions attributable to landfill, to the point where the EfW CHP Facility would have higher emissions than landfill: 82% higher than landfill for Scenario 18 (current UK grid average); 106% higher than landfill for Scenario 19 (UK grid decarbonisation); and marginally higher than landfill at 3% for Scenario 31 (UK grid decarbonisation combined with adoption of CCS). With the exception of Scenario 31, the 85% LFG capture rate scenarios represent the highest net emissions for the EfW CHP Facility compared to landfill.

Net Emissions – CCS scenarios

3.3.5 This section considers the lifetime net emissions for the CCS scenarios (excluding those CCS scenarios already discussed in previous sections for waste composition, CHP and LFG capture). **Figure 3.8** provides a comparison of net emissions for the ES Case with scenarios that consider the adoption of CCS technology for capturing carbon dioxide emissions from the EfW CHP Facility by 2030 (Scenarios 20 and 21) and 2040 (Scenarios 22 and 23).

Figure 3.8 <u>Net Emissions:</u> ES Case vs CCS scenarios



3.3.6 Each of the comparison scenarios show that the adoption of CCS technology at the EfW CHP Facility in the timescales indicated would deliver further improvements in the lifetime net emissions savings for the EfW CHP Facility compared to landfill. Compared to the ES Case, adoption of CCS would increase net emissions savings for the EfW CHP Facility from 24%, to between 51% and 89%. The CCS scenarios represent among the highest net emissions savings for the EfW CHP Facility compared to landfill.

4. Summary Discussion

4.1.1 Key findings from the sensitivity analysis and additional context are discussed in the following sections.

Waste composition

4.1.2 The majority of waste composition scenarios indicate that net emissions would be less for the EfW CHP Facility compared to the landfill alternative.

4.1.3 The waste composition scenarios with the greatest reduction in estimated net emissions compared to landfill are where there is a combined reduction in plastic and food in residual waste (Scenarios 3, 9 and 25) or a reduction in plastics only in residual waste (Scenarios 5, 12 and 27).

4.1.4 The waste composition scenarios where lifetime net emissions are higher for the EfW CHP Facility than landfill are where there is a reduction in organics only in residual waste (Scenarios 6 and 13), or the case where the CCC current waste profile is considered in combination with UK grid decarbonisation (Scenario 11).

4.1.5 While sensitivity testing can consider scenarios where only plastics or only organics are reduced in residual waste, this does not necessarily align with polices that are seeking to achieve reductions in both plastics and organics in residual waste, i.e. the scenarios may not be mutually exclusive. Further discussion regarding the characteristics of residual waste to be treated at the Proposed Development are included in the Waste Fuel Availability Assessment (**WFAA (Volume 7.3) [REP5-019] (Rev 3.0)**).

4.1.6 Policies targeting a reduction in organics and plastics in waste are described in the recent DEFRA consultation document[11], seeking evidence to support the elimination of biodegradable waste in landfill as part of the waste sector's road to Net Zero. Amongst other policies and regulations the document includes reference to: working towards eliminating food waste to landfill by 2030; achieving a 65% municipal waste recycling rate by 2035; implementation of the Plastic Packaging Tax (2022); and introduction of the Extended Producer Responsibility for Packaging (pEPR) scheme by 2024. The document also states:

> *Reforming the way in which recyclable material is collected will be essential to increasing recycling and minimising the volume of biodegradable municipal waste sent to landfill. This will be achieved through the mandatory consistent collection and recycling of a core set of materials (paper and card; glass; metal; plastic; food waste; and garden waste (from households only).*

4.1.7 Based on these policies the likelihood is that plastics and organics would both be reduced in residual waste (along with other recyclable materials), which is considered in part in Scenarios 3, 9 and 25 (ES Case with 90% less food and

[11] DEFRA (2023). *Call for evidence to support the near elimination of biodegradable waste disposal in landfill from 2028*

plastics), although the extent to which a 90% reduction of these materials in residual waste can be achieved is uncertain.

Electricity generation offsetting

4.1.1 The scenarios considering the sensitivity of the ES Case with respect to sources of electricity generation replaced by the EfW CHP Facility (CCGT and UK grid decarbonisation) both indicate that net emissions would be less for the EfW CHP Facility compared to landfill.

4.1.2 Compared to the net emissions savings for ES Case, there would be an increase in emissions savings where the EfW CHP Facility replaces electricity generated by CCGT (Scenario 7), but the scale of emissions savings would be reduced when compared to electricity generated taking into account UK grid decarbonisation (Scenario 8).

4.1.3 The grid is expected to be decarbonised in future years and sensitivity tests considering this are included in this sensitivity analysis (and in the **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**), as requested by stakeholders.

CHP, export of steam from the EfW CHP Facility

4.1.1 The scenarios that consider implementation of CHP for the EfW CHP Facility show that the export of steam in combination with electricity generation would deliver net emissions savings compared to landfill. The net emissions savings range from 6% for Scenario 15 (UK grid decarbonisation), to 55% for Scenario 29 (CHP with UK grid decarbonisation and adoption of CCS).

4.1.2 Operating in CHP mode is the preferred option for the EfW CHP Facility but has not been accounted for in the ES Case on a precautionary basis. As noted in the original sensitivity analysis for the ES opportunities to export steam in combination with electricity are subject to ongoing review to ensure the most effective application of this capability for the EfW CHP Facility.

LFG capture rate

4.1.3 The scenarios for LFG capture rates provide potentially the greatest disparity between estimated savings and increases in net emissions for the EfW CHP Facility compared to landfill.

4.1.4 At one end of the scale, the 52% LFG capture rate reported for older operational UK landfills[7] would result in net emissions savings for the EfW CHP Facility of between 35% and 67% (Scenarios 16, 17 and 30). Conversely, the 85% LFG capture rate reported by experts as the upper bound capture rate once gas collection infrastructure has been installed[7], would result in higher emissions for the EfW CHP Facility compared to landfill, in the order of 82% to 105% (for Scenarios 18 and 19); however, the difference is marginal when the adoption of CCS is also considered, i.e. in the order of 3% higher emissions for the Proposed Development for Scenario 31.

4.1.5 For the ES Case a 68% LFG capture rate has been used, which is considered to be representative of the instantaneous capture rate for modern, large landfill operations in the UK[7].

4.1.6 There is ongoing debate regarding the most appropriate LFG capture rate to use for landfill emissions. It is noted that in the Climate Change Committee's 6th Carbon Budget report for the waste sector[12], that although LFG capture rates increased significantly in the period up to the early 2010s, LFG capture rates have peaked and are now declining. The 6th Carbon Budget for the waste sector includes a baseline LFG capture rate of 60%; an aspirational LFG capture rate by 2050 of 80%; and includes the 68% LFG capture rate used in the ES Case (in the 'Widespread Engagement' scenario for 2030 and 2050). In a supplementary progress report[13] the Climate Change Committee identifies that the Government's pathway to Net Zero assumes no improvement to methane capture rates; the Climate Change Committee's own Balanced Pathway identifies an ambition to capture 80% landfill methane by 2050.

CCS

4.1.7 The scenarios that consider adoption of CCS for the EfW CHP Facility (by 2030 or 2040) show that for each of the scenarios there would be an improvement in the lifetime net emissions savings for the EfW CHP Facility compared to landfill. Compared to the ES Case, adoption of CCS would increase net emissions savings for the EfW CHP Facility from 24%, to between 51% and 89%. The CCS scenarios represent some of the highest net emissions savings for the EfW CHP Facility compared to landfill.

4.1.8 As identified in **Table 14.15, ES Chapter 14 Climate Change (Volume 6.2) [APP-041**], the EfW CHP Facility will be carbon capture retrofit ready with land set aside for a CCS Facility. It is noted that to support UK grid decarbonisation a carbon dioxide transmission pipeline is being considered at Kings Lynn. A connecting pipeline for carbon captured from the Proposed Development to this transmission pipeline is considered a viable option, which would support the adoption of CCS technology at the EfW CHP Facility.

4.1.9 The avoided emissions calculated for each of the scenarios that include adoption of CCS account for the capture of carbon dioxide from fossil sources only and does not include any carbon dioxide captured from biogenic carbon sources.

Evaluation of Likelihood

4.1.10 It is evident from the outputs of this sensitivity analysis (and previous sensitivity assessments) that there are several variables that can affect the determination of GHG emissions associated with treatment of residual waste by the EfW CHP Facility and its comparison with landfill.

[12] Climate Change Committee (2020). *The Sixth Carbon Budget, Waste*

[13] Climate Change Committee (2022). *Progress in reducing emissions, 2022 Report to Parliament*

4.1.11 The likelihood of each scenario has been considered in terms of the supporting technologies and national policies using the framework presented in **Table 4.1**.

Table 4.1 Parameters for determining likelihood for the sensitivity scenarios

Likelihood	Technology and its implementation	Regulations / National Policy
Highly Likely	Existing practice with numerous examples of permitted activity operating for ten years or more in England.	Regulations in place to ensure the change in practice occurs or the new conditions are met.
Likely	Existing practice with one or more examples of permitted activity operating for three years or more in England.	Policies in place and Regulations drafted or proposed to ensure the change in practice occurs or the new conditions are met.
Just as likely as unlikely	May not be existing practice but is identified as Best Available Technique (BAT) with one or more examples of permitted activity in the UK or Europe.	The change in practice or new conditions are the subject of policy consultation or recommendations made by the Climate Change Committee.
Unlikely	May not be existing practice and does not meet the definition of Best Available Technique (BAT).	The change in practice or new conditions have not been the subject of policy consultation or recommended by the Climate Change Committee.

4.1.12 **Table 4.2** evaluates the scenarios in terms of likelihood with respect to technology and with respect to the status of existing regulations and national policies. This does not necessarily remove the uncertainties but provides a sense-check on the relative significance of the scenarios when considering GHG emissions for the EfW CHP Facility.

4.1.13 Of the 31 scenarios, seven are considered *Highly Likely* both in terms of technology and policy. Compared to landfill, six of these scenarios would result in a net reduction in carbon emissions if the Proposed Development went ahead. The reduction in emissions for these six scenarios ranges between -361 and -5,404 ktCO_2e. There is one scenario (Scenario 11) that is *Highly Likely* and predicted to result in increased emissions, although the increase is only marginal (205 ktCO_2e).

4.1.14 Nine of the scenarios are considered *Likely* in terms of both technology and policy. Compared to landfill, all of these scenarios would result in a net reduction in carbon emissions if the Proposed Development went ahead. The reduction in emissions for these nine scenarios ranges between -3,460 and -11,484 ktCO_2e.

4.1.15 Ten of the scenarios are considered *Just as Likely as Unlikely* for either technology or policy. Eight of these scenarios would result in a net reduction in carbon emissions (-866 to -9,632 ktCO_2e) and two would result in a net increase (175 to 2,512 ktCO_2e) if the Proposed Development went ahead.

4.1.16 Three of the scenarios are considered *Likely* in terms of technology but *Unlikely* in terms of policy (scenarios 18, 19 and 31). Each of these scenarios include achieving an 85% LFG capture rate and would result in a net increase in carbon emissions for the Proposed Development (169 to 5,642 ktCO2e).

4.1.17 The remaining two scenarios are considered *Highly Likely* in terms of technology and *Likely* in terms of policy (scenarios 16 and 17). Both of these scenarios include achieving a 52% LFG capture rate and would result in a net reduction in carbon emissions for the Proposed Development (-6,011 to -8,391 ktCO2e).

Table 4.2 Review of sensitivity scenario likelihood

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
1) ES Case	-2,572	*Highly Likely*	*Highly Likely*	This scenario is already being achieved in the UK using existing technology, Local Authority (LA) waste management infrastructure, so is considered *Highly Likely* for implementation. EfW is preferable to landfill with respect to the waste management hierarchy and therefore remains *Highly Likely* with respect to existing regulations and national policy. Guidance from DEFRA[14] indicates that in 2014, replacement of electricity generated by CCGT was considered to be the source of energy that would be replaced by EfW plants (as the marginal energy factor was approximately the same as CCGT). However, the guidance recognises that the marginal energy mix is expected to vary over time as a result of the decarbonisation of the grid. As such, the electricity generation offset is based on emissions factor in ES for the current UK grid average (accounting for decarbonisation of the grid since 2014). This is considered to be the source of energy that would be replaced by the EfW CHP Facility.
Waste Composition – variations with respect to the ES Case				
2) ES Case with reduced recyclables (65% target)	-3,060	*Just as likely as unlikely*	*Likely*	It is considered that technology is available for achieving a 65% recycling rate. However, the latest DEFRA data indicates that current (2021) UK recycling rates are at 44.6% (44.1% for England), which shows limited improvement to the UK recycling

[14] DEFRA (2014). Energy recovery for residual waste A carbon based modelling approach

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
				rate in 2015, at 44.5% (44.3% for England)[15], and there is uncertainty regarding the effectiveness of LA waste management infrastructure to support the level of recycling considered for this scenario. National policies include targets to achieve 65% recycling by 2035 for local authority collected waste only. The EfW CHP Facility would also treat industrial and commercial waste for which there is no statutory recycling target.
3) ES Case with 90% less food and plastics	-9,632	*Just as likely as unlikely*	*Likely*	Technologies and infrastructure for the separate collection of food and plastic waste are available in the UK. However, the latest DEFRA data[15] indicates minimal improvement in recycling rates since 2015 (see comment for Scenario 2), so considering the implementation of existing LA waste management infrastructure it is unclear whether the 90% reduction in food and plastics in residual waste for this scenario is achievable. National policies are in place targeting a reduction in food and plastics in residual waste[11].
4) CCC: current residual waste	-1,940	*Highly Likely*	*Highly Likely*	This scenario is already being achieved by CCC using existing technology, waste management infrastructure and regulations.
5) CCC: 50% reduced plastics	-6,116	*Just as likely as unlikely*	*Likely* *(but not in isolation)*	Technologies and infrastructure for the separate collection of plastics are available in the UK; however, the latest DEFRA data[15] indicates minimal improvement in recycling rates since 2015 (see comment for Scenario 2), so considering the

[15] DEFRA (2023). https://www.gov.uk/government/statistics/uk-waste-data/uk-statistics-on-waste

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
				implementation of existing LA waste management infrastructure it is unclear whether a 50% reduction in plastics in residual waste for this Scenario is achievable. National policies are in place targeting a reduction in plastics in residual waste[11]; however, for Scenario 5 this unlikely to occur in isolation as policies are also targeting a reduction in organic material in residual waste.
6) CCC: 50% reduced organics	175	*Just as likely as unlikely*	*Likely* *(but not in isolation)*	Technologies and infrastructure for the separate collection of organic material are available in the UK; however, the latest DEFRA data[15] indicates minimal improvement in recycling rates since 2015 (see comment for Scenario 2), so considering the implementation of existing LA waste management infrastructure it is unclear whether a 50% reduction in organics in residual waste for this Scenario is achievable. National policies are in place targeting a reduction in organic material in residual waste[11]; however, for Scenario 6 this unlikely to occur in isolation as policies are also targeting a reduction in plastic material in residual waste.
Electricity generation offset – variations with respect to the ES Case				
7) Gas-fired power stations (CCGT)	-5,095	*Highly Likely*	*Highly Likely*	CCGT electricity generation is well established and the replacement of electricity generated by CCGT is in line with existing guidance from DEFRA[9] as the reasonable substitute for energy generated by EfW plants.
8) UK grid decarbonisation – for ES Case	-361	*Highly Likely*	*Highly Likely*	

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
9) UK grid decarbonisation – with reduced recyclables (65% target)	-866	*Just as likely as unlikely*	*Likely*	Grid decarbonisation is a key part of UK Government policy to achieve carbon net zero. The technologies and policies to make this happen are all considered *Highly Likely*. It is noted that as part of UK grid decarbonisation it is likely that CCS technology would be installed for the EfW CHP Facility, so the additional benefits identified for Scenarios 21 and 23 may be applicable for each of the UK grid decarbonisation scenarios. For the purposes of this sensitivity analysis, the technology and policy likelihood is based on the underlying scenario. For example, Scenario 2 underlines Scenario 9.
10) UK grid decarbonisation – with 90% less food and plastics	-7,801	*Just as likely as unlikely*	*Likely*	
11) UK grid decarbonisation – CCC: current residual waste	205	*Highly Likely*	*Highly Likely*	
12) UK grid decarbonisation – CCC: 50% reduced plastics	-4,253	*Just as likely as unlikely*	*Likely* *(but not in isolation)*	
13) UK grid decarbonisation – CCC: 50% reduced food	2,512	*Just as likely as unlikely*	*Likely* *(but not in isolation)*	
Combined Heat and Power (CHP) – variations with respect to the ES Case				
14) CHP, export of steam from the EfW CHP Facility	-5,404	*Highly Likely*	*Highly Likely*	This scenario is already being achieved in the UK using existing technology and regulations. Potential to use the heat generated by the EfW CHP Facility is supported the UK Government's Energy Bill[16], which includes

[16] UK Government (2022). *The Energy Bill 2022-23, parts 7-10: heat networks, smart appliances, load control and energy performance of buildings.* https://commonslibrary.parliament.uk/research-briefings/cbp-9787/

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
				provisions for the creation and regulation of designated heat network zones, where zoning will be used to require heat network installation in new buildings as the first option for heat provision.
15) CHP, export of steam from the EfW CHP Facility UK – including grid decarbonisation	-1,193	*Highly Likely*	*Highly Likely*	As for Scenario 14 (see comment above for Scenarios 8-13 regarding relevance of grid decarbonisation in relation to technology and regulation/policy).
Landfill Gas (LFG) capture rate – variations with respect to the ES Case				
16) 52% LFG capture rate	-8,391	*Highly Likely*	*Likely*	This scenario is already being achieved in the UK using existing technology and regulations.
17) 52% LFG capture rate – including grid decarbonisation	-6,011	*Highly Likely*	*Likely*	As for Scenario 17 (see comment above for Scenarios 8-13 regarding relevance of grid decarbonisation in relation to technology and regulation/policy).
18) 85% LFG capture rate	3,611	*Likely*	*Unlikely*	An instantaneous LFG capture rate of 85% is considered to be the upper bounds of what is achievable for UK landfill once gas collection infrastructure has been installed, although it is not certain how widely this is achieved in the UK and whether this can be sustained over the lifetime of a landfill. The Climate Change Committee identifies an ambition to achieve a lower LFG capture rate of 80% by 2050, and also

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
				identifies that the Government's pathway to Net Zero assumes no improvement to methane capture rates[13].
19) 85% LFG capture rate – including grid decarbonisation	5,642	*Likely*	*Unlikely*	As for Scenario 18 (see comment above for Scenarios 8-13 regarding relevance of grid decarbonisation in relation to technology and regulation/policy).
Carbon Capture & Storage (CCS) – variations with respect to the ES Case				
20) 2030 adoption of CCS by the EfW CHP Facility	-9,427	*Just as likely as unlikely*	*Likely*	There are no examples of CCS technology being applied to EfW facilities in the UK but CCS technology has been adopted by energy generation facilities in Europe and the UK, including use with Anaerobic Digestion facilities and trials for application to EfW facilities. For 2030 the implementation of CCS technology for EfW is considered *Just as likely as unlikely*, including trials for application to EfW facilities. The implementation of CCS technology for EfW by 2030 is considered *Just as likely as unlikely*. UK Government has laid out its goal of CCS being available for widespread deployment by 2030[17]. Additionally, the recent consultation response from the UK Government confirming that EfW facilities will be included in the UK Emissions Trading Scheme (UK ETS) from 2028, also highlights the potential incentive that UK ETS introduces to encourage the adoption of

[17] https://www.gov.uk/guidance/uk-carbon-capture-and-storage-government-funding-and-support

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
				CCS by EfW facilities and financial support to be available through the CCS Infrastructure Fund[18].
21) 2030 adoption of CCS by the EfW CHP Facility – including grid decarbonisation	-7,933	*Just as likely as unlikely*	*Likely*	As for Scenario 20 (see comment above for Scenarios 8-13 regarding relevance of grid decarbonisation in relation to technology and regulation/policy).
22) 2040 adoption of CCS by the EfW CHP Facility	-7,511	*Likely*	*Likely*	There are no examples of CCS technology being applied specifically to EfW facilities in the UK but CCS technology has been adopted in Europe and the UK, including use with Anaerobic Digestion facilities and trials for application to EfW facilities. For 2030 the implementation of CCS technology for EfW is considered *Just as likely as unlikely*, including trials for application to EfW facilities. The implementation of CCS technology for EfW by 2040 is considered *Likely*. UK Government has laid out its goal of CCS being available for widespread deployment by 2030[17]. Additionally, the recent consultation response from the UK Government confirming that EfW facilities will be included in the UK Emissions Trading Scheme (UK ETS) from 2028, also highlights the potential incentive that UK ETS introduces to encourage the adoption of CCS by EfW facilities and financial support to be available through the CCS Infrastructure Fund[18].

[18] UK Government (2023). *Developing the UK Emissions Trading Scheme: Main Response.* https://www.gov.uk/government/consultations/developing-the-uk-emissions-trading-scheme-uk-ets

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
23) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation	-5,834	*Likely*	*Likely*	As for Scenario 22 (see comment above for Scenarios 8-13 regarding relevance of grid decarbonisation in relation to technology and regulation/policy).
In-combination scenarios for UK grid decarbonisation and CCS				
24) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and reduced recyclables (65% target)	-6,212	*Likely*	*Likely*	On balance, with respect to implementation of CCS technology by 2040 this scenario is considered to be *Likely* (see Scenario 22). Noting the development of national policy with respect to CCS and incentives to adopt CCS prompted by the inclusion of EfW in UK ETS (see Scenario 20), this scenario is considered *Likely*.
25) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and 90% less food and plastics	-10,992	*Likely*	*Likely*	As for Scenario 24
26) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: current residual waste	-5,251	*Likely*	*Likely*	As for Scenario 24

Scenario	Difference in net lifetime emissions between Proposed Development and Landfill ($ktCO_2e$)	Likelihood		Comments
		Technology and its implementation	Regulations / National Policy	
27) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% plastics	-8,187	*Likely*	*Likely*	As for Scenario 24
28) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% organics	-3,460	*Likely*	*Likely*	As for Scenario 24
29) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CHP, export of steam from the EfW CHP Facility	-6,221	*Likely*	*Likely*	As for Scenario 24
30) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation at 52% LFG capture rate	-11,484	*Likely*	*Likely*	As for Scenario 24
31) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation at 85% LFG capture rate	169	*Likely*	*Unlikely*	As for Scenario 24 but noting comments under Scenario 18 with respect to the likelihood of achieving a LFG capture rate of 85% this scenario is considered to be Unlikely in terms of regulation and National policy.

Sensitivity analysis summary

4.1.18 The majority of scenarios show that the EfW CHP Facility would be expected to deliver a reduction in GHG emissions compared to landfill over the lifetime of the Proposed Development.

4.1.19 Future residual waste composition may vary, particularly when considering ambitions to increase recycling of plastics and organic materials; however, noting the latest data available on recycling rates for the UK and England[15], there is uncertainty regarding the ability of the UK to achieve its existing recycling targets for 2035, and the current assumed residual waste composition is considered to be appropriate for the ES Case. Feasible future scenarios where organics and plastics in the waste stream reduce in combination also indicate that the EfW CHP Facility would have lifetime GHG emissions lower than the landfill alternative.

4.1.20 If assessment considers decarbonisation of UK Grid electricity generation on an annual basis towards 2050, this would reduce the scale of savings derived from avoided emissions for the EfW CHP Facility; however, comparing the carbon intensity to the UK current grid average emissions (i.e. the current energy generation facilities that would be replaced by new developments) is considered to be appropriate for the ES Case (rather than CCGT, which was considered to be an appropriate comparator in 2014). It is also noted that as part of UK grid decarbonisation it is likely that CCS technology may be expected to be installed for the EfW CHP Facility as part of UK grid decarbonisation, so the additional benefits identified for Scenarios 21 and 23 to 31 may be applicable for each of the UK grid decarbonisation scenarios.

4.1.21 Exporting steam from the EfW CHP Facility in addition to electricity, and the adoption of CCS, would enhance the net savings in emissions attributable to the EfW CHP Facility. These were not considered in the ES Case as there are technical and commercial decisions that need to be made, but the Applicant is committed to these technologies (as set out in Requirements 22, 23 and 25 of Schedule 2 to the draft DCO Volume 3.1 (Rev 5) (Deadline 6 submission), so the benefits (that are not feasible in the landfill alternative) are considered *Highly Likely* (steam export) and *Likely* (CCS).

4.1.22 The additional sensitivity assessment presented in this document demonstrates the complexity in determining GHG emissions for a range of scenarios. Noting the points above, and that there is potential for variation in the factors for estimating GHG emissions for conceivable future scenarios, the assessment of GHG emissions presented in the original ES (the ES Case) is considered to be a reasonable and appropriate approach for the Proposed Development.

Appendix A
Technical Meeting Note Climate Change v2.pdf

Medworth Energy from Waste
Combined Heat and Power Facility

PINS ref. EN010110
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June 2023

Technical Note

Climate Change

We inspire
with energy.

Contents

1. Introduction

1.1.1 This technical note has been prepared in response to a request from Cambridgeshire County Council (CCC) at Issue Specific Hearing 4 (ISH 4) on 17 May 2023, where it was considered that further details on the original sensitivity analysis for the GHG assessment accompanying the Environmental Statement (ES) (**Appendix 14C (Volume 6.4) [APP-088]**) should be provided. See **ISH 4, action point No.7 [EV-059]**:

> *Submission of full sensitivity analysis for alternative scenarios to those provided in Appendix 14C of [APP-088] or signposting to existing submissions containing this information. At present in the sensitivity analysis both cases reduce plastics and food waste content and Cambridgeshire County Council wish to see these represented separately.*

1.1.2 As requested the Applicant has provided the details of the original sensitivity analysis to CCC.

1.1.3 The original sensitivity analysis for the ES sought to illustrate a range of scenarios in terms of the variables contributing to the assessment of greenhouse gas emissions, i.e. waste composition with increased recycling; offsets for UK energy supplies, including UK grid decarbonisation; and implementation of CHP for the EfW CHP facility. Stakeholders consider that it would be helpful to provide additional alternative scenarios, particularly with regard to waste composition.

1.1.4 The Applicant held a call with CCC's Carbon and Energy Manager on 07 June 2023 to agree the scope of additional sensitivity analysis, within the timescales of the DCO Examination. Following the discussion this technical note has been prepared outlining the approach to be agreed with CCC for carrying out further sensitivity analysis.

1.1.5 The technical note sets out:

- the methodology for assessment of GHG emissions;
- scenarios proposed to be included in the additional sensitivity analysis, including the assumptions for inputs to be used for each scenario; and
- the outline schedule to provide the additional sensitivity analysis by Deadline 6.

2. Assessment methodology

2.1.1 The methodology used for the GHG assessment in the ES is described in detail in **Section 14.8 of ES Chapter 14 Climate Change (Volume 6.2) [APP-041]**, with additional detail relevant to the sensitivity analysis for the ES included in **Appendix 14C (Volume 6.4) [APP-088]** and the subsequent **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**.

2.1.2 The methodology used by CCC for a comparable assessment of GHG emissions for additional waste composition scenarios is summarised in Fenland District Council's (FDC) **Deadline 1 Submission - Joint Local Impact Report with Cambridgeshire County Council (paras 9.4.9 to 9.4.10) [REP1-074]** and described in CCC and FDC's **Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**. This is reported to be based on the Waste Emissions Calculator for local authorities, from Local Partnerships; developed as part of a research project by University College London and CCC, funded by the Local Government Association.

2.1.3 A high-level comparison of the methodologies used by the Applicant and CCC is provided in Table 2.1. This highlights key differences between the approaches used and comments on how this can be addressed in the methodology for the additional sensitivity analysis (please note, this does not include assumptions regarding aspects such as waste composition or UK grid decarbonisation as these are included with the scenarios proposed in Section 3).

Table 2.1 GHG assessment methodology comparison

Assessment item	ES methodology	CCC methodology	Comment
Project lifecycle stages	The core case presented in the ES considered emissions for **construction, operation** and **decommissioning** of the EfW CHP facility, and emissions for operation of Landfill. The sensitivity analysis presented in ES Appendix C considered **operational process** emissions only for the EfW CHP facility and Landfill.	The CCC assessment considered the **operational process** emissions only for the EfW CHP facility and Landfill (in order to provide a comparison with the ES sensitivity analysis).	For completeness, and in line with the main ES Chapter 14, each of the scenarios proposed for the additional sensitivity analysis will include each project lifecycle stage, i.e. **construction, operation (process and transport)** and **decommissioning** (excluding construction and decommissioning for landfill).

Assessment item	ES methodology	CCC methodology	Comment
Lifetime emissions	The core case presented in the ES considered **operational lifetime emissions (over 40 years)** for the EfW CHP facility and Landfill. The sensitivity analysis presented in ES Appendix C considered **annual operational process emissions** for the EfW CHP facility and Landfill.	As well as an annual assessment the CCC assessment included **lifetime operational process emissions (over 40 years)** for the EfW CHP facility and Landfill.	**Operational lifetime emissions (over 40 years)** will be presented for each of the scenarios proposed for the additional sensitivity analysis (and as noted above, this will also include construction and decommissioning for the EfW CHP facility).
Gross emissions and net emissions	The ES core case presented a summary of **net emissions** for comparison of the EfW CHP facility and Landfill, which included offsetting of emissions for electricity generation in both cases. The sensitivity analysis in ES Appendix C presented a summary of **net annual emissions savings** for comparison of the EfW CHP facility with Landfill, which included offsetting of emissions for electricity generation for EfW and Landfill.	The CCC assessment presented a summary of **gross emissions** for comparison of the EfW CHP facility and Landfill, which excluded offsetting of emissions for electricity generation in both cases.	As well as presenting **net emissions**, the additional sensitivity analysis will clearly present the **gross emissions** for the EfW CHP facility as a standalone entity (irrespective of, or as well as, any comparison to Landfill), i.e. prior to accounting for any emissions saved by replacing alternative sources of electricity generation.
Waste composition categories	The waste composition for the ES core case and the sensitivity analysis in Appendix C is based on **19 waste category items** (based on WRAP 2017 residual waste composition data[1]).	The waste composition for the CCC assessment is based on **10 waste category items**, which combines some of the categories presented in the ES (e.g. *'Paper', 'Card' and 'Non-recyclable paper'* under *'Paper and card'*; *'Food',*	This is not considered to be a likely material difference between the methodologies but is highlighted as a potential source of discrepancy between the scale of emissions calculated for the same waste composition (as

[1] WRAP (2020). National Municipal Waste Composition, England 2017, Table 3.

Assessment item	ES methodology	CCC methodology	Comment
		'Garden' and *'Other Organic'* under *'Organic Waste'*).	combining waste category items may lead to differences in the carbon content derived). The additional sensitivity analysis will use the **most detailed breakdown of waste category items available**.
Waste carbon content	The carbon content and NCV value used in the ES core case and the sensitivity analysis in Appendix C is based on the **WRATE Greenhouse Gas Calculator for Municipal Waste model**[2] (and WRAP 2017 residual waste composition data[1]), which assigns factors to 15 separate waste categories.	The carbon content for the CCC assessment is based on allocation for waste categories in **IPCC Guidelines**[3], which assigns factors to 10 separate waste categories	This is not considered to be a likely material difference between the methodologies but as above regarding the level of detail for waste composition, is highlighted as a potential source of discrepancy between the scale of emissions calculated for the same waste composition. The additional sensitivity analysis will use the **WRATE model to derive carbon content and NCV values**, as this will be able to greater accommodate the additional detail in waste composition breakdown.

2.1.4 In summary, it is proposed that the methodology for assessing GHG emissions for the additional sensitivity analysis will be in line with **Section 14.8 of ES Chapter 14 Climate Change (Volume 6.2) [APP-041]**, but in addition to the approach used for the original ES sensitivity analysis (**Appendix 14C (Volume 6.4) [APP-088]**) and subsequent **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**, will include the following:

[2] WRATE (2011), Greenhouse Gas Calculator for Municipal Waste. WRATE v2

[3] IPCC (2006). Table 2.4 in 2006 IPCC Guidelines, Vol. 5, Ch. 2

- Emissions for the construction, operation and decommissioning stages for each scenario (where relevant for the EfW CHP facility and Landfill)
- Lifetime operational emissions for each scenario.
- Presentation of gross emissions for EfW and for Landfill, excluding offset of emissions for electricity in each case.

2.1.5 Allowing for expected discrepancies between the ES and CCC approaches identified in Table 2.1, this should ensure for a complete assessment of the lifetime net and gross emissions, and consistency for comparison with the GHG assessment reported in the ES.

3. Proposed scenarios and assumptions

3.1.1 The proposed scenarios for additional sensitivity analysis are set out in Table 3.1, along with the assumptions for inputs (subject to further review and agreement by CCC and the Applicant). This follows discussions with CCC on 07 June 2023, which as well as taking account of the request for greater consideration of alternatives for waste composition (**ISH 4, action point No.7 [EV-059]**), also considers other issues raised by CCC during the course of the DCO examination. Following feedback from CCC via email on 15 June 23 on the initial draft of the technical note (submitted to CCC on 14 June 2023), five additional scenarios are included to also consider UK grid decarbonisation for the scenarios relating to CHP, LFG capture rate and adoption of CCS. The proposed scenarios for sensitivity testing fall under the following broad categories:

- Waste composition;
- Electricity generation offsetting;
- Combined heat and power (CHP);
- Landfill gas (LFG) capture rate; and
- Adoption of Carbon Capture and Storage (CCS).

3.1.2 In total, 23 scenarios (including the ES core case) will be provided for comparison of lifetime net emissions for the EfW CHP facility and Landfill (i.e. including the offset of emissions for electricity generation). In addition, for each of the 23 scenarios gross emissions will be presented for the EfW CHP facility as a standalone entity (prior to the offset of emissions for electricity generation), as well as gross emissions in comparison to Landfill.

Table 3.1 Proposed scenarios for GHG assessment sensitivity analysis
(* indicates scenarios considered as part of the original ES sensitivity analysis or technical note update)

Scenario	Description	Input Assumptions
1	The ES Core Case	Assumptions and inputs for the ES Core Case are as described in **Section 14.8 of ES Chapter 14 Climate Change (Volume 6.2) [APP-041]**). In summary: • Assessment of lifetime emissions and project lifecycle stages • Waste composition based on WRAP 2017 profile for England[1] • Electricity generation offset based on emissions factor in ES for UK grid average[4] • Electricity export only for the EfW CHP facility, no steam export • 68% landfill gas capture rate for modern, large UK landfill[5] • No carbon capture and storage
Waste Composition – variations with respect to the ES Core Case		
2*	ES Core Case with reduced recyclables (65% target) (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume waste composition as per ***'Reduced Recyclables'*** in **Table 14C.1** of **Appendix 14C (Volume 6.4) [APP-088].** This is as for Scenario 1 ES Core Case, with a further reduction in recyclables in residual waste, in-line with UK Government policy to achieve a recycling rate of 65% for municipal solid waste by 2035[6].
3*	ES Core Case with 90% less food and plastics	Assume waste composition as per ***'Reduced Food & Plastic'*** in **Table 14C.1** of **Appendix 14C (Volume 6.4) [APP-088].** This is as for Scenario 1 ES Core

[4] BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
[5] DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
[6] HM Government (2018). England's National Waste Strategy. OUR WASTE, OUR RESOURCES: A STRATEGY FOR ENGLAND

Scenario	Description	Input Assumptions
	(included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Case, with a 90% reduction in food and plastics in residual waste, in addition to the 65% recycling rate for other recyclables.
4	CCC: current residual waste	Assume waste composition as per the ***'Cambridgeshire Current Residual Waste Composition'*** scenario (provided by CCC **in Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**).
5	CCC: 50% reduced plastics	Assume waste composition as per the ***'Reduced Plastics (50% Less than Baseline)'*** scenario (provided by CCC **in Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**).
6	CCC: 50% reduced organics	Assume waste composition as per the ***'Reduced Food and Garden Waste (50% Less than Baseline)'*** scenario (provided by CCC **in Deadline 4 Submission - Deadline 4 Submission - Cover letter and Appendices [REP4-028]**).
Electricity generation offset – variations with respect to the ES Core Case		
7*	Gas-fired power stations (CCGT) (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume latest emissions factor for electricity generation from natural gas[7]

[7] DESNZ (2023). Fuel Mix Disclosure Data Table 2021-2022

Scenario	Description	Input Assumptions
8*	UK grid decarbonisation – for ES Core Case (included as previous sensitivity scenarios for annual emissions comparison for 2035 and 2050 in **Appendix 14C (Volume 6.4) [APP-088]**, and 40 year emissions comparison in **Technical Meeting Note (TNCC01) (provided at Appendix 9.2c (Part 9) [REP1-036]**)	Assume waste composition as per Scenario 1, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065)
9	UK grid decarbonisation – with reduced recyclables	Assume waste composition as per Scenario 2, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065)
10	UK grid decarbonisation – with 90% less food and plastics	Assume waste composition as per Scenario 3, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065)
11	UK grid decarbonisation – CCC: current residual waste	Assume waste composition as per Scenario 4, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065)
12	UK grid decarbonisation – CCC: 50% reduced plastics	Assume waste composition as per Scenario 5, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065)
13	UK grid decarbonisation – CCC: 50% reduced food	Assume waste composition as per Scenario 6, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065)

[8] BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)

Scenario	Description	Input Assumptions
Combined Heat and Power (CHP) – variations with respect to the ES Core Case		
14*	CHP, export of steam from the EfW CHP facility (included as previous sensitivity scenario for annual emissions comparison in **Appendix 14C (Volume 6.4) [APP-088]**)	Assume that the EfW CHP Facility would export 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam. Assume latest emissions factors for offsetting UK grid electricity generation[7]. Assume latest emissions factor for offsetting the use of natural gas as fuel for heating[9].
15	CHP, export of steam from the EfW CHP facility UK – including grid decarbonisation	Assume that the EfW CHP Facility would export 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam. Assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065). Assume latest emissions factor for offsetting the use of natural gas as fuel for heating[9] up to 2035, and assume BEIS forecast emissions factors for UK grid electricity generation[8] as source for heating after 2035.
Landfill Gas (LFG) capture rate – variations with respect to the ES Core Case		
16	52% LFG capture rate	Assumption based on average LFG collection efficiency reported for all UK landfills[10].

[9] UK Government (2023). Greenhouse gas reporting: conversion factors 2023

[10] DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling

Scenario	Description	Input Assumptions
17	52% LFG capture rate – including grid decarbonisation	Assume LFG capture rate as per Scenario 16, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065).
18	85% LFG capture rate	Assumption based on experts' assumptions for the upper instantaneous LFG capture rate for landfill once gas collection infrastructure is installed[10].
19	85% LFG capture rate – including grid decarbonisation	Assume LFG capture rate as per Scenario 18, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065).
Carbon Capture & Storage (CCS) – variations with respect to the ES Core Case		
20	2030 adoption of CCS by the EfW CHP facility	Assume incorporation of carbon capture technology for the EfW CHP facility from 2030 onwards The CCS scenario will include emissions related to: • carbon capture and CO_2 separation (use of steam and electricity, raw materials and catalysts) • compression (use of electricity) • transmission by pipeline (construction of pipeline (from the nearby power station only), use of electricity to drive further compression along the pipeline) • underground storage (use of electricity) • leakage factors
21	2030 adoption of CCS by the EfW CHP facility – including grid decarbonisation	Assume adoption of CCS as per Scenario 20, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065).

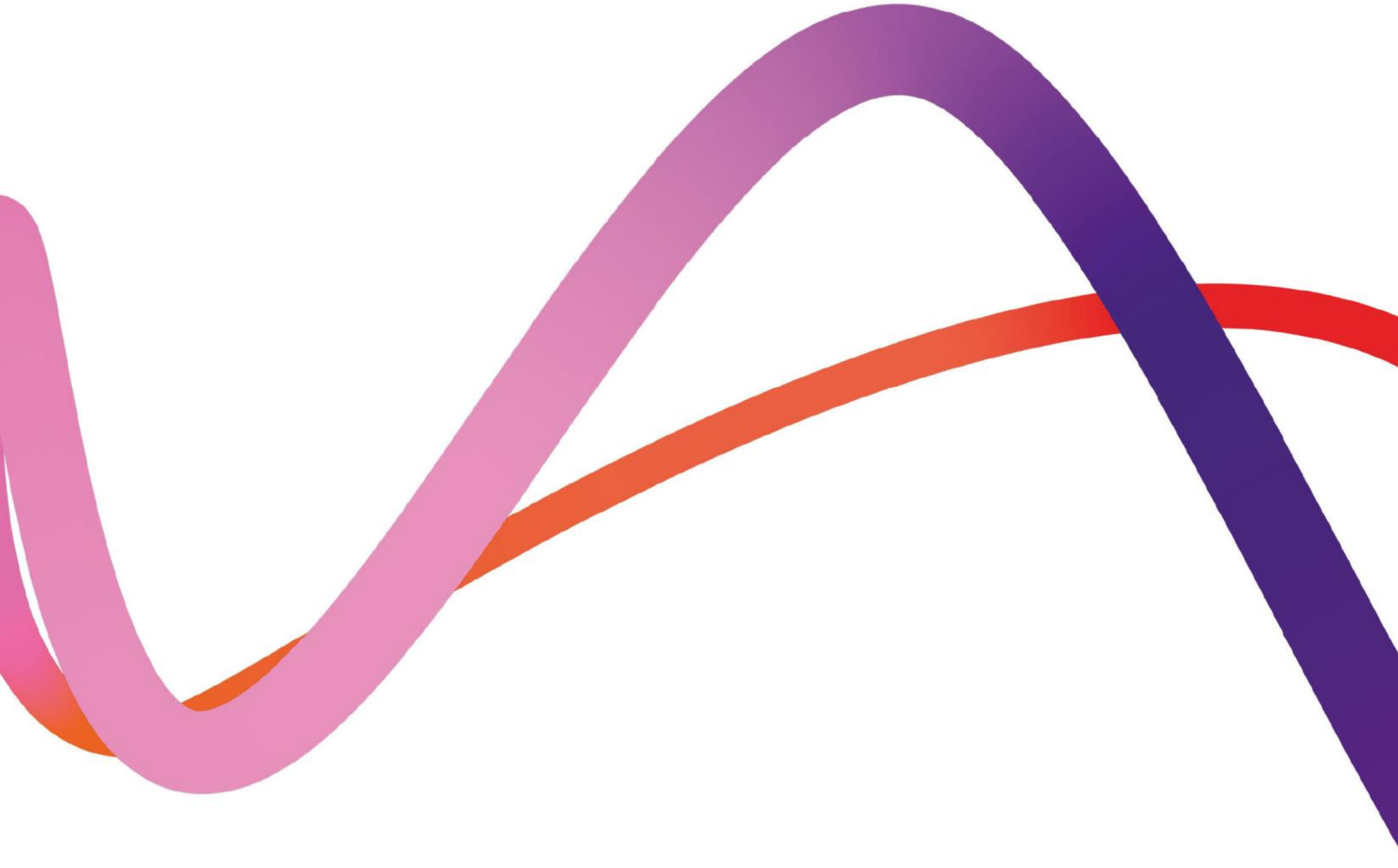
Scenario	Description	Input Assumptions
22	2040 adoption of CCS by the EfW CHP facility	Assume incorporation of carbon capture technology for the EfW CHP facility from 2040 onwards As for Scenario 20, the CCS scenario will include emissions related to: • carbon capture and CO_2 separation (use of steam and electricity, raw materials and catalysts) • compression (use of electricity) • transmission by pipeline (construction of pipeline (from the nearby power station only), use of electricity to drive further compression along the pipeline) • underground storage (use of electricity) • leakage factors
23	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation	Assume adoption of CCS as per Scenario 22, and assume BEIS forecast emissions factors for UK grid electricity generation[8] over 40 years (for the period 2026 to 2065).

4. Schedule

4.1.1 Table 4.1 sets out the schedule for providing the additional sensitivity analysis to the ExA by deadline 6 (12 July 2023), which allows for further discussion between the Applicant and CCC to agree the approach and review of the outputs.

Table 4.1 Schedule for additional sensitivity analysis

Date	Actions
14 June 2023	Draft technical note to be issued to CCC
16 June 2023	CCC to review GHG emissions calculation methodology in the EIA and provide feedback for Deadline 5
23 June 2023	CCC to provide any further feedback on the draft technical note (noting that feedback has already been received via email on 15 June 23). MVV and CCC to agree: • methodology for GHG assessment • selection of scenarios • input assumptions for each scenario
30 June 2023	Final sensitivity test calculations and analysis report to be issued to CCC
05 July 2023	Conference call for MVV to present results of the sensitivity analysis to CCC, including analysis on existing and emerging policy to determine the likelihood of each scenario.
12 July 2023 **(Deadline 6)**	MVV to submit sensitivity Analysis to ExA CCC to confirm agreement and/or any areas of disagreement, with the methodologies, scenarios and input assumptions and outputs, and may provide its own commentary on the scenario outputs.



Appendix B
Assumptions

ES Case – general assumptions

(variations to the general assumptions below for the ES Case are identified for each scenario in the next section)

	Assumption	Reference
1	The GHG assessment methodology is based on the Carbon Assessment carried out by the Carbon Trust for the Cory Riverside EfW Facility, comparing emissions from the combustion of residual waste as a fuel source in the EfW Facility, with the alternative scenario of landfill disposal with electricity generation from the collection of landfill gas (LFG)	Carbon Trust 2017. Cory Riverside Energy: A Carbon Case, Carbon Trust Peer Review https://www.corygroup.co.uk/application/files/7016/1890/4663/Cory-Carbon-Report-v1.1.pdf
2	Waste to be used as fuel for the Medworth EfW Facility is assumed to be the residual portion of commercial and household municipal solid waste (MSW) after recycling	WRAP 2020, National Municipal Waste Composition, England 2017, Table 3 https://wrap.org.uk/sites/default/files/2020-11/WRAP-National%20municipal%20waste%20composition_%20England%202017.pdf
3	The following is assumed for MSW biogenic carbon, non-biogenic (fossil) carbon and Net Calorific Value (NCV) values used in the assessment: - The separate WRAP categories for 'Recyclable Paper' and 'Card' are assumed to be equivalent to the WRATE category for 'Paper and Card' - The WRAP categories for 'Other Organic' and 'Wood' wastes are assumed to be equivalent to the WRATE category for 'Garden Organics' - The WRAP category for 'Other Waste' is assumed to be equivalent to the WRATE category for 'Misc Non-Combustibles'. - Assumed no carbon content or NCV for metals	WRAP 2020, National Municipal Waste Composition, England 2017, Table 3 https://wrap.org.uk/sites/default/files/2020-11/WRAP-National%20municipal%20waste%20composition_%20England%202017.pdf WRATE (2011), Greenhouse Gas Calculator for Municipal Waste. WRATE v2. (provided by MVV) Zero Waste Scotland, 2020, The climate change impacts of burning municipal waste in Scotland - Technical Report, Table 2 The estimated composition and carbon content of municipal waste in Scotland in 2018 https://www.zerowastescotland.org.uk/content/climate-change-impact-burning-municipal-waste-scotland
4	The Proposed Development ES Case is based on receiving 625,000 tonnes of residual (non-recyclable) waste per annum at a NCV of 9.53 MJ/kg. The net electricity generation for the EfW CHP Facility, operating in electricity only mode is 55 MWe (allowing for 5 MWe parasitic load). The EfW CHP Facility is designed to maintain a constant fuel input capacity, so the quantity of waste inputs may be adjusted according to the calorific value of the material. i.e. less waste may be required for material with a higher calorific value and vice versa.	Based on design information confirmed by MVV 02Feb22 (Medworth ES - questions for MVV_SG.docx) and NCV value calculated from WRAP and WRATE info
5	The GHG assessment includes an estimate of N_2O and CH_4 emissions associated with Stationary Combustion Processes, based on IPCC Guidelines for Greenhouse Gas Inventories and factors for Global Warming Potential (GWP): - N_2O default emissions factor for Stationary Combustion, municipal wastes (non-biomass fraction) = 4 kg N_2O/TJ - N_2O to CO_2 GWP = 265 kg CO_{2e} /kg N_2O - CH_4 default emissions factor for Stationary Combustion, municipal wastes (non-biomass fraction) = 30 kg CH_4/TJ - CH_4 to CO_2 GWP = 28 kg CO_{2e} /kg CH_4	IPCC 2006. IPCC Guidelines for Greenhouse Gas Inventories, Vol 2, table 2.2 Default Emissions Factors for Stationary Combustion in the Energy Industries https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf IPCC 2014. IPCC 5th Assessment Report (AR5) https://www.ipcc.ch/pdf/assessmentreport/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf

	Assumption	Reference
6	The GHG assessment includes an estimate of GHG emissions for the use of fuel in auxiliary burners during the start-up and shut-down of the EfW CHP Facility. It is assumed that: - The EfW CHP Facility would use 1,939,360 litres per annum of gas oil (diesel), 90% of which would be used for the auxiliary burners and the remaining 10% would be used for maintenance, repair, replacement and refurbishment activities. - 'Gas Oil' represents the type of fuel that would be used in the auxiliary burners, with an equivalent CO2 emissions factor of 2.75857 kgCO2e/litre (BEIS 2021)	Based on design information confirmed by MVV 02Feb22 (Medworth ES - questions for MVV_SG.docx) BEIS UK Government GHG Conversion Factors for Company Reporting 2021 https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021
7	The GHG assessment includes an estimate of GHG emissions offset by electricity generated by the EfW (the benefits for generated heat is not included in the main GHG assessment). It is assumed that: - the net electrical output for export to local users and the national grid is 55MWe (allowing 5MWe for parasitic load) - for the assessment it is assumed that the EFW Facility would operate for a minimum of 8,000 hrs per year (not stated in the PEIR) - for the ES Case electricity generated by the EfW Facility would displace the use of UK gid average electricity with an equivalent CO2 emissions factor of 182 g/kWh (BEIS 2020-2021)	Based on design information confirmed by MVV 02Feb22 (Medworth ES - questions for MVV_SG.docx) BEIS Fuel Mix Disclosure Data Table 2020-2021 https://www.gov.uk/government/publications/fuel-mix-disclosure-data-table
8	The estimate of GHG emissions associated with landfill disposal of residual waste and electricity generation from landfill gas (LFG) is based on the following factors referenced in a DEFRA report on landfill methane emissions modelling based on a UK scenario: - The percentage of biogenic carbon which is converted to LFG is 50% - The ratio of methane to carbon dioxide in UK landfill gas is calculated to be 57:43% rather than the generally assumed 50:50% - The quantum of methane that is flared from operational sites with landfill gas utliisation is estimated to be 1/11th of the methane utilised in gas engines. (i.e. 9.1%) - Net electrical efficiency assumption of 36% (including losses for parasitic load) - The collection efficiency for a subset of modern, large landfill operations in the UK is 68% (data from 2011) - Landfill Methane Oxidation. It is recommended that until further measurements are made at UK landfill sites, the IPCC default value for methane oxidation of 10% is retained.	DEFRA 2014. DEFRA Review of Landfill Methane Emissions Modelling http://randd.defra.gov.uk/Document.aspx?Document=12439_WR1908ReviewofMethaneEmissionsModelling.pdf
9	The GHG assessment includes an estimate of GHG emissions offset by electricity generated by the use of LFG in gas engines at landfill sites. It is assumed that: - the calorific value of methane is 50 MJ/kg - for the ES Case electricity generated by LFG combustion would displace the use the use of UK gid average electricity with an equivalent CO2 emissions factor of 182 g/kWh (BEIS 2020-2021)	DEFRA 2014. DEFRA Review of Landfill Methane Emissions Modelling http://randd.defra.gov.uk/Document.aspx?Document=12439_WR1908ReviewofMethaneEmissionsModelling.pdf

Sensitivity Scenarios – variations to assumptions for the ES Case

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
Scenario 1) ES Case		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 2) ES Case with reduced recyclables (65% target)		
1a	Waste composition based on: target 65% of municipal waste is recycled by 2035, with 44.5% already recycled in 2019	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017), with a 20% reduction in paper, card, food, plastics, glass, metals, garden and wood in residual waste
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 615,668 t/yr)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 3) ES Case with 90% less food and plastics		
1a	Waste composition based on: 90% reduction in food and plastics, in addition to 20% reduction in other recyclables	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017), with a 90% reduction in food and plastics, in addition to 20% reduction in other recyclables for the residual waste
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 54.08)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 4) CCC: current residual waste		
1a	Waste composition based on: Cambridgeshire Current Residual Waste Composition	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028])

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,713 per yr)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 5) CCC: 50% reduced plastics		
1a	Waste composition based on: Cambridgeshire current residual waste with plastics reduced 50% less than baseline	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028])
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 51.94)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 6) CCC: 50% reduced organics		
1a	Waste composition based on: Cambridgeshire current residual waste with organics reduced 50% less than baseline	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028])
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 503,804 t/yr)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 7) Gas-fired power stations (CCGT)		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	Electricity generation using natural gas, offset for 40 years, based on latest UK emissions factor 2021/22 = 372 g/kWh	DESNZ (2023). Fuel Mix Disclosure Data Table 2021-2022
3	Electricity export only for the EfW CHP Facility, no steam export	N/A

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 8) UK grid decarbonisation – for ES Case		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 9) UK grid decarbonisation - with reduced recyclables (65% target)		
1a	Waste composition based on: target 65% of municipal waste is recycled by 2035, with 44.5% already recycled in 2019	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017), with a 20% reduction in paper, card, food, plastics, glass, metals, garden and wood in residual waste
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 615,668 t/yr)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 10) UK grid decarbonisation - with 90% less food and plastics		
1a	Waste composition based on: 90% reduction in food and plastics, in addition to 20% reduction in other recyclables	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017), with a 90% reduction in food and plastics, in addition to 20% reduction in other recyclables for the residual waste
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 54.08)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 11) UK grid decarbonisation - CCC: current residual waste		
1a	Waste composition based on: Cambridgeshire Current Residual Waste Composition	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028])
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,713 per yr)	Operating Parameters for NCV provided by MVV

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 12) UK grid decarbonisation - CCC: 50% reduced plastics		
1a	Waste composition based on: Cambridgeshire current residual waste with plastics reduced 50% less than baseline	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028])
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 51.94)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 13) UK grid decarbonisation - CCC: 50% reduced organics		
1a	Waste composition based on: Cambridgeshire current residual waste with organics reduced 50% less than baseline	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028])
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 503,804 t/yr)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 14) CHP, export of steam from the EfW CHP Facility UK		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 48.8)	Operating Parameters for NCV provided by MVV
2a	Electricity generation offset for 40 years based on latest UK grid average emissions factor 2021/22 = 198 g/kWh	DESNZ (2023). Fuel Mix Disclosure Data Table 2021-2022
2b	Fuel for heating offset for 40 years based on latest natural gas emissions factor 2021/22 = 202.67 g/kWh	UK Government (2023). Greenhouse gas reporting: conversion factors 2023
3	CHP EfW Facility exports 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam	MVV design info

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 15) CHP, export of steam from the EfW CHP Facility UK – including grid decarbonisation		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 48.8)	Operating Parameters for NCV provided by MVV
2a	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
2b	Fuel for heating offset to 2035 based on latest natural gas emissions factor 2021/22 = 202.67 g/kWh Fuel for heating offset after 2035 based on BEIS forecast emissions factors for UK grid electricity generation	UK Government (2023). Greenhouse gas reporting: conversion factors 2023; BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	CHP EfW Facility exports 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam	MVV design info
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 16) 52% LFG Capture Rate		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for older operational UK landfill (Type 3 MELMod) = 52%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 17) 52% LFG Capture Rate – including grid decarbonisation		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for older operational UK landfill (Type 3 MELMod) = 52%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
Scenario 18) 85% LFG Capture Rate		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	Upper limit for instantaneous LFG capture rate for a modern UK landfill = 85% based on experts' opinion	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 19) 85% LFG Capture Rate – including grid decarbonisation		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	Upper limit for instantaneous LFG capture rate for a modern UK landfill = 85% based on experts' opinion	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A
Scenario 20) 2030 adoption of CCS by the EfW CHP Facility		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2030 onwards (36 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 21) 2030 adoption of CCS by the EfW CHP Facility – including grid decarbonisation		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2030 onwards (36 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO_2e/km	Internal estimate based on other project examples
Scenario 22) 2040 adoption of CCS by the EfW CHP Facility		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO_2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO_2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO_2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO_2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO_2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO_2 storage at Bacton cluster
5h	CCS - leakage rate for CO_2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO_2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO_2e/km	Internal estimate based on other project examples
Scenario 23) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 24) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and reduced recyclables (65% target)		
1a	Waste composition based on: target 65% of municipal waste is recycled by 2035, with 44.5% already recycled in 2019	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017), with a 20% reduction in paper, card, food, plastics, glass, metals, garden and wood in residual waste
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 615,668 t/yr)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 25) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and 90% less food and plastics		
1a	Waste composition based on: 90% reduction in food and plastics, in addition to 20% reduction in other recyclables	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017), with a 90% reduction in food and plastics, in addition to 20% reduction in other recyclables for the residual waste
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 54.08)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 26) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: current residual waste		
1a	Waste composition based on: Cambridgeshire Current Residual Waste Composition	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028]
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,713 per yr)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 27) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% reduced plastics		
1a	Waste composition based on: Cambridgeshire current residual waste with plastics reduced 50% less than baseline	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028]
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 51.94)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 28) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CCC: 50% reduced organics		
1a	Waste composition based on: Cambridgeshire current residual waste with organics reduced 50% less than baseline	CCC Deadline 4 Submission - Cover letter and Appendices [REP4-028]
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 503,804 t/yr)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples
Scenario 29) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation and CHP, export of steam from the EfW CHP Facility		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2a	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
2b	Fuel for heating offset to 2035 based on latest natural gas emissions factor 2021/22 = 202.67 g/kWh Fuel for heating offset after 2035 based on BEIS forecast emissions factors for UK grid electricity generation	UK Government (2023). Greenhouse gas reporting: conversion factors 2023; BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	CHP EfW Facility exports 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam	MVV design info
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO_2 storage at Bacton cluster
5h	CCS - leakage rate for CO_2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO_2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO_2e/km	Internal estimate based on other project examples
Scenario 30) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation at 52% LFG Capture		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for older operational UK landfill (Type 3 MelMOD) = 52%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO_2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO_2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO_2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO_2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO_2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO_2 storage at Bacton cluster
5h	CCS - leakage rate for CO_2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO_2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO_2e/km	Internal estimate based on other project examples
Scenario 31) 2040 adoption of CCS by the EfW CHP Facility – including grid decarbonisation at 85% LFG Capture		
1a	Waste composition based on WRAP 2017 profile for England	ES Case waste composition (WRAP 2020, National Municipal Waste Composition, England 2017)

Assumptions for Sensitivity Scenarios (red type indicates variation with respect to the ES Case)		Reference
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	Operating Parameters for NCV provided by MVV
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	Upper limit for instantaneous LFG capture rate for a modern UK landfill = 85% based on experts' opinion	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Appendix C
Grid Offset Comparator – Development Application Examples

Grid Offset Comparators – Development Application Examples

Example of grid offset comparator for development application	Reference
Longfield Solar Farm 6.7.34 Comparing the Scheme against a gas fired Combined Cycle Gas Turbine (CCGT) generating facility, currently the most carbon-efficient fossil-fuelled technology available, a representative figure for the carbon intensity of a CCGT is 354g CO2e/kWh (Ref 6-37). The operational carbon intensity of the Scheme is therefore 95.2% lower than that of the counterfactual CCGT. Each kilowatt hour of electricity generated by the Scheme will emit 337g CO2e less than if it was generated by a gas fired CCGT generating facility.	***PINS Ref: EN010118*** https://infrastructure.planninginspectorate.gov.uk/projects/eastern/longfield-solar-farm/?ipcsection=docs&stage=app&filter1=Environmental+Statement https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010118/EN010118-000163-6.1%20ES%20Chapter%206%20_%/20Climate%20Change.pdf
Wheelabrator Kemsley Generating Station (K3) and Wheelabrator Kemsley North (WKN) Waste to Energy Facility 6.3.18 The baseline for electricity generation that would be displaced by electricity exported by either facility is assumed in WRATE to be 0.349 tCO2e/MWh (representative of a combined cycle gas turbine [CCGT] power station). The marginal source will change over time, and so for future years in the main scenario, the BEIS projections of the carbon intensity of long-run marginal electricity generation [Ref. 6.22] have also been considered in this chapter	***PINS Ref: EN010083*** https://infrastructure.planninginspectorate.gov.uk/projects/south-east/wheelabrator-kemsley-generating-station-k3-and-wheelabrator-kemsley-north-wkn-waste-to-energy-facility/?ipcsection=docs&stage=app&filter1=Environmental+Statement https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010083/EN010083-000381-EN010083%20-%203.1%20-%202019%20ES%20Chapter%206%20Climate%20Change.pdf
Mallard Pass Solar Project 13.4.15 The generation of electricity from the Proposed Development will displace and would replace the generation of electricity from other conventional power sources over time. The Digest of UK Energy Statistics (DUKES) [Ref 13-22, Ref 13-23] indicate across the mix of sources of electricity that currently contribute power to the grid, the average emission of CO2 in 2020 was estimated as 182 kg/MWh. If this emission of CO2 was avoided as a result of the Proposed Development, it would equate to a reduction of approximately 64,000 teCO2/y entering the atmosphere over the operational lifetime of the Proposed Development. Grid decarbonisation will reduce the average emissions of CO2 and therefore the total reduction of savings above associated with the Proposed Development correspondingly. To achieve decarbonisation of the grid, energy sources such as the Proposed Development are required to meet Government targets relating to GHG emissions. Therefore, whilst the decarbonisation of the grid would reduce the savings associated with the Proposed Development, infrastructure such as the Proposed Development is a pre-requisite to such decarbonisation. In the National Grid Future Energy Scenario (FES) 'best case' decarbonisation scenario, grid CO2 intensities and the output of Proposed Development accounting for panel degradation have been utilised to calculate the potential reduction of CO2 emissions avoided as a result of the Proposed Development, which accounts for decarbonisation and degradation with results in Plate 13-1. This shows a total reduction in CO2 of 423,580 teCO2 across the lifetime of the Proposed Development and an average of 10,589 teCO2/y.	***PINS Ref: EN010127*** https://national-infrastructure-consenting.planninginspectorate.gov.uk/projects/EN010127/documents?category-Developer%27s+Application=Environmental+Statement&date-from-day=&date-from-month=&date-from-year=&date-to-day=&date-to-month=&date-to-year=&searchTerm=climate&itemsPerPage=25 https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010127/EN010127-000115-13%20Climate%20Change.pdf

Example of grid offset comparator for development application	Reference
North Lincolnshire Green Energy Park 5.3.3.8 Electricity generated by the ERF will be exported to the national grid or used by other facilities within the Project, including the PRF, H2 production facility and other businesses in the local area. This assessment assumes that in the absence of the ERF, capacity for the production of this electricity would otherwise be met by a gas-fired power station. This is in line with the Guide which states "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". 5.3.3.9 As the UK completes the phasing out of producing electricity from coal, CCGT will continue to be a significant contributor to the UK grid electricity fuel mix. Construction of the ERF will not impact decisions relating to the development of renewables such as solar and wind, given the GHG emission reduction targets which have been set by the UK. Given the intermittency of solar and wind power, alternative generation methods which can respond to demand, such as CCGT and ERFs, are likely to be required for some time yet. The Guide = Energy from Waste – A Guide to the debate (DEFRA, 2014) ('the Guide')	***PINS Ref: EN010116*** https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/north-lincolnshire-green-energy-park/?ipcsection=docs&stage=app&filter1=Environmental+Statement https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010116/EN010116-000404-6.2.6%20-%20ES%20-%20Chapter%206%20-%20Climate.pdf
South Humber Bank Energy Centre 19.6.25 The operation of the Proposed Development will generate GHGs (mainly from burning fuel (76.1% from refuse derived fuel usage)) but will also beneficially avoid GHGs from landfill and metals that can be recycled from bottom ash to displace the use of virgin metal sources. The net GHGs during operation are therefore predicted to be 45,297 tCO2e per year, which equates to a carbon intensity of 72 tCO2e per GWh (assuming that the gross electrical output from the Proposed Development is around 76 MW, rather than 95 MW). This is favourable compared to the current grid average carbon intensity (BEIS, 2019) of 173 tCO2e per GWh. As the operational emissions (gross or net) are considerably less than 1% of the UK carbon budget for 2028-2032, the effect is considered to be minor adverse	***PINS Ref: EN010107*** https://infrastructure.planninginspectorate.gov.uk/projects/yorkshire-and-the-humber/south-humber-bank-energy-centre/?ipcsection=docs&stage=app&filter1=Environmental+Statement https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010107/EN010107-000179-SHBEC%20DCO%20-%206.2.19%20ES%20Vol%20I%20Chapter%2019%20Sustainability%20and%20Climate%20Change.pdf

Appendix D
Sensitivity Analysis Scenario Outputs

Waste Compositon Variation

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ES Case: Current Residual Waste
(for Scenarios: 1, 7, 8, and 14-23)

(WRAP survey, 2017: as per 'Current (Core Case)' in Table 14C.1 of Appendix 14C (Volume 6.4) [APP-088])

Waste Stream	Municipal Residual Waste: Commercial and Household (% by weight)	Biogenic Carbon (% of waste stream)	Non-Biogenic Carbon (% of waste stream)	Net Calorific Value (MJ/kg)	Biogenic Carbon (% by weight)	Non-Biogenic Carbon (% by weight)	Total Carbon (% by weight)	Total NCV (MJ/kg)
Recyclable Paper	5.9%	31.27%		10.749	1.84%		1.84%	0.63
Card	6.3%	31.27%		10.749	1.97%		1.97%	0.68
Non-recyclable Paper	8.9%	28.69%		9.735	2.55%		2.55%	0.87
Dense Plastic	7.8%		54.76%	24.682		4.27%	4.27%	1.93
Plastic film	8.2%		48.11%	21.279		3.95%	3.95%	1.74
Textiles	5.5%	19.93%	19.93%	14.327	1.10%	1.10%	2.19%	0.79
Misc. Combustible	9.3%	23.69%	15.79%	14.612	2.20%	1.47%	3.67%	1.36
Misc. Non-Combustible	3.6%	2.94%	4.05%	2.573	0.11%	0.15%	0.25%	0.09
Other Wastes	0.3%	2.94%	4.05%	2.573	0.01%	0.01%	0.02%	0.01
Glass	2.6%	0.31%		1.414	0.01%		0.01%	0.04
Ferrous Metals	2.4%							0.00
Non-Ferrous Metals	1.1%							0.00
Food Waste	27.0%	13.46%		3.460	3.63%		3.63%	0.93
Garden Waste	2.7%	17.17%		4.210	0.46%		0.46%	0.11
Other Organic	2.3%	17.17%		4.210	0.39%		0.39%	0.10
Wood	2.3%	17.17%		4.210	0.39%		0.39%	0.10
WEEE	1.1%		15.81%	7.060		0.17%	0.17%	0.08
Hazardous	0.5%	0.61%	19.76%	0.000	0.00%	0.10%	0.10%	0.00
Fines	2.2%	13.75%		3.479	0.30%	0.00%	0.30%	0.08
Total	100.0%				15.0%	11.2%	26.2%	9.53
					57.20%	42.80%		

EfW CHP Facility Operating Parameters for NCV (provided by MVV)

Net Calorific Value (MJ/kg)	**Note:** 100% design point with 55 MWe net power output and waste throughput below 625,600 tpa	9.53
Total waste input (tonnes/yr)		613,573
EfW Facility operations (hrs/yr)		8,000
EfW Facility electricity generation (MWe)		55

ES Case: with Reduced Recyclables
(for Scenarios: 2 and 9)

(by 2035, with 44.5% already recycled in 2019: as per 'Reduced Recyclables' in Table 14C.1 of Appendix 14C (Volume 6.4) [APP-088])

Waste Stream	Current Residual Waste: Commercial and Household (% by weight)	Future Waste: 20% reduction in paper, card, food, plastics, glass, metals, garden and wood in residual waste	Equivalent weight of residual waste (tonnes)	Future Residual Waste: (% by weight)	Biogenic Carbon (% of waste stream)	Non-Biogenic Carbon (% of waste stream)	Net Calorific Value (MJ/kg)	Biogenic Carbon (% by weight)	Non-Biogenic Carbon (% by weight)	Total Carbon (% by weight)	Total NCV (MJ/kg)
Recyclable Paper	5.9%	20.0%	0.047	5.5%	31.27%		10.749	1.72%		1.72%	0.59
Card	6.3%	20.0%	0.050	5.9%	31.27%		10.749	1.84%		1.84%	0.63
Non-recyclable Paper	8.9%		0.089	10.4%	28.69%		9.735	2.98%		2.98%	1.01
Dense Plastic	7.8%	20.0%	0.062	7.3%		54.76%	24.682		3.99%	3.99%	1.80
Plastic film	8.2%	20.0%	0.066	7.7%		48.11%	21.279		3.69%	3.69%	1.63
Textiles	5.5%	20.0%	0.044	5.1%	19.93%	19.93%	14.327	1.02%	1.02%	2.05%	0.74
Misc. Combustible	9.3%		0.093	10.9%	23.69%	15.79%	14.612	2.57%	1.71%	4.29%	1.59
Misc. Non-Combustible	3.6%		0.036	4.2%	2.94%	4.05%	2.573	0.12%	0.17%	0.29%	0.11
Other Wastes	0.3%		0.003	0.4%	2.94%	4.05%	2.573	0.01%	0.01%	0.02%	0.01
Glass	2.6%	20.0%	0.021	2.4%	0.31%		1.414	0.008%		0.008%	0.03
Ferrous Metals	2.4%	20.0%	0.019	2.2%							
Non-Ferrous Metals	1.1%	20.0%	0.009	1.0%							
Food Waste	27.0%	20.0%	0.216	25.2%	13.46%		3.460	3.39%		3.39%	0.87
Garden Waste	2.7%	20.0%	0.022	2.5%	17.17%		4.210	0.43%		0.43%	0.11
Other Organic	2.3%		0.023	2.7%	17.17%		4.210	0.46%		0.46%	0.11
Wood	2.3%	20.0%	0.018	2.1%	17.17%		4.210	0.37%		0.37%	0.09
WEEE	1.1%		0.011	1.3%		15.81%	7.060		0.20%	0.20%	0.09
Hazardous	0.5%		0.005	0.6%	0.61%	19.76%	0.000	0.00%	0.12%	0.12%	0.00
Fines	2.2%		0.022	2.6%	13.75%		3.479	0.35%	0.00%	0.35%	0.09
Total	100.0%		0.856	100%				15.3%	10.9%	26.2%	9.50
								58.35%	41.65%		

EfW CHP Facility Operating Parameters for NCV (provided by MVV)

Net Calorific Value (MJ/kg)	**Note:** 100% design point with 55 MWe net power output and waste throughput below 625,600 tpa	9.50
Total waste input (tonnes/yr)		615,668
EfW Facility operations (hrs/yr)		8,000
EfW Facility electricity generation (MWe)		55

ES Case: with 90% less food and plastics
(for Scenarios: 3 and 10)

(90% reduction in food and plastics, in addition to 20% reduction in other recyclables: as per 'Reduced Food & Plastic' in Table 14C.1 of Appendix 14C (Volume 6.4) [APP-088])

Waste Stream	Current Residual Waste: Commercial and Household (% by weight)	Future Waste: 90% reduction in plastics and food and 19.5% reduction in other recyclables in residual waste	Equivalent weight of residual waste (tonnes)	Future Residual Waste: (% by weight)	Biogenic Carbon (% of waste stream)	Non-Biogenic Carbon (% of waste stream)	Net Calorific Value (MJ/kg)	Biogenic Carbon (% by weight)	Non-Biogenic Carbon (% by weight)	Total Carbon (% by weight)	Total NCV (MJ/kg)
Recyclable Paper	5.9%	20.0%	0.047	8.5%	31.27%		10.749	2.66%		2.66%	0.91
Card	6.3%	20.0%	0.050	9.1%	31.27%		10.749	2.84%		2.84%	0.98
Non-recyclable Paper	8.9%		0.089	16.0%	28.69%		9.735	4.60%		4.60%	1.56
Dense Plastic	7.8%	90.0%	0.008	1.4%		54.76%	24.682		0.77%	0.77%	0.35
Plastic film	8.2%	90.0%	0.008	1.5%		48.11%	21.279		0.71%	0.71%	0.31
Textiles	5.5%	20.0%	0.044	7.9%	19.93%	19.93%	14.327	1.58%	1.58%	3.16%	1.14
Misc. Combustible	9.3%		0.093	16.7%	23.69%	15.79%	14.612	3.97%	2.64%	6.61%	2.45
Misc. Non-Combustible	3.6%		0.036	6.5%	2.94%	4.05%	2.573	0.19%	0.26%	0.45%	0.17
Other Wastes	0.3%		0.003	0.5%	2.94%	4.05%	2.573	0.02%	0.02%	0.04%	0.01
Glass	2.6%	20.0%	0.021	3.7%	0.31%		1.414	0.012%		0.012%	0.05
Ferrous Metals	2.4%	20.0%	0.019	3.5%							
Non-Ferrous Metals	1.1%	20.0%	0.009	1.6%							
Food Waste	27.0%	90.0%	0.027	4.9%	13.46%		3.460	0.65%		0.65%	0.17
Garden Waste	2.7%	20.0%	0.022	3.9%	17.17%		4.210	0.67%		0.67%	0.16
Other Organic	2.3%		0.023	4.1%	17.17%		4.210	0.71%		0.71%	0.17
Wood	2.3%	20.0%	0.018	3.3%	17.17%		4.210	0.57%		0.57%	0.14
WEEE	1.1%		0.011	2.0%		15.81%	7.060		0.31%	0.31%	0.14
Hazardous	0.5%		0.005	0.9%	0.61%	19.76%	0.000	0.01%	0.18%	0.18%	0.00
Fines	2.2%		0.022	4.0%	13.75%		3.479	0.54%	0.00%	0.54%	0.14
Total	100.0%		0.555	100%				19.0%	6.5%	25.5%	8.85
								74.58%	25.42%		

EfW CHP Facility Operating Parameters for NCV (provided by MVV)

Net Calorific Value (MJ/kg)	**Note:** Reduced boiler load through maximum mechanical throughput of 40.8 tph each line and MWe output plus reduced operation hours not to exceed maximum waste throughput of 625,600 tpa	8.85
Total waste input (tonnes/yr)		625,600
EfW Facility operations (hrs/yr)		7,667
EfW Facility electricity generation (MWe)		54.08

CCC current residual waste
(for Scenarios: 4 and 11)

(provided by CCC in Deadline 4 Submission - Cover letter and Appendices [REP4-028])

Waste Stream	CCC Current Residual Waste 2021 (% by weight)	Biogenic Carbon (% of waste stream)	Non-Biogenic Carbon (% of waste stream)	Net Calorific Value (MJ/kg)	Biogenic Carbon (% by weight)	Non-Biogenic Carbon (% by weight)	Total Carbon (% by weight)	Total NCV (MJ/kg)
Paper & Card	12.37%	31.27%		10.749	3.87%		3.87%	1.33
Plastics	13.17%		54.76%	24.682		7.21%	7.21%	3.25
Textiles	3.88%	19.93%	19.93%	14.327	0.77%	0.77%	1.55%	0.56
Misc. Combustible	14.10%	23.69%	15.79%	14.612	3.34%	2.23%	5.57%	2.06
Misc. Non-Combustible	5.82%	2.94%	4.05%	2.573	0.17%	0.24%	0.41%	0.15
Other Wastes	0.0%	2.94%	4.05%	2.573	0.00%	0.00%	0.00%	0.00
Glass & Metals	4.96%							
Organic Waste	41.42%	13.46%		3.460	5.58%		5.58%	1.43
Wood	1.04%	17.17%		4.210	0.18%		0.18%	0.04
WEEE	3.25%		15.81%	7.060	0.00%	0.51%	0.51%	0.23
Total	100.0%				13.9%	11.0%	24.87%	9.05
					55.92%	44.08%		

EfW CHP Facility Operating Parameters for NCV (provided by MVV)

Net Calorific Value (MJ/kg)	**Note:** 100% design point with 55 MWe net power output, but reduced operation hours not to exceed maximum waste throughput of 625,600 tpa	9.05
Total waste input (tonnes/yr)		625,600
EfW Facility operations (hrs/yr)		7,713
EfW Facility electricity generation (MWe)		55

CCC current residual waste: with 50% less plastic
(for Scenarios: 5 and 12)

(provided by CCC in Deadline 4 Submission - Cover letter and Appendices [REP4-028])

Waste Stream	CCC 50% less plastic (% by weight)	Biogenic Carbon (% of waste stream)	Non-Biogenic Carbon (% of waste stream)	Net Calorific Value (MJ/kg)	Biogenic Carbon (% by weight)	Non-Biogenic Carbon (% by weight)	Total Carbon (% by weight)	Total NCV (MJ/kg)
Paper & Card	23.10%	31.27%		10.749	7.22%		7.22%	2.48
Plastics	8.00%		54.76%	24.682		4.38%	4.38%	1.97
Textiles	6.00%	19.93%	19.93%	14.327	1.20%	1.20%	2.39%	0.86
Misc. Combustible	10.20%	23.69%	15.79%	14.612	2.42%	1.61%	4.03%	1.49
Misc. Non-Combustible	3.90%	2.94%	4.05%	2.573	0.11%	0.16%	0.27%	0.10
Other Wastes	0.9%	2.94%	4.05%	2.573	0.03%	0.04%	0.06%	0.02
Glass & Metals	6.70%							
Organic Waste	35.00%	13.46%		3.460	4.71%		4.71%	1.21
Wood	2.50%	17.17%		4.210	0.43%		0.43%	0.11
WEEE	3.60%		15.81%	7.060	0.00%	0.57%	0.57%	0.25
Total	99.9%				16.1%	8.0%	24.07%	8.50
					66.96%	33.04%		

EfW CHP Facility Operating Parameters for NCV (provided by MVV)

Net Calorific Value (MJ/kg)	**Note:** Reduced boiler load through maximum mechanical throughput of 40.8 tph each line and MWe output plus reduced operation hours not to exceed maximum waste throughput of 625,600 tpa	8.50
Total waste input (tonnes/yr)		625,600
EfW Facility operations (hrs/yr)		7,667
EfW Facility electricity generation (MWe)		51.94

CCC current residual waste: with 50% less organics
(for Scenarios: 6 and 13)

(provided by CCC in Deadline 4 Submission - Cover letter and Appendices [REP4-028])

Waste Stream	CCC 50% less organics (% by weight)	Biogenic Carbon (% of waste stream)	Non-Biogenic Carbon (% of waste stream)	Net Calorific Value (MJ/kg)	Biogenic Carbon (% by weight)	Non-Biogenic Carbon (% by weight)	Total Carbon (% by weight)	Total NCV (MJ/kg)
Paper & Card	26.10%	31.27%		10.749	8.16%		8.16%	2.81
Plastics	19.80%		54.76%	24.682		10.84%	10.84%	4.89
Textiles	6.80%	19.93%	19.93%	14.327	1.36%	1.36%	2.71%	0.97
Misc. Combustible	11.50%	23.69%	15.79%	14.612	2.72%	1.82%	4.54%	1.68
Misc. Non-Combustible	4.40%	2.94%	4.05%	2.573	0.13%	0.18%	0.31%	0.11
Other Wastes	1.0%	2.94%	4.05%	2.573	0.03%	0.04%	0.07%	0.03
Glass & Metals	7.50%							
Organic Waste	16.00%	13.46%		3.460	2.15%		2.15%	0.55
Wood	2.80%	17.17%		4.210	0.48%		0.48%	0.12
WEEE	4.10%		15.81%	7.060	0.00%	0.65%	0.65%	0.29
Total	100.0%				15.0%	14.9%	29.91%	11.45
					50.26%	49.74%		

EfW CHP Facility Operating Parameters for NCV (provided by MVV)

Net Calorific Value (MJ/kg)	**Note:** 100% design point with 55 MWe net power output and waste throughput below 625,600 tpa	11.45
Total waste input (tonnes/yr)		503,804
EfW Facility operations (hrs/yr)		8,000
EfW Facility electricity generation (MWe)		55

Net Emisssions Summary

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Analysis Category	Item	Description	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)	Lifetime Net change from Proposed Development (ktCO2e)	% difference to LFG
ES Case	Sc 1	ES Case	10,611	8,040	-2,572	-24.2%
	Sc 2	ES Case with reduced recyclables (65% target)	10,868	7,808	-3,060	-28.2%
	Sc 3	ES Case with 90% less food and plastics	13,688	4,055	-9,632	-70.4%
Waste Composition (WC)	Sc 4	CCC: current residual waste	10,048	8,109	-1,940	-19.3%
	Sc 5	CCC: 50% reduced plastics	11,625	5,509	-6,116	-52.6%
	Sc 6	CCC: 50% reduced organics	8,765	8,940	175	2.0%
	Sc 7	Gas-fired power stations (CCGT)	9,791	4,696	-5,095	-52.0%
	Sc 8	UK grid decarbonisation – for ES Case	11,330	10,970	-361	-3.2%
	Sc 9	UK grid decarbonisation – with reduced recyclables (65% target)	11,604	10,738	-866	-7.5%
Electricity Generation Offset (EGO)	Sc 10	UK grid decarbonisation – with 90% less food and plastics	14,618	6,816	-7,801	-53.4%
	Sc 11	UK grid decarbonisation – CCC: current residual waste	10,729	10,934	205	1.9%
	Sc 12	UK grid decarbonisation – CCC: 50% reduced plastics	12,414	8,161	-4,253	-34.3%
	Sc 13	UK grid decarbonisation – CCC: 50% reduced organics	9,357	11,870	2,512	26.8%
Combined Heat and Power (CHP)	Sc 14	CHP, export of steam from the EfW CHP facility	10,542	5,139	-5,404	-51.3%
	Sc 15	CHP, export of steam from the EfW CHP facility – including grid decarbonisation	11,330	10,583	-747	-6.6%
	Sc 16	52% LFG capture rate	16,431	8,040	-8,391	-51.1%
Landfill Gas capture rate (LFG)	Sc 17	52% LFG capture rate – including grid decarbonisation	16,980	10,970	-6,011	-35.4%
	Sc 18	85% LFG capture rate	4,428	8,040	3,611	81.5%
	Sc 19	85% LFG capture rate – including grid decarbonisation	5,327	10,970	5,642	105.9%
	Sc 20	2030 adoption of CCS by the EfW CHP facility	10,611	1,185	-9,427	-88.8%
Carbon Capture and Storage (CCS)	Sc 21	2030 adoption of CCS by the EfW CHP facility – including grid decarbonisation	11,330	3,397	-7,933	-70.0%
	Sc 22	2040 adoption of CCS by the EfW CHP facility	10,611	3,100	-7,511	-70.8%
	Sc 23	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation	11,330	5,496	-5,834	-51.5%
	Sc 24	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and reduced recyclables (65% target)	11,604	5,392	-6,212	-53.5%
	Sc 25	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and 90% less food and plastics	14,618	3,625	-10,992	-75.2%
	Sc 26	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: current residual waste	10,729	5,478	-5,251	-48.9%
Decarbonisation and CCS combined (D&CCS)	Sc 27	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced plastics	12,414	4,226	-8,187	-66.0%
	Sc 28	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced organics	9,357	5,897	-3,460	-37.0%
	Sc 29	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CHP, export of steam from the EfW CHP facility	11,330	5,110	-6,221	-54.9%
	Sc 30	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 52% LFG capture rate	16,980	5,496	-11,484	-67.6%
	Sc 31	2041 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 85% LFG capture rate	5,327	5,496	169	3.2%

Gross Emisssions Summary

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Analysis Category	Item	Description	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)	Lifetime Net change from Proposed Development (ktCO2e)	% difference to LFG
ES Case	Sc 1	ES Case	11,397	11,243	-155	-1.4%
	Sc 2	ES Case with reduced recyclables (65% target)	11,673	11,011	-662	-5.7%
	Sc 3	ES Case with 90% less food and plastics	14,704	7,074	-7,631	-51.9%
Waste Composition (WC)	Sc 4	CCC: current residual waste	10,792	11,197	405	3.8%
	Sc 5	CCC: 50% reduced plastics	12,487	8,409	-4,079	-32.7%
	Sc 6	CCC: 50% reduced organics	9,413	12,143	2,730	29.0%
	Sc 7	Gas-fired power stations (CCGT)	11,397	11,243	-155	-1.4%
	Sc 8	UK grid decarbonisation – for ES Case	11,397	11,243	-155	-1.4%
	Sc 9	UK grid decarbonisation – with reduced recyclables (65% target)	11,673	11,011	-662	-5.7%
Electricity Generation Offset (EGO)	Sc 10	UK grid decarbonisation – with 90% less food and plastics	14,704	7,074	-7,631	-51.9%
	Sc 11	UK grid decarbonisation – CCC: current residual waste	10,792	11,197	405	3.8%
	Sc 12	UK grid decarbonisation – CCC: 50% reduced plastics	12,487	8,409	-4,079	-32.7%
	Sc 13	UK grid decarbonisation – CCC: 50% reduced organics	9,413	12,143	2,730	29.0%
Combined Heat and Power (CHP)	Sc 14	CHP, export of steam from the EfW CHP facility	11,397	11,243	-155	-1.4%
	Sc 15	CHP, export of steam from the EfW CHP facility – including grid decarbonisation	11,397	11,243	-155	-1.4%
	Sc 16	52% LFG capture rate	17,032	11,243	-5,789	-34.0%
Landfill Gas capture rate (LFG)	Sc 17	52% LFG capture rate – including grid decarbonisation	17,032	11,243	-5,789	-34.0%
	Sc 18	85% LFG capture rate	5,411	11,243	5,832	107.8%
	Sc 19	85% LFG capture rate – including grid decarbonisation	5,411	11,243	5,832	107.8%
	Sc 20	2030 adoption of CCS by the EfW CHP facility	11,397	11,285	-113	-1.0%
Carbon Capture and Storage (CCS)	Sc 21	2030 adoption of CCS by the EfW CHP facility – including grid decarbonisation	11,397	11,285	-113	-1.0%
	Sc 22	2040 adoption of CCS by the EfW CHP facility	11,397	11,285	-113	-1.0%
	Sc 23	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation	11,397	11,285	-113	-1.0%
	Sc 24	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and reduced recyclables (65% target)	11,673	11,053	-620	-5.3%
	Sc 25	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and 90% less food and plastics	14,704	7,116	-7,589	-51.6%
	Sc 26	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: current residual waste	10,792	11,239	447	4.1%
Decarbonisation and CCS combined (D&CCS)	Sc 27	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced plastics	12,487	8,451	-4,037	-32.3%
	Sc 28	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced organics	9,413	12,185	2,772	29.5%
	Sc 29	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CHP, export of steam from the EfW CHP facility	11,397	11,285	-113	-1.0%
	Sc 30	2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 52% LFG capture rate	17,032	11,285	-5,747	-33.7%
	Sc 31	2041 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 85% LFG capture rate	5,411	11,285	5,874	108.6%

Scenario 1

ES Case

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	Headline assumptions for ES Case (additional to the general assumptions)	**Reference**
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 1
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 1
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**80,080**
EfW Net emissions (tCO2e/yr)	**188,085**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 1
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**19,650**
LFG Net emissions (tCO2e/yr)	**262,062**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 1
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Net operational emissions (ktCO2e)	7,523
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	786
LFG Net operational emissions (ktCO2e)	10,482

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 1) ES Case	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-786.01	-3,203.20
TOTAL	**10,611.36**	**8,039.57**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-2,571.79

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 2

ES Case with reduced recyclables (65% target)

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on: target 65% of municipal waste is recycled by 2035, with 44.5% already recycled in 2019	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 615,668 t/yr)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 2
Recyclable Paper	5.5%
Card	5.9%
Non-recyclable Paper	10.4%
Dense Plastic	7.3%
Plastic film	7.7%
Textiles	5.1%
Misc. Combustible	10.9%
Misc. Non-Combustible	4.2%
Other Wastes	0.4%
Glass	2.4%
Ferrous Metals	2.2%
Non-Ferrous Metals	1.0%
Food Waste	25.2%
Garden Waste	2.5%
Other Organic	2.7%
Wood	2.1%
WEEE	1.3%
Hazardous	0.6%
Fines	2.6%
Net Calorific Value (MJ/kg)	9.50
Total waste input (tonnes/yr)	615,668
Total Carbon (% by weight)	26.21%
Biogenic Carbon (% of Total Carbon)	58.35%
Non-Biogenic Carbon (% of Total Carbon)	41.65%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 2
Total waste input (tonnes/yr)	615,668
Total Carbon (% by weight)	26.21%
Non-Biogenic Carbon (% of Total Carbon)	41.65%
Mass of fossil carbon in residual waste (tonnes carbon)	67,213
Fossil derived CO2 emissions (tCO2)	246,449
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,201
CH4 emissions from residual waste combustion (tonnes)	176
Equivalent CO2 emissions (tCO2e)	4,914
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**262,379**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**80,080**
EfW Net emissions (tCO2e/yr)	**182,299**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 2
Mass of biogenic carbon in residual waste (tonnes carbon)	94,182
Total carbon converted to LFG (tonnes carbon)	47,091
Methane in LFG released from residual waste (tCH4)	35,789
Methane in LFG captured for use in gas engines (tCH4)	24,337
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,145
Uncaptured LFG released to atmosphere as methane (tCH4)	10,307
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**288,604**
Methane in LFG captured for use in gas engines (tCH4)	24,337
Methane used in gas engines (tCH4)	22,122
Fuel input to LFG engines (GJ)	398,197
Power generated by LFG engines (MWh)	110,610
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**20,131**
LFG Net emissions (tCO2e/yr)	**268,473**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 2
EfW Gross operational emissions (ktCO2e)	10,495
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Net operational emissions (ktCO2e)	7,292
LFG Gross operational emissions (ktCO2e)	11,544
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	805
LFG Net operational emissions (ktCO2e)	10,739

Step 5) Lifetime carbon emissions

Project Lifecycles	**Scenario 2) ES Case with reduced recyclables (65% target)**	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,495.14
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,544.17	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-805.24	-3,203.20
TOTAL	**10,867.82**	**7,808.13**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-3,059.69

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 3

ES Case with 90% less food and plastics

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	**Reference**
1a	Waste composition based on: 90% reduction in food and plastics, in addition to 20% reduction in other recyclables	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 54.08)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	**Scenario 3**
Recyclable Paper	8.5%
Card	9.1%
Non-recyclable Paper	16.0%
Dense Plastic	1.4%
Plastic film	1.5%
Textiles	7.9%
Misc. Combustible	16.7%
Misc. Non-Combustible	6.5%
Other Wastes	0.5%
Glass	3.7%
Ferrous Metals	3.5%
Non-Ferrous Metals	1.6%
Food Waste	4.9%
Garden Waste	3.9%
Other Organic	4.1%
Wood	3.3%
WEEE	2.0%
Hazardous	0.9%
Fines	4.0%
Net Calorific Value (MJ/kg)	8.85
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	25.49%
Biogenic Carbon (% of Total Carbon)	74.58%
Non-Biogenic Carbon (% of Total Carbon)	25.42%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	**Scenario 3**
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	25.49%
Non-Biogenic Carbon (% of Total Carbon)	25.42%
Mass of fossil carbon in residual waste (tonnes carbon)	40,528
Fossil derived CO2 emissions (tCO2)	148,603
N2O emissions from residual waste combustion (tonnes)	22
Equivalent CO2 emissions (tCO2e)	5,868
CH4 emissions from residual waste combustion (tonnes)	166
Equivalent CO2 emissions (tCO2e)	4,650
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**163,935**
EfW Facility electricity generation (MWe)	54
EfW Facility operations (hrs/yr)	7,667
Electricity generated by EfW Facility (MWh)	414,613
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**75,460**
EfW Net emissions (tCO2e/yr)	**88,475**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	**Scenario 3**
Mass of biogenic carbon in residual waste (tonnes carbon)	118,912
Total carbon converted to LFG (tonnes carbon)	59,456
Methane in LFG released from residual waste (tCH4)	45,187
Methane in LFG captured for use in gas engines (tCH4)	30,727
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,446
Uncaptured LFG released to atmosphere as methane (tCH4)	13,014
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**364,386**
Methane in LFG captured for use in gas engines (tCH4)	30,727
Methane used in gas engines (tCH4)	27,931
Fuel input to LFG engines (GJ)	502,755
Power generated by LFG engines (MWh)	139,654
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**25,417**
LFG Net emissions (tCO2e/yr)	**338,969**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	**Scenario 3**
EfW Gross operational emissions (ktCO2e)	6,557
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,018
EfW Net operational emissions (ktCO2e)	3,539
LFG Gross operational emissions (ktCO2e)	14,575
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	1,017
LFG Net operational emissions (ktCO2e)	13,559

Step 5) Lifetime carbon emissions

Project Lifecycles	**Scenario 3) ES Case with 90% less food and plastics**	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	6,557.40
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	14,575.42	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-1,016.68	-3,018.39
TOTAL	**13,687.63**	**4,055.21**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-9,632.42

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 4

CCC: current residual waste

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on: Cambridgeshire Current Residual Waste Composition	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,713 per yr)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 4
Paper & Card	12.4%
Plastics	13.2%
Textiles	3.9%
Misc. Combustible	14.1%
Misc. Non-Combustible	5.8%
Other Wastes	0.0%
Glass & Metals	5.0%
Food Waste	41.4%
Wood	1.0%
WEEE	3.3%
Net Calorific Value (MJ/kg)	9.05
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.87%
Biogenic Carbon (% of Total Carbon)	55.92%
Non-Biogenic Carbon (% of Total Carbon)	44.08%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 4
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.87%
Non-Biogenic Carbon (% of Total Carbon)	44.08%
Mass of fossil carbon in residual waste (tonnes carbon)	68,576
Fossil derived CO2 emissions (tCO2)	251,445
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,003
CH4 emissions from residual waste combustion (tonnes)	170
Equivalent CO2 emissions (tCO2e)	4,757
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**267,020**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	7,713
Electricity generated by EfW Facility (MWh)	424,215
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**77,207**
EfW Net emissions (tCO2e/yr)	**189,813**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 4
Mass of biogenic carbon in residual waste (tonnes carbon)	86,996
Total carbon converted to LFG (tonnes carbon)	43,498
Methane in LFG released from residual waste (tCH4)	33,058
Methane in LFG captured for use in gas engines (tCH4)	22,480
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,058
Uncaptured LFG released to atmosphere as methane (tCH4)	9,521
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**266,583**
Methane in LFG captured for use in gas engines (tCH4)	22,480
Methane used in gas engines (tCH4)	20,434
Fuel input to LFG engines (GJ)	367,812
Power generated by LFG engines (MWh)	102,170
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**18,595**
LFG Net emissions (tCO2e/yr)	**247,988**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 4
EfW Gross operational emissions (ktCO2e)	10,681
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,088
EfW Net operational emissions (ktCO2e)	7,593
LFG Gross operational emissions (ktCO2e)	10,663
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	744
LFG Net operational emissions (ktCO2e)	9,920

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 4) CCC: current residual waste	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,680.81
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	10,663.30	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-743.80	-3,088.29
TOTAL	**10,048.39**	**8,108.71**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-1,939.68

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 5

CCC: 50% reduced plastics

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	**Reference**
1a	Waste composition based on: Cambridgeshire current residual waste with plastics reduced 50% less than baseline	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 51.94)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 5
Paper & Card	23.1%
Plastics	8.0%
Textiles	6.0%
Misc. Combustible	10.2%
Misc. Non-Combustible	3.9%
Other Wastes	0.9%
Glass & Metals	6.7%
Food Waste	35.0%
Wood	2.5%
WEEE	3.6%
Net Calorific Value (MJ/kg)	8.50
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.07%
Biogenic Carbon (% of Total Carbon)	66.96%
Non-Biogenic Carbon (% of Total Carbon)	33.04%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 5
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.07%
Non-Biogenic Carbon (% of Total Carbon)	33.04%
Mass of fossil carbon in residual waste (tonnes carbon)	49,742
Fossil derived CO2 emissions (tCO2)	182,389
N2O emissions from residual waste combustion (tonnes)	21
Equivalent CO2 emissions (tCO2e)	5,638
CH4 emissions from residual waste combustion (tonnes)	160
Equivalent CO2 emissions (tCO2e)	4,468
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**197,309**
EfW Facility electricity generation (MWe)	52
EfW Facility operations (hrs/yr)	7,667
Electricity generated by EfW Facility (MWh)	398,241
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**72,480**
EfW Net emissions (tCO2e/yr)	**124,829**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 5
Mass of biogenic carbon in residual waste (tonnes carbon)	100,825
Total carbon converted to LFG (tonnes carbon)	50,412
Methane in LFG released from residual waste (tCH4)	38,313
Methane in LFG captured for use in gas engines (tCH4)	26,053
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,226
Uncaptured LFG released to atmosphere as methane (tCH4)	11,034
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**308,960**
Methane in LFG captured for use in gas engines (tCH4)	26,053
Methane used in gas engines (tCH4)	23,682
Fuel input to LFG engines (GJ)	426,282
Power generated by LFG engines (MWh)	118,412
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**21,551**
LFG Net emissions (tCO2e/yr)	**287,409**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 5
EfW Gross operational emissions (ktCO2e)	7,892
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	2,899
EfW Net operational emissions (ktCO2e)	4,993
LFG Gross operational emissions (ktCO2e)	12,358
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	862
LFG Net operational emissions (ktCO2e)	11,496

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 5) CCC: 50% reduced plastics	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	7,892.35
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	12,358.39	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-862.04	-2,899.19
TOTAL	**11,625.25**	**5,509.35**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-6,115.90

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxillary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 6

CCC: 50% reduced organics

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on: Cambridgeshire current residual waste with organics reduced 50% less than baseline	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 503,804 t/yr)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 6
Paper & Card	26.1%
Plastics	19.8%
Textiles	6.8%
Misc. Combustible	11.5%
Misc. Non-Combustible	4.4%
Other Wastes	1.0%
Glass & Metals	7.5%
Food Waste	16.0%
Wood	2.8%
WEEE	4.1%
Net Calorific Value (MJ/kg)	11.45
Total waste input (tonnes/yr)	503,804
Total Carbon (% by weight)	29.91%
Biogenic Carbon (% of Total Carbon)	50.26%
Non-Biogenic Carbon (% of Total Carbon)	49.74%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 6
Total waste input (tonnes/yr)	503,804
Total Carbon (% by weight)	29.91%
Non-Biogenic Carbon (% of Total Carbon)	49.74%
Mass of fossil carbon in residual waste (tonnes carbon)	74,971
Fossil derived CO2 emissions (tCO2)	274,893
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,113
CH4 emissions from residual waste combustion (tonnes)	173
Equivalent CO2 emissions (tCO2e)	4,844
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**290,665**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**80,080**
EfW Net emissions (tCO2e/yr)	**210,585**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 6
Mass of biogenic carbon in residual waste (tonnes carbon)	75,740
Total carbon converted to LFG (tonnes carbon)	37,870
Methane in LFG released from residual waste (tCH4)	28,781
Methane in LFG captured for use in gas engines (tCH4)	19,571
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	921
Uncaptured LFG released to atmosphere as methane (tCH4)	8,289
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**232,093**
Methane in LFG captured for use in gas engines (tCH4)	19,571
Methane used in gas engines (tCH4)	17,790
Fuel input to LFG engines (GJ)	320,226
Power generated by LFG engines (MWh)	88,952
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**16,189**
LFG Net emissions (tCO2e/yr)	**215,904**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 6
EfW Gross operational emissions (ktCO2e)	11,627
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Net operational emissions (ktCO2e)	8,423
LFG Gross operational emissions (ktCO2e)	9,284
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	648
LFG Net operational emissions (ktCO2e)	8,636

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 6) CCC: 50% reduced organics	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	11,626.60
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	9,283.72	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-647.57	-3,203.20
TOTAL	**8,765.05**	**8,939.59**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	174.55

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 7

Gas-fired power stations (CCGT)

Link back to index table

Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	**Reference**
1a Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2 Electricity generation using natural gas, offset for 40 years, based on latest UK emissions factor 2021/22 = 372 g/kWh	DESNZ (2023). Fuel Mix Disclosure Data Table 2021-2022
3 Electricity export only for the EfW CHP facility, no steam export	N/A
4 LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5 No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 7
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 7
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	372
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**163,680**
EfW Net emissions (tCO2e/yr)	**104,485**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 7
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	372
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**40,164**
LFG Net emissions (tCO2e/yr)	**241,548**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 7
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	6,547
EfW Net operational emissions (ktCO2e)	4,179
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	1,607
LFG Net operational emissions (ktCO2e)	9,662

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 7) Gas-fired power stations (CCGT)	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-1,606.57	-6,547.20
TOTAL	**9,790.80**	**4,695.57**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e) -5,095.23

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 8

UK grid decarbonisation – for ES Case

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 8
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 8
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E59:AR59
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E60:AR60
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18
EfW offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920

	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	18	17	16	15	15	14	13	8	8	7
EfW offset (tCO2e/yr)	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2
EfW offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880

	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	2	2	2	2	2	2	2	2	2	2
EfW offset (tCO2e/yr)	880	880	880	880	880	880	880	880	880	880

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 8
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E70:AR70
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E71:AR71
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18
LFG offset (tCO2e/yr)	9,717	7,234	6,262	5,290	4,859	4,103	3,239	2,591	2,051	1,943

	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	18	17	16	15	15	14	13	8	8	7
LFG offset (tCO2e/yr)	1,943	1,835	1,727	1,620	1,620	1,512	1,404	864	864	756

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2
LFG offset (tCO2e/yr)	756	540	540	324	216	216	216	216	216	216

	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	2	2	2	2	2	2	2	2	2	2
LFG offset (tCO2e/yr)	216	216	216	216	216	216	216	216	216	216

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 8
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Net operational emissions (ktCO2e)	10,453
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	67
LFG Net operational emissions (ktCO2e)	11,201

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 8) UK grid decarbonisation – for ES Case LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.63
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.46	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 –C3 –C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-67.03	-273.24
TOTAL	**11,330.32**	**10,969.53**
Net change in GHG emissions resulting from the Proposed Development (ktCO2e)		-360.79

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 9

UK grid decarbonisation – with reduced recyclables (65% target)

Link back to index table

	Headline assumptions for forecasts (red font indicates variation with respect to the PS1 text)	Reference
1a	Waste composition based on: target 65% of municipal waste is recycled by 2035, with 44.5% already recycled in 2019	See worksheet: 'Waste composition variation'
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 615,668 t/yr)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 9
Recyclable Paper	5.5%
Card	5.9%
Non-recyclable Paper	10.4%
Dense Plastic	7.3%
Plastic Film	7.7%
Textiles	5.1%
Misc. Combustible	10.9%
Misc. Non-Combustible	4.3%
Other Wastes	0.4%
Glass	2.4%
Ferrous Metals	2.2%
Non-Ferrous Metals	1.0%
Food Waste	25.2%
Garden Waste	2.5%
Other Organic	2.7%
Wood	2.1%
WEEE	1.3%
Hazardous	0.6%
Fines	2.6%
Net Calorific Value (MJ/kg)	9.50
Total waste input (tonnes/yr)	615,668
Total Carbon (% by weight)	26.21%
Biogenic Carbon (% of Total Carbon)	58.35%
Non-Biogenic Carbon (% of Total Carbon)	41.65%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 9
Total waste input (tonnes/yr)	615,668
Total Carbon (% by weight)	26.21%
Non-Biogenic Carbon (% of Total Carbon)	41.65%
Mass of fossil carbon in residual waste (tonnes carbon)	67,213
Fossil derived CO2 emissions (tCO2)	246,449
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,205
CH4 emissions from residual waste combustion (tonnes)	176
Equivalent CO2 emissions (tCO2e)	4,934
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**262,379**
EfW Facility electricity generation (MWe)	50
EfW Facility operations (hrs/yr)	8,800
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E52:AR52
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E53:AR53
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 9
Mass of biogenic carbon in residual waste (tonnes carbon)	94,182
Total carbon converted to LFG (tonnes carbon)	47,091
Methane in LFG released from residual waste (tCH4)	35,788
Methane in LFG captured for use in gas engines (tCH4)	24,337
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,145
Uncaptured LFG released to atmosphere as methane (tCH4)	10,307
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**288,604**
Methane in LFG captured for use in gas engines (tCH4)	24,337
Methane used in gas engines (tCH4)	22,122
Fuel input to LFG engines (GJ)	1,106,107
Power generated by LFG engines (MWh)	110,610
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset (tCO2e/yr)	9,955	7,411	6,415	5,420	4,977	4,203	3,318	2,655	2,102	1,991	1,991	1,880	1,770	1,659	1,659	1,549	1,438	885	885	774

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset (tCO2e/yr)	774	553	553	332	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 9
EfW Gross operational emissions (ktCO2e)	10,495
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Net operational emissions (ktCO2e)	10,222
LFG Gross operational emissions (ktCO2e)	11,544
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	69
LFG Net operational emissions (ktCO2e)	11,475

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 9) UK grid decarbonisation – with reduced recyclables (65% target) LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,495.14
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,544.17	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-68.69	-273.24
TOTAL	**11,604.37**	**10,738.09**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-866.28

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 10

UK grid decarbonisation – with 90% less food and plastics

Link back to index table

	Headline assumptions for forecasts (red font indicates variation with respect to the PS-F test)	Reference
1a	Waste composition based on: 90% reduction in food and plastics, in addition to 30% reduction in other recyclables	See worksheet: 'Waste composition variation'
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 54.08)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19 supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 10
Recyclable Paper	8.5%
Card	9.1%
Non-recyclable Paper	16.0%
Dense Plastic	1.4%
Plastic Film	1.5%
Textiles	7.9%
Misc. Combustible	16.7%
Misc. Non-Combustible	6.5%
Other Wastes	0.5%
Glass	3.7%
Ferrous Metals	3.5%
Non-Ferrous Metals	1.6%
Food Waste	4.9%
Garden Waste	3.9%
Other Organic	4.1%
Wood	3.3%
WEEE	2.0%
Hazardous	0.9%
Fines	4.0%
Net Calorific Value (MJ/kg)	8.95
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	25.49%
Biogenic Carbon (% of Total Carbon)	74.58%
Non-Biogenic Carbon (% of Total Carbon)	25.42%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 10
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	25.49%
Non-Biogenic Carbon (% of Total Carbon)	25.42%
Mass of fossil carbon in residual waste (tonnes carbon)	40,528
Fossil derived CO2 emissions (tCO2)	148,605
N2O emissions from residual waste combustion (tonnes)	22
Equivalent CO2 emissions (tCO2e)	5,868
CH4 emissions from residual waste combustion (tonnes)	166
Equivalent CO2 emissions (tCO2e)	4,650
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**163,938**
EfW Facility electricity generation (MWe)	54
EfW Facility operations (hrs/yr)	7,667
Electricity generated by EfW Facility (MWh)	414,611
CO2 emissions factor for energy generation (g/kWh)	See cells E58:AR58
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E59:AR59
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor for energy generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	37,315	27,779	24,048	20,316	18,658	15,755	12,438	9,951	7,878	7,463	7,463	7,048	6,634	6,219	6,219	5,805	5,390	3,317	3,317	2,902

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for energy generation (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	2,902	2,073	2,073	1,244	829	829	829	829	829	829	829	829	829	829	829	829	829	829	829	829

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 10
Mass of biogenic carbon in residual waste (tonnes carbon)	118,912
Total carbon converted to LFG (tonnes carbon)	59,456
Methane in LFG released from residual waste (tCH4)	45,187
Methane in LFG captured for use in gas engines (tCH4)	30,727
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,446
Uncaptured LFG released to atmosphere as methane (tCH4)	13,014
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**364,386**
Methane in LFG captured for use in gas engines (tCH4)	30,727
Methane used in gas engines (tCH4)	27,931
Fuel input to LFG engines (GJ)	502,755
Power generated by LFG engines (MWh)	139,654
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor for electricity generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	12,569	9,357	8,100	6,843	6,284	5,307	4,190	3,352	2,653	2,514	2,514	2,374	2,234	2,095	2,095	1,955	1,816	1,117	1,117	978

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor for electricity generation (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	978	698	698	419	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 10
EfW Gross operational emissions (ktCO2e)	6,557
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	257
EfW Net operational emissions (ktCO2e)	6,300
LFG Gross operational emissions (ktCO2e)	14,575
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	87
LFG Net operational emissions (ktCO2e)	14,489

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 10) UK grid decarbonisation – with 90% less food and plastics	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	6,557.40
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	14,575.42	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-86.73	-257.47
TOTAL	**14,617.59**	**6,816.12**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-7,801.47

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 11
UK grid decarbonisation – CCC: current residual waste
Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the PS-F test)	Reference
1a	Waste composition based on: Cambridgeshire Current Residual Waste Composition	See worksheet: 'Waste composition variation'
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,753 per yr)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 11
Paper & Card	12.4%
Plastics	13.2%
Textiles	3.9%
Misc. Combustible	14.1%
Misc. Non-Combustible	5.8%
Other Wastes	0.0%
Glass & Metals	5.0%
Food Waste	41.4%
Wood	1.0%
WEEE	3.3%
Net Calorific Value (MJ/kg)	9.00
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.87%
Biogenic Carbon (% of Total Carbon)	55.92%
Non-Biogenic Carbon (% of Total Carbon)	44.08%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 11
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.87%
Non-Biogenic Carbon (% of Total Carbon)	44.08%
Mass of fossil carbon in residual waste (tonnes carbon)	68,576
Fossil derived CO2 emissions (tCO2)	251,445
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,093
CH4 emissions from residual waste combustion (tonnes)	170
Equivalent CO2 emissions (tCO2e)	4,757
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**267,020**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	7,753
Electricity generated by EfW Facility (MWh)	424,215
CO2 emissions factor for energy generation (g/kWh)	See cells E50:AR50
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E51:AR51
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
g/kWh	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7
tCO2e/yr	38,179	28,422	24,604	20,787	19,090	16,120	12,726	10,181	8,060	7,636	7,636	7,212	6,787	6,363	6,363	5,939	5,515	3,394	3,394	2,970	2,970

	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
g/kWh	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
tCO2e/yr	2,121	2,121	1,273	848	848	848	848	848	848	848	848	848	848	848	848	848	848	848	848

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 11
Mass of biogenic carbon in residual waste (tonnes carbon)	86,996
Total carbon converted to LFG (tonnes carbon)	43,498
Methane in LFG released from residual waste (tCH4)	33,058
Methane in LFG captured for use in gas engines (tCH4)	22,480
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,058
Uncaptured LFG released to atmosphere as methane (tCH4)	9,521
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**266,583**
Methane in LFG captured for use in gas engines (tCH4)	22,480
Methane used in gas engines (tCH4)	20,434
Fuel input to LFG engines (GJ)	[illegible]
Power generated by LFG engines (MWh)	102,170
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
g/kWh	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7
tCO2e/yr	9,195	6,845	5,926	5,006	4,598	3,882	3,065	2,452	1,941	1,839	1,839	1,737	1,635	1,533	1,533	1,430	1,328	817	817	715	715

	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
g/kWh	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
tCO2e/yr	511	511	307	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 11
EfW Gross operational emissions (ktCO2e)	10,681
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	263
EfW Net operational emissions (ktCO2e)	10,417
LFG Gross operational emissions (ktCO2e)	10,663
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	63
LFG Net operational emissions (ktCO2e)	10,600

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 11) UK grid decarbonisation – CCC: current residual waste LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,680.81
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	10,663.30	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-63.45	-263.44
TOTAL	**10,728.74**	**10,933.56**
Net change in GHG emissions resulting from the Proposed Development (ktCO2e)		204.82

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 12

UK grid decarbonisation – CCC: 50% reduced plastics

Link back to index table

	Headline assumptions for forecasts (red type indicates variation with respect to the ES ? test)	Reference
1a	Waste composition based on Cambridgeshire current residual waste with plastics reduced 50% less than baseline	See worksheet: 'Waste composition variation'
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 51.94)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 12
Paper & Card	23.1%
Plastics	8.0%
Textiles	6.0%
Misc. Combustible	10.2%
Misc. Non-Combustible	3.9%
Other Wastes	0.9%
Glass & Metals	6.7%
Food Waste	35.0%
Wood	2.5%
WEEE	3.6%
Net Calorific Value (MJ/kg)	8.50
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.07%
Biogenic Carbon (% of Total Carbon)	66.96%
Non-Biogenic Carbon (% of Total Carbon)	33.04%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 12
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.07%
Non-Biogenic Carbon (% of Total Carbon)	33.04%
Mass of fossil carbon in residual waste (tonnes carbon)	49,742
Fossil derived CO2 emissions (tCO2)	182,389
N2O emissions from residual waste combustion (tonnes)	21
Equivalent CO2 emissions (tCO2e)	5,638
CH4 emissions from residual waste combustion (tonnes)	160
Equivalent CO2 emissions (tCO2e)	4,468
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**197,309**
EfW Facility electricity generation (MWe)	52
EfW Facility operations (hrs/yr)	7,667
Electricity generated by EfW Facility (MWh)	398,241
CO2 emissions factor for energy generation (g/kWh)	See cells E60:AR60
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E61:AR61
EfW Net emissions (tCO2e/yr)	**N/A**

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
35,842	26,682	23,098	19,514	17,921	15,133	11,947	9,558	7,567	7,168	7,168	6,770	6,372	5,974	5,974	5,575	5,177	3,186	3,186	2,788

Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2,788	1,991	1,991	1,195	796	796	796	796	796	796	796	796	796	796	796	796	796	796	796	796

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 12
Mass of biogenic carbon in residual waste (tonnes carbon)	100,825
Total carbon converted to LFG (tonnes carbon)	50,412
Methane in LFG released from residual waste (tCH4)	38,313
Methane in LFG captured for use in gas engines (tCH4)	26,053
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,226
Uncaptured LFG released to atmosphere as methane (tCH4)	11,034
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**308,962**
Methane in LFG captured for use in gas engines (tCH4)	26,053
Methane used in gas engines (tCH4)	23,682
Fuel input to LFG engines (GJ)	426,282
Power generated by LFG engines (MWh)	118,412
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
10,657	7,934	6,868	5,802	5,329	4,500	3,552	2,842	2,250	2,131	2,131	2,013	1,895	1,776	1,776	1,658	1,539	947	947	829

Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
829	592	592	355	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 12
EfW Gross operational emissions (ktCO2e)	7,892
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	247
EfW Net operational emissions (ktCO2e)	7,645
LFG Gross operational emissions (ktCO2e)	12,358
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	74
LFG Net operational emissions (ktCO2e)	12,285

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 12) UK grid decarbonisation – CCC: 50% reduced plastics LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	7,892.35
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	12,358.39	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-73.53	-247.31
TOTAL	**12,413.75**	**8,161.24**
Net change in GHG emissions resulting from the Proposed Development (ktCO2e)		-4,252.51

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 13
UK grid decarbonisation – CCC: 50% reduced organics
Link back to index table

	Headline assumptions for forecasts (red type indicates variation with respect to the IPJ test)	Reference
1a	Waste composition based on: Cambridgeshire current residual waste with organics reduced 50% less than baseline	See worksheet: 'Waste composition variables'
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 503,804 t/yr)	See worksheet: 'Waste composition variables'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 13
Paper & Card	26.1%
Plastics	19.8%
Textiles	6.8%
Misc. Combustible	11.5%
Misc. Non-Combustible	4.4%
Other Wastes	1.0%
Glass & Metals	7.5%
Food Waste	16.0%
Wood	2.8%
WEEE	4.1%
Net Calorific Value (MJ/kg)	11.45
Total waste input (tonnes/yr)	503,804
Total Carbon (% by weight)	29.91%
Biogenic Carbon (% of Total Carbon)	50.26%
Non-Biogenic Carbon (% of Total Carbon)	49.74%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 13
Total waste input (tonnes/yr)	503,804
Total Carbon (% by weight)	29.91%
Non-Biogenic Carbon (% of Total Carbon)	49.74%
Mass of fossil carbon in residual waste (tonnes carbon)	74,971
Fossil derived CO2 emissions (tCO2)	274,893
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,115
CH4 emissions from residual waste combustion (tonnes)	173
Equivalent CO2 emissions (tCO2e)	4,846
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**290,660**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E48:AR48
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E49:AR49
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3		Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027		2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67		58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset (tCO2e/yr)	39,600	29,480		25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 13
Mass of biogenic carbon in residual waste (tonnes carbon)	75,740
Total carbon converted to LFG (tonnes carbon)	37,870
Methane in LFG released from residual waste (tCH4)	28,781
Methane in LFG captured for use in gas engines (tCH4)	19,571
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	921
Uncaptured LFG released to atmosphere as methane (tCH4)	8,289
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**232,092**
Methane in LFG captured for use in gas engines (tCH4)	19,571
Methane used in gas engines (tCH4)	17,790
Fuel input to LFG engines (GJ)	320,226
Power generated by LFG engines (MWh)	88,952
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3		Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027		2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67		58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset (tCO2e/yr)	8,006	5,960		5,159	4,359	4,003	3,380	2,669	2,135	1,690	1,601	1,601	1,512	1,423	1,334	1,334	1,245	1,156	712	712	623

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset (tCO2e/yr)	623	445	445	267	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 13
EfW Gross operational emissions (ktCO2e)	11,627
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Net operational emissions (ktCO2e)	11,353
LFG Gross operational emissions (ktCO2e)	9,284
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	55
LFG Net operational emissions (ktCO2e)	9,228

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 13) UK grid decarbonisation – CCC: 50% reduced organics	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	11,626.60
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	9,283.72	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-55.24	-273.24
TOTAL	**9,357.37**	**11,869.55**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	2,512.18

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 14

CHP, export of steam from the EfW CHP facility UK

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 48.8)	See worksheet: *'Waste composition variation'*
2a	Electricity generation offset for 40 years based on latest UK grid average emissions factor 2021/22 = 198 g/kWh	DESNZ (2023). Fuel Mix Disclosure Data Table 2021-2022
2b	Fuel for heating offset for 40 years based on latest natural gas emissions factor 2021/22 = 202.67 g/kWh	UK Government (2023). Greenhouse gas reporting: conversion factors 2023
3	CHP EfW facility exports 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam	MVV design info
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 14
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 14
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	48.8
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	390,400
CO2 emissions factor for energy generation (g/kWh)	198
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	*77,299*
EfW Facility heat generation (MWth)	23.6
EfW Facility operations (hrs/yr)	8,000
Heat exported by EfW facility (MWh)	188,800
CO2 emissions factor for heat generation (g/kWh) - gas	202.67
EfW Equivalent CO2 offset for heat generation by Facility (tCO2e)	*38,264*
EfW Equivalent CO2 offset for electricity and heat energy generation by Facility (tCO2e/yr)	**115,564**
EfW Net emissions (tCO2e/yr)	**152,601**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 14
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	198
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**21,378**
LFG Net emissions (tCO2e/yr)	**260,334**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 14
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity and heat energy generation by Facility (ktCO2e)	6,104
EfW Net operational emissions (ktCO2e)	4,623
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	855
LFG Net operational emissions (ktCO2e)	10,413

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 14) CHP, export of steam from the EfW CHP facility UK	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-855.11	-6,104.04
TOTAL	**10,542.26**	**5,138.73**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-5,403.53

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 15

CHP, export of steam from the EfW CHP facility – including grid decarbonisation

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet 'Waste composition variation'
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 48.8)	See worksheet 'Waste composition variation'
2a	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
2b	Fuel for heating offset to 2035 based on latest natural gas emissions factor 2021/22 = 202.67 g/kWh Fuel for heating offset after 2035 based on BEIS forecast emissions factors for UK grid electricity generation	UK Government (2023). Greenhouse gas reporting: conversion factors 2022; BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	CHP EfW facility exports 48.8MWe of electricity (allowing for 5MWe parasitic load) and 23.6MWth of steam	MVV design info
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 15
Recyclable Paper	5.3%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.8%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.5%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP facility

Parameter	Scenario 15
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,243
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	48.8
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	390,400
CO2 emissions factor for energy generation (g/kWh)	See cells [illegible]
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells [illegible]
EfW Facility heat generation (MWth)	23.6
EfW Facility operations (hrs/yr)	8,000
Heat exported by EfW facility (MWh)	188,800
CO2 emissions factor for heat generation (g/kWh) - gas to 2035, grid elec after 2035	See cells [illegible]
EfW Equivalent CO2 offset for heat generation by Facility (tCO2e)	See cells [illegible]
EfW Equivalent CO2 offset for electricity and heat energy generation by Facility (tCO2e/yr)	**N/A**
EfW Net emissions (tCO2e/yr)	**N/A**

EfW electricity offset by year:

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
Offset (tCO2e/yr)	35,136	26,157	22,643	19,130	17,568	14,835	11,712	9,370	7,418	7,027	7,027	6,637	6,246	5,856	5,856	5,466	5,075	3,123	3,123	2,733

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Offset (tCO2e/yr)	2,733	1,952	1,952	1,171	781	781	781	781	781	781	781	781	781	781	781	781	781	781	781	781

EfW heat offset by year:

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	202.67	202.67	202.67	202.67	202.67	202.67	202.67	202.67	202.67	202.67	18	17	16	15	15	14	13	8	8	7
Offset (tCO2e)	38,264	38,264	38,264	38,264	38,264	38,264	38,264	38,264	38,264	38,264	3,398	3,210	3,021	2,832	2,832	2,643	2,454	1,510	1,510	1,322

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Offset (tCO2e)	1,322	944	944	566	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 15
Mass of biogenic carbon in residual waste (tonnes carbon)	91,953
Total carbon converted to LFG (tonnes carbon)	45,977
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E84:AR84
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E85:AR85
LFG Net emissions (tCO2e/yr)	**N/A**

LFG electricity offset by year:

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
Offset (tCO2e/yr)	9,717	7,234	6,262	5,290	4,859	4,103	3,239	2,591	2,051	1,943	1,943	1,835	1,727	1,620	1,620	1,512	1,404	864	864	756

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Offset (tCO2e/yr)	756	540	540	324	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 15
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity and heat energy generation by Facility (ktCO2e)	660
EfW Net operational emissions (ktCO2e)	10,067
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	67
LFG Net operational emissions (ktCO2e)	11,201

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 15) CHP, export of steam from the EfW CHP facility – including grid decarbonisation LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-67.05	-659.63
TOTAL	**11,330.32**	**10,583.14**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-747.19

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 16

52% LFG capture rate

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for older operational UK landfill (Type 3 MelMOD) = 52%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 16
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 16
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**80,080**
EfW Net emissions (tCO2e/yr)	**188,085**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 16
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	18,166
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,677
Uncaptured LFG released to atmosphere as methane (tCH4)	15,092
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**422,568**
Methane in LFG captured for use in gas engines (tCH4)	18,166
Methane used in gas engines (tCH4)	16,513
Fuel input to LFG engines (GJ)	297,231
Power generated by LFG engines (MWh)	82,564
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**15,027**
LFG Net emissions (tCO2e/yr)	**407,541**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 16
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Net operational emissions (ktCO2e)	7,523
LFG Gross operational emissions (ktCO2e)	16,903
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	601
LFG Net operational emissions (ktCO2e)	16,302

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 16) 52% LFG capture rate	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	16,902.72	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-601.07	-3,203.20
TOTAL	**16,430.55**	**8,039.57**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-8,390.98

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	52%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 17

52% LFG capture rate – including grid decarbonisation

Link back to index table

	Headline assumptions for forecasts (red type indicates variation with respect to the PS-F test)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: '*Waste composition variation*'
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: '*Waste composition variation*'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for older operational UK landfill (Type 3 MetMOD) = 52%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 17
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non Ferrous Metals	1.5%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 17
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E59:AR59
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E60:AR60
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 17
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	18,166
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,677
Uncaptured LFG released to atmosphere as methane (tCH4)	15,092
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**422,568**
Methane in LFG captured for use in gas engines (tCH4)	18,166
Methane used in gas engines (tCH4)	16,513
Fuel input to LFG engines (GJ)	297,231
Power generated by LFG engines (MWh)	82,564
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset (tCO2e/yr)	7,431	5,532	4,789	4,046	3,715	3,137	2,477	1,982	1,569	1,486	1,486	1,404	1,321	1,238	1,238	1,156	1,073	661	661	578

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset (tCO2e/yr)	578	413	413	248	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 17
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Net operational emissions (ktCO2e)	10,453
LFG Gross operational emissions (ktCO2e)	16,903
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	51
LFG Net operational emissions (ktCO2e)	16,851

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 17) 52% LFG capture rate – including grid decarbonisation: LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	16,902.72	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-51.27	-273.24
TOTAL	**16,980.34**	**10,969.53**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-6,010.81

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	52%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 18

85% LFG capture rate

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	Upper limit for instantaneous LFG capture rate for a modern UK landfill = 85% based on experts' opinion	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 18
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 18
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	**80,080**
EfW Net emissions (tCO2e/yr)	**188,085**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 18
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	29,694
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	524
Uncaptured LFG released to atmosphere as methane (tCH4)	4,716
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**132,053**
Methane in LFG captured for use in gas engines (tCH4)	29,694
Methane used in gas engines (tCH4)	26,992
Fuel input to LFG engines (GJ)	485,859
Power generated by LFG engines (MWh)	134,961
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**24,563**
LFG Net emissions (tCO2e/yr)	**107,490**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 18
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Net operational emissions (ktCO2e)	7,523
LFG Gross operational emissions (ktCO2e)	5,282
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	983
LFG Net operational emissions (ktCO2e)	4,300

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 18) 85% LFG capture rate LFG (ktCO2e)	 EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	5,282.10	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-982.51	-3,203.20
TOTAL	**4,428.48**	**8,039.57**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	3,611.09

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	85%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 19

85% LFG capture rate – including grid decarbonisation

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Headline assumptions for Scenario (red type indicates variation with respect to the [illegible])		Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: 'Waste composition variation'
1b	EfW CHP Facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP Facility, no steam export	N/A
4	Upper limit for instantaneous LFG capture rate for a modern UK landfill = 85% based on experts' opinion	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5	No CCS	N/A

Step 1) Residual Waste Composition

Waste Stream	Scenario 19
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic Film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.8%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 19
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells [illegible]
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells [illegible]
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 19
Mass of biogenic carbon in residual waste (tonnes carbon)	91,955
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	29,694
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	524
Uncaptured LFG released to atmosphere as methane (tCH4)	4,716
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**132,053**
Methane in LFG captured for use in gas engines (tCH4)	29,694
Methane used in gas engines (tCH4)	26,992
Fuel input to LFG engines (GJ)	[illegible]
Power generated by LFG engines (MWh)	134,961
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E78:AR78
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E79:AR79
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset (tCO2e/yr)	12,146	9,042	7,828	6,613	6,073	5,129	4,049	3,239	2,564	2,429	2,429	2,294	2,159	2,024	2,024	1,889	1,754	1,080	1,080	945

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset (tCO2e/yr)	945	675	675	405	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 19
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Net operational emissions (ktCO2e)	10,453
LFG Gross operational emissions (ktCO2e)	5,282
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	84
LFG Net operational emissions (ktCO2e)	5,198

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 19) 85% LFG capture rate – including grid decarbonisation LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	5,282.10	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
General		
D – Avoided emissions	-83.81	-273.24
TOTAL	**5,327.18**	**10,969.53**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	5,642.35

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	85%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 20

2030 adoption of CCS by the EfW CHP facility

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2030 onwards (36 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 20
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 20
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	*80,080*
Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2030	
Operating Parameters	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	*214,406*
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	182
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	*21,072*
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	*1,540*
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	*213*
EfW net CCS emissions captured and stored (tCO2e/yr)	*191,581*
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 20
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**19,650**
LFG Net emissions (tCO2e/yr)	**N/A**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 20
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Equivalent CO2 captured by CCS from 2030: 36 years (ktCO2e)	6,897
EfW Net operational emissions (ktCO2e)	626
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	786
LFG Net operational emissions (ktCO2e)	10,482

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 20) 2030 adoption of CCS by the EfW CHP facility	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-786.01	-10,100.13
TOTAL	**10,611.36**	**1,184.64**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-9,426.72

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 21

2030 adoption of CCS by the EfW CHP facility – including grid decarbonisation

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the FS Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2030 onwards (36 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 21
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 21
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2030

Operating Parameters	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	*214,406*
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells I76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells I77:AR77
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	*1,540*
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	*213*
EfW net CCS emissions captured and stored (tCO2e/yr)	*N/A*
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)					45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)					5,210	4,400	3,473	2,779	2,200	2,084	2,084	1,968	1,852	1,737	1,737	1,621	1,505	926	926	810

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	810	579	579	347	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 21
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset (tCO2e/yr)	9,717	7,234	6,262	5,290	4,859	4,103	3,239	2,591	2,051	1,943	1,943	1,835	1,727	1,620	1,620	1,512	1,404	864	864	756

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset (tCO2e/yr)	756	540	540	324	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 21
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Equivalent CO2 captured by CCS from 2030: 36 years (ktCO2e)	7,634
EfW Net operational emissions (ktCO2e)	2,820
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	67
LFG Net operational emissions (ktCO2e)	11,201

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 21) 2030 adoption of CCS by the EfW CHP facility – including grid decarbonisation LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.55
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.31
B6 – Operational energy	25.06	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 – C3 – C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.39
C1 – C2 – C3 – C4 – CCS connecting pipeline, End of life		21.00
General		
D – Avoided emissions	-67.05	-7,887.42
TOTAL	**11,330.32**	**3,397.35**
Net change in GHG emissions resulting from the Proposed Development (ktCO2e)		-7,932.98

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 22

2040 adoption of CCS by the EfW CHP facility

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	Electricity generation offset for 40 years based on emissions factor in ES for UK grid average 2020/21 = 182 g/kWh	BEIS (2021). Fuel Mix Disclosure Data Table 2020-2021
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 22
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 22
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	182
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	*80,080*
Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040	
Operating Parameters	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	*214,406*
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	182
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	*21,072*
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	*1,540*
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	*213*
EfW net CCS emissions captured and stored (tCO2e/yr)	*191,581*
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 22
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	182
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	**19,650**
LFG Net emissions (tCO2e/yr)	**N/A**

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 22
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	3,203
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	4,981
EfW Net operational emissions (ktCO2e)	2,542
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	786
LFG Net operational emissions (ktCO2e)	10,482

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 22) 2040 adoption of CCS by the EfW CHP facility	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-786.01	-8,184.32
TOTAL	**10,611.36**	**3,100.45**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-7,510.91

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 23

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the FS Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: *'Waste composition variation'*
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 23
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 23
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	*214,406*
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells S76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells I77:AR77
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	*1,540*
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	*213*
EfW net CCS emissions captured and stored (tCO2e/yr)	*N/A*
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)															15	14	13	8	8	7
CCS CO2 emissions (tCO2e/yr)															1,737	1,621	1,505	926	926	810

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CCS CO2 emissions (tCO2e/yr)	810	579	579	347	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 23
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG CO2 offset (tCO2e/yr)	9,717	7,234	6,262	5,290	4,859	4,103	3,239	2,591	2,051	1,943	1,943	1,835	1,727	1,620	1,620	1,512	1,404	864	864	756

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG CO2 offset (tCO2e/yr)	756	540	540	324	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 23
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	5,515
EfW Net operational emissions (ktCO2e)	4,938
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	67
LFG Net operational emissions (ktCO2e)	11,201

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 23) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation: LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 – C3 – C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.39
C1 – C2 – C3 – C4 – CCS connecting pipeline, End of life		21.00
General		
D – Avoided emissions	-67.05	-5,788.69
TOTAL	**11,330.32**	**5,496.09**
Net change in GHG emissions resulting from the Proposed Development (ktCO2e)		**-5,834.23**

EfW Parameters:

N2O Emissions Factor Kg N2O/TJ (IPCC)	4
N2O Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor Kg CH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,039,360
Auxilliary burners - % of annual Gas Oil consumption	60%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in residual waste converted to landfill gas (LFG)	50%
Propition of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 24

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and reduced recyclables (65% target)

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on: target 65% of municipal waste is recycled by 2035, with 44.5% already recycled in 2019	See worksheet: 'Waste composition variation'
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 615,668 t/yr)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 24
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.50
Total waste input (tonnes/yr)	615,668
Total Carbon (% by weight)	26.21%
Biogenic Carbon (% of Total Carbon)	58.35%
Non-Biogenic Carbon (% of Total Carbon)	41.65%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 24
Total waste input (tonnes/yr)	615,668
Total Carbon (% by weight)	26.21%
Non-Biogenic Carbon (% of Total Carbon)	41.65%
Mass of fossil carbon in residual waste (tonnes carbon)	67,213
Fossil derived CO2 emissions (tCO2)	246,449
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,201
CH4 emissions from residual waste combustion (tonnes)	176
Equivalent CO2 emissions (tCO2e)	4,914
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**262,379**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	209,481
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells S76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells I77:AR77
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	1,540
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	208
EfW net CCS emissions captured and stored (tCO2e/yr)	N/A
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CCS emissions factor (gCO2e/kWh)															15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CCS emissions (tCO2e/yr)															1,697	1,584	1,471	905	905	792	792	566	566	339	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 24
Mass of biogenic carbon in residual waste (tonnes carbon)	94,182
Total carbon converted to LFG (tonnes carbon)	47,091
Methane in LFG released from residual waste (tCH4)	35,789
Methane in LFG captured for use in gas engines (tCH4)	24,337
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,145
Uncaptured LFG released to atmosphere as methane (tCH4)	10,307
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**288,604**
Methane in LFG captured for use in gas engines (tCH4)	24,337
Methane used in gas engines (tCH4)	22,122
Fuel input to LFG engines (GJ)	398,197
Power generated by LFG engines (MWh)	110,610
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG offset (tCO2e/yr)	9,955	7,411	6,415	5,420	4,977	4,203	3,318	2,655	2,102	1,991	1,991	1,880	1,770	1,659	1,659	1,549	1,438	885	885	774	774	553	553	332	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 24
EfW Gross operational emissions (ktCO2e)	10,495
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Equivalent CO2 captured by CCS from 2040- 26 years (ktCO2e)	5,388
EfW Net operational emissions (ktCO2e)	4,834
LFG Gross operational emissions (ktCO2e)	11,544
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	69
LFG Net operational emissions (ktCO2e)	11,475

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 24) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and reduced recyclables (65% target) LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.31
B6 – Operational energy	25.04	10,495.14
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,544.17	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 – C3 – C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.36
C1 – C2 – C3 – C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-68.68	-5,661.07
TOTAL	**11,604.37**	**5,392.26**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-6,212.11

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N2O Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxiliary burners – % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2735
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in residual waste converted to landfill gas (LFG)	50%
Proportion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 25
2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and 90% less food and plastics
Link back to index table

	Headline assumptions for Scenario (red text indicates variation with respect to the FS Case)	Reference
1a	Waste composition based on 90% reduction in food and plastics, in addition to 20% reduction in other recyclables	See worksheet "Waste composition variation"
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 54.08)	See worksheet "Waste composition variation"
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil-derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120kWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 (tg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 10km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 25
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	3.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.85
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	25.49%
Biogenic Carbon (% of Total Carbon)	74.58%
Non-Biogenic Carbon (% of Total Carbon)	25.42%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 25
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	25.49%
Non-Biogenic Carbon (% of Total Carbon)	25.42%
Mass of fossil carbon in residual waste (tonnes carbon)	40,528
Fossil derived CO2 emissions (tCO2)	148,603
N2O emissions from residual waste combustion (tonnes)	22
Equivalent CO2 emissions (tCO2e)	5,868
CH4 emissions from residual waste combustion (tonnes)	166
Equivalent CO2 emissions (tCO2e)	4,650
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**163,935**
EfW Facility electricity generation (MWe)	54
EfW Facility operations (hrs/yr)	7,667
Electricity generated by EfW Facility (MWh)	414,613
CO2 emissions factor for energy generation (g/kWh)	See cells E47:AR47
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E48:AR48

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
	37,315	27,779	24,048	20,316	18,658	15,755	12,438	9,951	7,878	7,463	7,463	7,048	6,634	6,219	6,219	5,805	5,390	3,317	3,317	2,902

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	2,902	2,073	2,073	1,244	829	829	829	829	829	829	829	829	829	829	829	829	829	829	829	829

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil-derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	126,312
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells E56:AR56
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells E57:AR57
Fugitive CO2 emissions during pipeline transport (tg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	1,540
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	126
EfW net CO2 emissions captured and stored (tCO2e/yr)	N/A
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
															15	14	13	8	8	7
															1,023	955	887	546	546	477

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	477	341	341	205	136	136	136	136	136	136	136	136	136	136	136	136	136	136	136	136

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 25
Mass of biogenic carbon in residual waste (tonnes carbon)	118,912
Total carbon converted to LFG (tonnes carbon)	59,456
Methane in LFG released from residual waste (tCH4)	45,187
Methane in LFG captured for use in gas engines (tCH4)	30,727
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,446
Uncaptured LFG released to atmosphere as methane (tCH4)	13,014
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**364,386**
Methane in LFG captured for use in gas engines (tCH4)	30,727
Methane used in gas engines (tCH4)	27,931
Fuel input to LFG engines (GJ)	[illegible]
Power generated by LFG engines (MWh)	139,654
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
	12,569	9,357	8,100	6,843	6,284	5,307	4,190	3,352	2,653	2,514	2,514	2,374	2,234	2,095	2,095	1,955	1,816	1,117	1,117	978

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	978	698	698	419	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 25
EfW Gross operational emissions (ktCO2e)	6,557
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	257
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	3,233
EfW Net operational emissions (ktCO2e)	3,067
LFG Gross operational emissions (ktCO2e)	14,575
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	87
LFG Net operational emissions (ktCO2e)	14,489

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 25) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and 90% less food and plastics: LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	6,557.40
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	14,575.42	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-86.73	-3,490.33
TOTAL	**14,617.59**	**3,625.27**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-10,992.32

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 26

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: current residual waste

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the PS Case)	Reference
1a	Waste composition based on: Cambridgeshire Current Residual Waste Composition	See worksheet "Waste composition variables"
1b	EfW CHP Facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,713 per yr)	See worksheet "Waste composition variables"
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil-derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120kWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 (tg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 26
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic Film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.00
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.87%
Biogenic Carbon (% of Total Carbon)	55.92%
Non-Biogenic Carbon (% of Total Carbon)	44.08%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 26
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.87%
Non-Biogenic Carbon (% of Total Carbon)	44.08%
Mass of fossil carbon in residual waste (tonnes carbon)	68,576
Fossil derived CO2 emissions (tCO2)	251,445
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,003
CH4 emissions from residual waste combustion (tonnes)	170
Equivalent CO2 emissions (tCO2e)	4,757
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**267,020**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	7,713
Electricity generated by EfW Facility (MWh)	424,215
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor for energy generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset (tCO2e/yr)	38,179	28,422	24,604	20,787	19,090	16,120	12,726	10,181	8,060	7,636	7,636	7,212	6,787	6,363	6,363	5,939	5,515	3,394	3,394	2,970

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for energy generation (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset (tCO2e/yr)	2,970	2,121	2,121	1,273	848	848	848	848	848	848	848	848	848	848	848	848	848	848	848	848

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil-derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	213,728
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells E76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells E77:AR77
Fugitive CO2 emissions during pipeline transport (tg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	2,540
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	212
EfW net CO2 emissions captured and stored (tCO2e/yr)	N/A
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)															15	14	13	8	8	7
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)															1,731	1,616	1,500	923	923	808

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	808	577	577	346	231	231	231	231	231	231	231	231	231	231	231	231	231	231	231	231

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 26
Mass of biogenic carbon in residual waste (tonnes carbon)	86,996
Total carbon converted to LFG (tonnes carbon)	43,498
Methane in LFG released from residual waste (tCH4)	33,058
Methane in LFG captured for use in gas engines (tCH4)	22,480
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,058
Uncaptured LFG released to atmosphere as methane (tCH4)	9,521
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**266,583**
Methane in LFG captured for use in gas engines (tCH4)	22,480
Methane used in gas engines (tCH4)	20,434
Fuel input to LFG engines (GJ)	367,812
Power generated by LFG engines (MWh)	102,170
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor for electricity generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset (tCO2e/yr)	9,195	6,845	5,926	5,006	4,598	3,882	3,065	2,452	1,941	1,839	1,839	1,737	1,635	1,533	1,533	1,430	1,328	817	817	715

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor for electricity generation (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset (tCO2e/yr)	715	511	511	307	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 26
EfW Gross operational emissions (ktCO2e)	10,681
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	263
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	5,498
EfW Net operational emissions (ktCO2e)	4,919
LFG Gross operational emissions (ktCO2e)	10,663
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	63
LFG Net operational emissions (ktCO2e)	10,600

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 26) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: current residual waste	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,680.81
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	10,663.30	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-63.45	-5,761.31
TOTAL	**10,728.74**	**5,477.68**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-5,251.06

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 27

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced plastics

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on: Cambridgeshire current residual waste with plastics reduced 50% less than baseline	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 625,600 t/yr; hours = 7,667 per yr; MWe = 51.94)	See worksheet: *'Waste composition variation'*
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 27
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	8.50
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.07%
Biogenic Carbon (% of Total Carbon)	66.96%
Non-Biogenic Carbon (% of Total Carbon)	33.04%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 27
Total waste input (tonnes/yr)	625,600
Total Carbon (% by weight)	24.07%
Non-Biogenic Carbon (% of Total Carbon)	33.04%
Mass of fossil carbon in residual waste (tonnes carbon)	49,742
Fossil derived CO2 emissions (tCO2)	182,389
N2O emissions from residual waste combustion (tonnes)	21
Equivalent CO2 emissions (tCO2e)	5,638
CH4 emissions from residual waste combustion (tonnes)	160
Equivalent CO2 emissions (tCO2e)	4,468
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**197,309**
EfW Facility electricity generation (MWe)	52
EfW Facility operations (hrs/yr)	7,667
Electricity generated by EfW Facility (MWh)	398,241
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Year 11*	*Year 12*	*Year 13*	*Year 14*	*Year 15*	*Year 16*	*Year 17*	*Year 18*	*Year 19*	*Year 20*
	2026	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*	*2036*	*2037*	*2038*	*2039*	*2040*	*2041*	*2042*	*2043*	*2044*	*2045*
CO2 emissions factor for energy generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	35,842	26,682	23,098	19,514	17,921	15,133	11,947	9,558	7,567	7,168	7,168	6,770	6,372	5,974	5,974	5,575	5,177	3,186	3,186	2,788

	Year 21	*Year 22*	*Year 23*	*Year 24*	*Year 25*	*Year 26*	*Year 27*	*Year 28*	*Year 29*	*Year 30*	*Year 31*	*Year 32*	*Year 33*	*Year 34*	*Year 35*	*Year 36*	*Year 37*	*Year 38*	*Year 39*	*Year 40*
	2046	*2047*	*2048*	*2049*	*2050*	*2051*	*2052*	*2053*	*2054*	*2055*	*2056*	*2057*	*2058*	*2059*	*2060*	*2061*	*2062*	*2063*	*2064*	*2065*
CO2 emissions factor for energy generation (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	2,788	1,991	1,991	1,195	796	796	796	796	796	796	796	796	796	796	796	796	796	796	796	796

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	*155,030*
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells S76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells I77:AR77
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	*1,540*
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	*153*
EfW net CCS emissions captured and stored (tCO2e/yr)	*N/A*
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Year 11*	*Year 12*	*Year 13*	*Year 14*	*Year 15*	*Year 16*	*Year 17*	*Year 18*	*Year 19*	*Year 20*
	2026	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*	*2036*	*2037*	*2038*	*2039*	*2040*	*2041*	*2042*	*2043*	*2044*	*2045*
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)															15	14	13	8	8	7
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)															1,256	1,172	1,088	670	670	586

	Year 21	*Year 22*	*Year 23*	*Year 24*	*Year 25*	*Year 26*	*Year 27*	*Year 28*	*Year 29*	*Year 30*	*Year 31*	*Year 32*	*Year 33*	*Year 34*	*Year 35*	*Year 36*	*Year 37*	*Year 38*	*Year 39*	*Year 40*
	2046	*2047*	*2048*	*2049*	*2050*	*2051*	*2052*	*2053*	*2054*	*2055*	*2056*	*2057*	*2058*	*2059*	*2060*	*2061*	*2062*	*2063*	*2064*	*2065*
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	586	419	419	251	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167	167

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 27
Mass of biogenic carbon in residual waste (tonnes carbon)	100,825
Total carbon converted to LFG (tonnes carbon)	50,412
Methane in LFG released from residual waste (tCH4)	38,313
Methane in LFG captured for use in gas engines (tCH4)	26,053
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,226
Uncaptured LFG released to atmosphere as methane (tCH4)	11,034
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**308,960**
Methane in LFG captured for use in gas engines (tCH4)	26,053
Methane used in gas engines (tCH4)	23,682
Fuel input to LFG engines (GJ)	426,282
Power generated by LFG engines (MWh)	118,412
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Year 11*	*Year 12*	*Year 13*	*Year 14*	*Year 15*	*Year 16*	*Year 17*	*Year 18*	*Year 19*	*Year 20*
	2026	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*	*2036*	*2037*	*2038*	*2039*	*2040*	*2041*	*2042*	*2043*	*2044*	*2045*
UK grid CO2 emissions factor for electricity generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	10,657	7,934	6,868	5,802	5,329	4,500	3,552	2,842	2,250	2,131	2,131	2,013	1,895	1,776	1,776	1,658	1,539	947	947	829

	Year 21	*Year 22*	*Year 23*	*Year 24*	*Year 25*	*Year 26*	*Year 27*	*Year 28*	*Year 29*	*Year 30*	*Year 31*	*Year 32*	*Year 33*	*Year 34*	*Year 35*	*Year 36*	*Year 37*	*Year 38*	*Year 39*	*Year 40*
	2046	*2047*	*2048*	*2049*	*2050*	*2051*	*2052*	*2053*	*2054*	*2055*	*2056*	*2057*	*2058*	*2059*	*2060*	*2061*	*2062*	*2063*	*2064*	*2065*
UK grid CO2 emissions factor for electricity generation (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	829	592	592	355	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 27
EfW Gross operational emissions (ktCO2e)	7,892
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	247
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	3,977
EfW Net operational emissions (ktCO2e)	3,668
LFG Gross operational emissions (ktCO2e)	12,358
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	74
LFG Net operational emissions (ktCO2e)	12,285

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 27) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced plastics	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	7,892.35
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	12,358.39	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-73.53	-4,224.27
TOTAL	**12,413.75**	**4,226.27**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-8,187.48

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 28

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced organics

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	**Reference**
1a	Waste composition based on: Cambridgeshire current residual waste with organics reduced 50% less than baseline	See worksheet: 'Waste composition variation'
1b	EfW CHP facility operating parameters adjusted for NCV (waste = 503,804 t/yr)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 28
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	11.45
Total waste input (tonnes/yr)	503,804
Total Carbon (% by weight)	29.91%
Biogenic Carbon (% of Total Carbon)	50.26%
Non-Biogenic Carbon (% of Total Carbon)	49.74%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 28
Total waste input (tonnes/yr)	503,804
Total Carbon (% by weight)	29.91%
Non-Biogenic Carbon (% of Total Carbon)	49.74%
Mass of fossil carbon in residual waste (tonnes carbon)	74,971
Fossil derived CO2 emissions (tCO2)	274,893
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,113
CH4 emissions from residual waste combustion (tonnes)	173
Equivalent CO2 emissions (tCO2e)	4,844
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**290,665**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	233,659
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells S76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells I77:AR77
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	1,540
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	232
EfW net CCS emissions captured and stored (tCO2e/yr)	N/A
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)															15	14	13	8	8	7
CCS CO2 emissions (tCO2e/yr)															1,893	1,766	1,640	1,009	1,009	883

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CCS CO2 emissions (tCO2e/yr)	883	631	631	379	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252	252

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 28
Mass of biogenic carbon in residual waste (tonnes carbon)	75,740
Total carbon converted to LFG (tonnes carbon)	37,870
Methane in LFG released from residual waste (tCH4)	28,781
Methane in LFG captured for use in gas engines (tCH4)	19,571
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	921
Uncaptured LFG released to atmosphere as methane (tCH4)	8,289
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**232,093**
Methane in LFG captured for use in gas engines (tCH4)	19,571
Methane used in gas engines (tCH4)	17,790
Fuel input to LFG engines (GJ)	320,226
Power generated by LFG engines (MWh)	88,952
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG CO2 offset (tCO2e/yr)	8,006	5,960	5,159	4,359	4,003	3,380	2,669	2,135	1,690	1,601	1,601	1,512	1,423	1,334	1,334	1,245	1,156	712	712	623

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG CO2 offset (tCO2e/yr)	623	445	445	267	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178	178

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 28
EfW Gross operational emissions (ktCO2e)	11,627
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	6,014
EfW Net operational emissions (ktCO2e)	5,339
LFG Gross operational emissions (ktCO2e)	9,284
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	55
LFG Net operational emissions (ktCO2e)	9,228

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 28) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CCC: 50% reduced organics	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 – Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	11,626.60
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	9,283.72	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 – C3 – C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C2 – C2 – C3 – C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-55.24	-6,287.53
TOTAL	**9,357.37**	**5,897.26**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-3,460.12

EfW Parameters:

N2O Emissions Factor 4 kgN2O/T) (IPCC)	4
N2O Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/T) (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2701
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in residual waste converted to landfill gas (LFG)	50%
Proportion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 29
2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CHP, export of steam from the EfW CHP facility

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: *'Waste composition variation'*
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 48.8)	See worksheet: *'Waste composition variation'*
2a	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
2b	Fuel for heating offset to 2035 based on latest natural gas emissions factor 2021/22 = 202.67 g/kWh Fuel for heating offset after 2035 based on BEIS forecast emissions factors for UK grid electricity generation	UK Government (2023). Greenhouse gas reporting: conversion factors 2023; BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for modern, large UK landfill = 68%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120KWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120KWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 29
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 29
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxilliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxilliary Burners - emissions for use of fuel (tCO2e)	*4,815*
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	48.8
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	390,400
CO2 emissions factor for energy generation (g/kWh)	See cells E68:AR68
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E67:AR67
EfW Facility heat generation (MWth)	23.6
EfW Facility operations (hrs/yr)	8,000
Heat exported by EfW facility (MWh)	188,800
CO2 emissions factor for heat generation (g/kWh) - gas to 2035, grid elec after 2035	See cells E73:AR73
EfW Equivalent CO2 offset for heat generation by Facility (tCO2e)	See cells E74:AR74

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for energy generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	35,136	26,157	22,643	19,130	17,568	14,835	11,712	9,370	7,418	7,027	7,027	6,637	6,246	5,856	5,856	5,466	5,075	3,123	3,123	2,733	2,733	1,952	1,952	1,171	781	781	781	781	781	781	781	781	781	781	781	781	781	781	781	781

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for heat generation (g/kWh)	202.67	202.67	202.67	202.67	202.67	202.67	202.67	202.67	202.67	202.67	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW Equivalent CO2 offset for heat generation by Facility (tCO2e)	38,264	38,264	38,264	38,264	38,264	38,264	38,264	38,264	38,264	38,264	3,398	3,210	3,021	2,832	2,832	2,643	2,454	1,510	1,510	1,322	1,322	944	944	566	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378	378

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	*214,406*
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells S82:AR82
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells I83:AR83
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	*1,540*
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	*213*
EfW net CCS emissions captured and stored (tCO2e/yr)	*N/A*
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor for CCS energy inputs (gCO2e/kWh)															15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)															1,737	1,621	1,505	926	926	810	810	579	579	347	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 29
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	23,755
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,118
Uncaptured LFG released to atmosphere as methane (tCH4)	10,061
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**281,712**
Methane in LFG captured for use in gas engines (tCH4)	23,755
Methane used in gas engines (tCH4)	21,594
Fuel input to LFG engines (GJ)	388,687
Power generated by LFG engines (MWh)	107,969
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E111:AR111
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E112:AR112
LFG Net emissions (tCO2e/yr)	**N/A**

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor for electricity generation (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	9,717	7,234	6,262	5,290	4,859	4,103	3,239	2,591	2,051	1,943	1,943	1,835	1,727	1,620	1,620	1,512	1,404	864	864	756	756	540	540	324	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216	216

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 29
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity and heat energy generation by Facility (ktCO2e)	660
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	5,515
EfW Net operational emissions (ktCO2e)	4,552
LFG Gross operational emissions (ktCO2e)	11,268
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	67
LFG Net operational emissions (ktCO2e)	11,201

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 29) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation and CHP, export of steam from the EfW CHP facility LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	11,268.48	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-67.05	-6,175.07
TOTAL	**11,330.32**	**5,109.70**
Net change in GHG emissions resulting from the Proposed Development (ktCO2e)		-6,220.62

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N2O Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	68%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 30

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 52% LFG Capture

Link back to index table

	Headline assumptions for Scenario: Red font indicates variation with respect to the ES Case	**Reference**
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: 'Waste composition variation'
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	LFG capture rate for older operational UK landfill (Type 3 MeMOD) = 52%	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 80%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120kWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 (g/km/yr)	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110 km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 30
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 30
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells H67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68

Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040

Parameter	
Proportion of EfW fossil derived CO2 emissions captured	80%
EfW emissions captured (tCO2e/yr)	214,532
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells E76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells E77:AR77
Fugitive CO2 emissions during pipeline transport (t/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	1,540
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	213
EfW net CCS emissions captured and stored (tCO2e/yr)	N/A
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

EfW grid electricity (Step 2a, rows 67–68):

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
EfW CO2 offset (tCO2e/yr)	39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EfW CO2 offset (tCO2e/yr)	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

CCS energy inputs (Step 2b, rows 76–77):

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
CO2 emissions factor (gCO2e/kWh)															15	14	13	8	8	7
CCS CO2 emissions (tCO2e/yr)															1,737	1,621	1,505	926	926	810

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
CO2 emissions factor (gCO2e/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CCS CO2 emissions (tCO2e/yr)	810	579	579	347	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 30
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	18,166
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	1,677
Uncaptured LFG released to atmosphere as methane (tCH4)	15,092
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**422,568**
Methane in LFG captured for use in gas engines (tCH4)	18,166
Methane used in gas engines (tCH4)	16,533
Fuel input to LFG engines (GJ)	297,231
Power generated by LFG engines (MWh)	82,564
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

LFG grid electricity (Step 3, rows 105–106):

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
UK grid CO2 emissions factor (g/kWh)	90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7
LFG CO2 offset (tCO2e/yr)	7,431	5,532	4,789	4,046	3,715	3,137	2,477	1,982	1,569	1,486	1,486	1,404	1,321	1,238	1,238	1,156	1,073	661	661	578

	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
UK grid CO2 emissions factor (g/kWh)	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
LFG CO2 offset (tCO2e/yr)	578	413	413	248	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165	165

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 30
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	5,515
EfW Net operational emissions (ktCO2e)	4,938
LFG Gross operational emissions (ktCO2e)	16,903
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	51
LFG Net operational emissions (ktCO2e)	16,851

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 30) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 52% LFG Capture	
	LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	16,902.72	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-51.27	-5,788.68
TOTAL	**16,980.34**	**5,496.09**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	-11,484.25

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	52%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%

Scenario 31

2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 85% LFG Capture

Link back to index table

	Headline assumptions for Scenario (red type indicates variation with respect to the ES Case)	Reference
1a	Waste composition based on WRAP 2017 profile for England	See worksheet: 'Waste composition variation'
1b	EfW CHP facility operating parameters for NCV of 9.53 MJ/kg (waste 613,573 t/yr; hours = 8,000 per yr; MWe = 55)	See worksheet: 'Waste composition variation'
2	BEIS forecast emissions factors for UK grid electricity generation over 40 years (for the period 2026 to 2065)	BEIS (2023). Treasury Green Book – Data Tables 1-19: supporting the toolkit and the guidance (updated 17 April 2023, to fix formatting errors)
3	Electricity export only for the EfW CHP facility, no steam export	N/A
4	Upper limit for instantaneous LFG capture rate for a modern UK landfill = 85% based on experts' opinion	DEFRA (2014). DEFRA Review of Landfill Methane Emissions Modelling
5a	CCS post-combustion systems from 2040 onwards (26 years)	N/A
5b	CCS - fossil derived CO2 capture rate = 85%	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Section 5.3
5c	CCS - electricity for capture = 300kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5d	CCS - electricity for compression (including pipeline transport) = 120kWh/tCO2	Jackson and Brodal (2019). Optimization of the Energy Consumption of a Carbon Capture and Sequestration Related Carbon Dioxide Compression Processes
5e	CCS - electricity for storage = 120kWh/tCO2	Average assumed to be same as electricity for compression
5f	CCS - fugitive CO2 emissions during pipeline transport: High = 0.014 Gg/km/yr	IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage, Table 5.2
5g	CCS - transmission pipeline length = 110km	MVV estimate for connection to CO2 storage at Bacton cluster
5h	CCS - leakage rate for CO2 during storage (less than 0.1%)	DESNZ (2023). Deep geological storage of carbon dioxide (CO2), offshore UK: containment certainty
5i	CCS - connecting pipeline length = 15km	MVV estimate for connection to main pipeline at Kings Lynn
5j	CCS - connecting pipeline carbon factor for manufacture, transport, excavation and construction = 1,400 tCO2e/km	Internal estimate based on other project examples

Step 1) Residual Waste Composition

Waste Stream	Scenario 31
Recyclable Paper	5.9%
Card	6.3%
Non-recyclable Paper	8.9%
Dense Plastic	7.8%
Plastic film	8.2%
Textiles	5.5%
Misc. Combustible	9.3%
Misc. Non-Combustible	3.6%
Other Wastes	0.3%
Glass	2.6%
Ferrous Metals	2.4%
Non-Ferrous Metals	1.1%
Food Waste	27.0%
Garden Waste	2.7%
Other Organic	2.3%
Wood	2.3%
WEEE	1.1%
Hazardous	0.5%
Fines	2.2%
Net Calorific Value (MJ/kg)	9.53
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Biogenic Carbon (% of Total Carbon)	57.20%
Non Biogenic Carbon (% of Total Carbon)	42.80%

Step 2a) Carbon emissions from residual waste combustion in EfW CHP Facility

Parameter	Scenario 31
Total waste input (tonnes/yr)	613,573
Total Carbon (% by weight)	26.20%
Non-Biogenic Carbon (% of Total Carbon)	42.80%
Mass of fossil carbon in residual waste (tonnes carbon)	68,793
Fossil derived CO2 emissions (tCO2)	252,242
N2O emissions from residual waste combustion (tonnes)	23
Equivalent CO2 emissions (tCO2e)	6,197
CH4 emissions from residual waste combustion (tonnes)	175
Equivalent CO2 emissions (tCO2e)	4,911
Auxiliary Burners - Fuel: Gas Oil (litres)	1,745,424
Auxiliary Burners - emissions for use of fuel (tCO2e)	4,815
EfW Gross emissions (tCO2e/yr)	**268,165**
EfW Facility electricity generation (MWe)	55
EfW Facility operations (hrs/yr)	8,000
Electricity generated by EfW Facility (MWh)	440,000
CO2 emissions factor for energy generation (g/kWh)	See cells E67:AR67
EfW Equivalent CO2 offset for electricity generation by Facility (tCO2e/yr)	See cells E68:AR68
Step 2b) Carbon emissions from CCS for EfW CHP Facility from 2040	
Parameter	
Proportion of EfW fossil derived CO2 emissions captured	85%
EfW emissions captured (tCO2e/yr)	214,406
Energy for carbon capture, using electricity (kWh/tCO2)	300
Energy for CO2 compression and transport, using electricity (kWh/tCO2)	120
Energy for CO2 storage injection, using electricity (kWh/tCO2)	120
CO2 emissions factor for CCS energy inputs, using electricity (gCO2e/kWh)	See cells E76:AR76
Carbon capture, compression, transport and storage CO2 emissions (tCO2e/yr)	See cells E77:AR77
Fugitive CO2 emissions during pipeline transport (Gg/km/yr)	0.014
Pipeline length (km)	110
Fugitive CO2 emissions during transport (tCO2e/yr)	1,540
Leakage rate for CO2 during storage	0.1%
Leakage of CO2 during storage (tCO2e/yr)	213
EfW net CCS emissions captured and stored (tCO2e/yr)	N/A
Construction Parameters (connecting pipeline)	
Length of CCS connecting pipeline (km)	15
Carbon factor for CCS connecting pipeline construction (tCO2e/km)	1,400
Carbon for CCS connecting pipeline construction - manufacture, transport and installation (tCO2e)	21,000
EfW Net emissions (tCO2e/yr)	**N/A**

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
39,600	29,480	25,520	21,560	19,800	16,720	13,200	10,560	8,360	7,920	7,920	7,480	7,040	6,600	6,600	6,160	5,720	3,520	3,520	3,080	3,080	2,200	2,200	1,320	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880	880

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
														15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
														1,737	1,621	1,505	926	926	810	810	579	579	347	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232	232

Step 3) Carbon emissions from landfilling residual waste and LFG combustion

Parameter	Scenario 31
Mass of biogenic carbon in residual waste (tonnes carbon)	91,933
Total carbon converted to LFG (tonnes carbon)	45,966
Methane in LFG released from residual waste (tCH4)	34,935
Methane in LFG captured for use in gas engines (tCH4)	29,694
Uncaptured LFG oxidised to CO2 in landfill cap (tCH4)	524
Uncaptured LFG released to atmosphere as methane (tCH4)	4,716
LFG Equivalent CO2 Gross emissions released to atmosphere (tCO2e/yr)	**132,052**
Methane in LFG captured for use in gas engines (tCH4)	29,694
Methane used in gas engines (tCH4)	26,992
Fuel input to LFG engines (GJ)	485,859
Power generated by LFG engines (MWh)	134,961
UK grid CO2 emissions factor for electricity generation (g/kWh)	See cells E105:AR105
LFG Equivalent CO2 offset for electricity generation from combustion (tCO2e/yr)	See cells E106:AR106
LFG Net emissions (tCO2e/yr)	**N/A**

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30	Year 31	Year 32	Year 33	Year 34	Year 35	Year 36	Year 37	Year 38	Year 39	Year 40
2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
90	67	58	49	45	38	30	24	19	18	18	17	16	15	15	14	13	8	8	7	7	5	5	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12,146	9,042	7,828	6,613	6,073	5,129	4,049	3,239	2,564	2,429	2,429	2,294	2,159	2,024	2,024	1,889	1,754	1,080	1,080	945	945	675	675	405	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270

Step 4) Carbon emissions from operational processes over 40 years

Parameter	Scenario 31
EfW Gross operational emissions (ktCO2e)	10,727
EfW Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	273
EfW Equivalent CO2 captured by CCS from 2040: 26 years (ktCO2e)	5,515
EfW Net operational emissions (ktCO2e)	4,938
LFG Gross operational emissions (ktCO2e)	5,282
LFG Equivalent CO2 offset for electricity generation by Facility (ktCO2e)	84
LFG Net operational emissions (ktCO2e)	5,198

Step 5) Lifetime carbon emissions

Project Lifecycles	Scenario 31) 2040 adoption of CCS by the EfW CHP facility – including grid decarbonisation at 85% LFG Capture: LFG (ktCO2e)	EfW CHP Facility (ktCO2e)
Construction		
A1 – A2 – A3 - Raw materials supply, transport and manufacture		35.55
A5 – Construction process stage		4.90
A4 – Construction Transport		7.93
A1 – A2 – A3 – A4 CCS connecting pipeline (manufacture, transport and construction)		21.00
Operation		
B2 – B5 – Maintenance, repair, replacement and refurbishment		4.91
B6 – Operational energy	25.04	10,726.58
B7 – Operational water		0.24
B8 – Other operational processes: Landfill	5,282.10	
B8 – Other operational processes: Operational transport	103.85	271.68
B8 – Other operational processes: IBA and APCr		142.60
Decommissioning		
C1 – C2 -C3 -C4 – End of life, including deconstruction, transport, waste processing for recovery and disposal		48.38
C1 – C2 -C3 -C4 – CCS connecting pipeline: End of life		21.00
General		
D – Avoided emissions	-83.81	-5,788.68
TOTAL	**5,327.18**	**5,496.09**

Net change in GHG emissions resulting from the Proposed Development (ktCO2e)	168.91

EfW Parameters:

N2O Emissions Factor 4 kgN2O/TJ (IPCC)	4
N20 Global Warming Potential (kgCO2e / kgN2O)	265
CH4 Emissions Factor 4 kgCH4/TJ (IPCC)	30
CH4 Global Warming Potential (kgCO2e / kgCH4)	28
Total Gas Oil (diesel) consumption (litres)	1,939,360
Auxilliary burners - % of annual Gas Oil consumption	90%
Fuel (Gas Oil) emissions factor (kgCO2e/kWh)	0.2731
Fuel (Gas Oil) emissions factor (kgCO2e/litre)	2.75857

LFG Parameters:

Calorific value of methane (MJ/kg)	50
Biogenic carbon in resdual waste converted to landfill gas (LFG)	50%
Proprtion of methane in LFG	57%
Proportion of LFG recovered from residual waste	85%
Oxidation of LFG released from residual waste to CO2 in landfill cap	10%
Proportion of LFG used in gas engines	91%
LFG engine efficiency: 36%	36%