Wheelabrator
TECHNOLOGIES

Deadline 3: Applicant's Response to Submissions at Deadline 2

Wheelabrator Kemsley (K3 Generating Station) and Wheelabrator Kemsley North (WKN) Waste to Energy facility Development Consent Order

PINS Ref: EN010083

Document 11.3
April 2020 - Deadline 3

fieldfisher rps hendeca dha

Contents

1 Introduction

1.1 Purpose of this document

1.1.1 This Document has been prepared at Deadline 3 of the Examination by the Planning Inspectorate into an application by WTI/EFW Holdings Ltd (a subsidiary of Wheelabrator Technologies Inc – "WTI") under the Planning Act 2008 for a Development Consent Order (a "DCO") for the construction and operation of the Wheelabrator Kemsley ("K3") and Wheelabrator Kemsley North ("WKN") waste-to-energy generating stations on land at Kemsley, Sittingbourne in Kent.

1.1.2 This Document provides the response by the applicant to the Deadline 2 submissions made to the Examining Authority by Interested Parties.

1.1.3 For ease and completeness this document briefly summarises the proposed development and identifies the application site before providing the applicant's response to relevant Deadline 2 submissions. The Deadline 2 submissions are not replicated within this document but can be viewed on the project page of the Planning Inspectorate's website:

https://infrastructure.planninginspectorate.gov.uk/projects/south-east/wheelabrator-kemsley-generating-station-k3-and-wheelabrator-kemsley-north-wkn-waste-to-energy-facility/?ipcsection=docs

1.2 Context

1.1.1 The application for a Development Consent Order seeks consent for the construction and operation of a 75MW waste-to-energy facility, 'the Wheelabrator Kemsley Generating Station' ("K3") and for the construction and operation of a 42MW waste-to-energy facility, 'Wheelabrator Kemsley North' ("WKN").

1.1.2 K3 is a waste-to-energy facility located adjacent to and east of the DS Smith Kemsley paper mill, to the north of Sittingbourne, Kent. Planning permission was granted for K3 in 2012 by Kent County Council with a generating capacity of 49.9MW and a waste processing capacity of 550,000 tonnes per annum. The facility became operational in Q2 2020.

1.1.3 The applicant has identified that K3 would be capable of processing an additional 107,000 tonnes of waste per annum and, without any change to the external design, generating an additional 25.1MW of electricity. However, in order for the K3 project to be properly categorised and consented under the Planning Act 2008 the applicant is required to seek consent for the construction of K3 at its total generating capacity of 75MW (i.e. 49.9MW consented + 25.1MW upgrade), together with the separate proposed total tonnage throughput of 657,000 tonnes per annum (550,000 consented + 107,000 tonnage increase).

1.1.4 The proposed new Waste-to-Energy plant, Wheelabrator Kemsley North (WKN), would be a single 125Mwth line facility capable of processing 390,000 tonnes of waste per annum, with a generating capacity of 42MW. WKN is not therefore a Nationally Significant Infrastructure Project (NSIP) by virtue of its generating capacity.

1.1.5 Instead WTI made a formal application on the 1st June 2018 to the Secretary of State (SoS) for Business, Energy and Industrial Strategy under Section 35 of the Planning Act 2008 for a direction as to whether the project is nationally significant. The SoS issued their direction on the 27th June 2018 confirming that WKN is to be considered and treated as a development which requires development consent due to its context with other nationally significant projects in the vicinity, the benefits to K3 and WKN being assessed comprehensively through the same DCO process and the removal of the need for separate consents to be sought.

1.1.6 A single Development Consent Order is being sought for K3 and WKN through a single application to the Planning Inspectorate (PINS), prior to being determined by the Secretary of State (SoS) for Business, Energy and Industrial Strategy.

1.3 The Site and its surroundings

1.3.1 The K3 and WKN sites lie to the north-east of the village of Kemsley, which itself sits at the north-eastern edge of Sittingbourne in Kent. The K3 and WKN sites lie immediately to the east of the Kemsley Paper Mill, a substantial industrial complex which is operated by DS Smith.

1.3.2 In April 2018 DS Smith lodged an application for a Development Consent Order (DCO) which would allow for the construction and operation of 'K4', a gas fired Combined Heat and Power Plant within the Kemsley Mill site. This DCO was granted on 5th July 2019.

1.4 Proposed Development

Wheelabrator Kemsley – K3

1.4.1 Planning permission was granted for K3 in 2012 by Kent County Council under reference SW/10/444. As consented and being constructed, K3 can process up to 550,000 tonnes of waste each year and has a generation capacity of 49.9MW. K3 will export electricity to the grid and will supply steam to the DS Smith Kemsley Paper Mill. The construction of K3 began in 2016 and it became operational in Q2 2020.

1.4.2 WTI has identified that K3 would be capable of processing an additional 107,000 tonnes of waste per annum and, without any change to the external design, generating an additional 25.1MW of electricity.

1.4.3 The 2018 consultation and publicity sought views from interested parties on an application for consent for that power upgrade and increased tonnage throughput, without any construction works being required, as an extension to the K3 facility under Section 15 of the Planning Act 2008.

1.4.4 However, in order for the K3 project to be properly categorised and consented under the Planning Act 2008 the applicant is now seeking consent for the construction of K3 at its total generating capacity of 75MW (49.9MW consented + 25.1MW upgrade), together with the separate proposed total tonnage throughput of 657,000 tonnes per annum (550,000 consented + 107,000 tonnage increase).

1.4.5 A further consultation was undertaken in 2019 to advise S42 consultees and notify the public through a number of S48 notices that construction and operation of K3 was now being sought as part of the DCO, in the context of the K3 facility already being substantially constructed at that time.

1.4.6 As the K3 facility is now operational the effect in reality of the proposed application ('the practical effect') would be the K3 facility as consented but generating an additional 25.1MW, together with being able to process an additional 107,000 tonnes of waste per year.

Wheelabrator Kemsley North – WKN

1.4.7 WKN would be an entirely new and separate waste-to-energy facility on land to the north of K3, which is currently being used as the K3 construction laydown area. WKN would provide clean, sustainable electricity to power UK homes and businesses via the National Grid distribution network and would have the ability to export steam should a user for that steam become available.

1.4.8 WKN would have a generating capacity of 42MW and a waste processing capacity of 390,000 tonnes per annum and be a self-contained and fully enclosed facility with its own reception hall, waste fuel bunker, boiler, flue gas treatment, turbine, air-cooled condensers, transformers, office accommodation, weighbridge, administration building, car parking and drainage. WKN would have its own grid connection to allow for the exporting of electricity to the national grid.

2 Deadline 2 submissions from Interested Parties

2.1.1 Deadline 2 submissions were made by the following Interested Parties:

- Environment Agency (18th March 2020);
- Natural England (18th March 2020);
- Marine Management Organisation (18th March 2020);
- Kent County Council (23rd March 2020);
- SEWPAG (23rd March 2020);
- Royal Mail Group Limited (8th March 2020).

2.1.2 The KCC submission was accepted as a late Deadline 2 submission by the ExA and has therefore been addressed within this Statement. For ease the Royal Mail Group Limited submission of the 8th March 2020 has then also been addressed within this document.

2.1.3 Each of those submissions is addressed in turn within this Statement.

2.2 Environment Agency (18th March 2020)

2.2.1 The Applicant notes the EA's response to Q1.3.10 and does not have any specific comments to make at this stage. The Applicant has continued to discuss the application with the EA in order to be able to submit a signed SoCG at the appropriate time.

2.3 Natural England (18th March 2020)

2.3.1 The Applicant welcomes the fact that NE do not raise any issues with the approach taken in respect of the Critical Load point addressed in Q1.5.8 and the site and feature selection in the HRA addressed in Q1.8.22. It is noted that NE will comment on the conclusions of the HRAR in due course and the Applicant will continue to liaise with NE to address any comments arising as the examination proceeds, in order to be able to submit a signed SoCG at the appropriate time.

2.4 Marine Management Organisation (18th March 2020)

2.4.1 The Applicant notes the submission made by the MMO and will liaise directly with the MMO to clarify their position.

2.4.2 For the avoidance of doubt, at this stage the Applicant's position is as follows:

- The licensable activity for the purpose of the Marine and Coastal Access Act 2009 is the construction of the outfalls. Under that Act, construction includes maintenance;
- The existing marine licence (L/2017/00482/2), which has been varied to allow for the K3 and WKN outfalls has already been issued separately to the DCO. It is not necessary to included deemed marine licences in the DCO;
- Licence conditions and other environmental regulatory regimes do not need to be replicated in the DCO as requirements or otherwise;
- The operation of the outfalls is not a licensable activity under the MCAA 2009;
- The original K3 planning permission included provision for the first outfall, which has now been constructed. Both that outfall and the second outfall to serve WKN are contained in the DCO as part of works 1E and 7 and will be regulated as required by the relevant requirements such as design details and construction methodology;
- The quality of water the water being discharged will be such that it does not require either an operational requirement under the DCO or environmental permitting. This is confirmed by Chapter 10 of the 2019 K3/WKN Environmental Statement which confirms that only clean water will be discharged into the Swale Estuary and that the licence amendment application (L/2017/00482/2) was accompanied by a Marine Conservation Zone and Water Framework Directive Assessments which concluded no likely significant effects on water quality;
- The decommissioning of the outfall will be licensed separately under the MCAA 2009 as required and under the planning regime.

2.4.3 As demonstrated by the above the Applicant's position at this stage is that there are no potential overlaps in jurisdiction and that consequently no changes are needed to either the DCO or to the Marine Licence. The Applicant will provide a further update once that position has been reviewed and commented on by the MMO.

2.5 Kent County Council (23rd March 2020)

ExQ1.1.1

2.5.1 KCC introduces its response to Ex Q1.1 with overarching comments that K3/WKN conflicts with policy and would undermine the waste planning principles of Kent and the wider South East. The Applicant has previously responded to these comments at Deadline 2 [REP2-010 and REP2-011]. This submission is made to provide further detail as necessary but is limited to responding only to substantive points raised by KCC in its Deadline 2 [REP2-044] submission.

2.5.2 On page 3, KCC introduces the waste hierarchy, summarising the legislation that is set out in more detail at section 2 of the Waste Hierarchy and Fuel Availability Report [APP-086, the 'WHFAR']. The quote relied upon by KCC to make its objection (presented in bold text) is taken from the Executive Summary of the WHFAR; it does not present the whole of the Applicant's case on this matter and is simply an overview of how the legal requirements of the waste hierarchy are delivered. Real world initiatives are required to deliver legislative requirements, not least as recognised in the Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste[1] which incorporates the following amendment to the rWFD[2] :

> *'3. Member States shall make use of economic instruments and other measures to provide incentives for the application of the waste hierarchy, such as those indicated in Annex IVa or other appropriate instruments and measures.' (At Article 1(4))*

2.5.3 KCC's reference to the figure at page 6 of Defra's document 'Guidance on applying the waste hierarchy' does nothing to change the waste hierarchy as set out at Article 4 of the rWFD and presented graphically at page 3 of Defra's Guidance. It is simply an illustrative demonstration of the different technologies available. The preference for CHP is made clear in the Resources and Waste Strategy[3] and is delivered, to the extent viable, by K3/WKN.

2.5.4 KCC seeks to suggest that WKN does not compare well to alternatives. In response, the Applicant reiterates the points made at Paragraph 62 of their response to Annex 1 of KCC's Written Representation (Appendix 1 of REP2-011), specifically that WKN will at certain times be operated in CHP mode, to supply steam to the paper mill when K3 is not operating, and have the potential to supply future steam customers. As addressed in our response to ExQ1A_1.35,

---

[1] https://www.legislation.gov.uk/eudr/2018/851 [25.03.2020@10:11]

[2] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives https://www.legislation.gov.uk/eudr/2008/98 [25.03.2020@10:13]

[3] Our Waste, Our Resources: A Strategy for England, Defra, December 2018.
https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england
[25.03.2020@10:32]

RDF export to continental Europe is declining and is not a guaranteed outlet. The RDF export scenario included in the Carbon Assessment presented an RDF export scenario as a conservative benchmark, on the basis that there would only be a carbon benefit for RDF export if all the waste processed by WKN was redirected from RDF export. This is a highly unlikely scenario, as in reality waste diverted from landfill is expected to be the majority fuel source (not least as demonstrated by the tonnages in the WHFAR [APP-086]). This scenario demonstrates a carbon benefit for the WKN proposal. Furthermore the Carbon Assessment models a typical European EfW operating in CHP mode; if RDF was diverted from WKN to a lower performing EfW on the continent then that would reduce or remove any carbon benefit which might have existed. In addition, the export of RDF to mainland Europe fails to deliver any of the other benefits gained by the recovery of energy from waste within the UK: supply of decentralised, renewable/low carbon energy (with demand sought for electricity as well as steam); economic investment; and the resultant societal benefits.

2.5.5 Policy CSW2 of the Kent Minerals and Waste Local Plan ('KMWLP') is:

> *'To deliver sustainable waste management solutions for Kent, proposals for waste management must demonstrate how the proposal will help drive waste to ascend the Waste Hierarchy whenever possible.'*

2.5.6 K3/WKN would demonstrably take waste out of landfill and into recovery; this actively helps to drive waste to ascend the Waste Hierarchy. K3/WKN fully comply with adopted policy CSW2. In doing so, they also comply with all other legislative requirements in relation to the waste hierarchy. Not least this is demonstrated by reference to the Environmental Permit already granted for the existing K3 Facility which requires that wastes accepted at this facility shall be 'treated' such that they will be the residual output of re-use and recycling activities.[4] It is to be expected that the same restriction would apply to WKN.

2.5.7 On page 17 of its Deadline 2 submission [REP2-044], KCC refers to a recent appeal decision (the 'Britanniacrest Appeal', Appeal ref: APP/P3800/W/18/3218965 made by Britanniacrest Recycling Ltd). The Inspector determining the Britanniacrest Appeal made clear (at paragraph 16) that little weight should be given to '*the concern raised that the provision of energy from waste capacity may result in waste being managed further down the Waste Hierarchy than would otherwise be the case*' and (at paragraph 112) that no condition is required in relation to this matter.

2.5.8 K3 has not gained R1 status to date; it has not been operating long enough to do so. However, as a CHP plant, delivering steam to the DS Smith facility, there is little doubt it will achieve R1 status. It would be nonsensical for an energy recovery facility not to be run efficiently; this would mean a reduction of power output and consequent earnings. The Applicant seeks to gain R1 accreditation

[4] The full description from the Environmental Permit is given at [APP2-011] Applicant's response to WR, Appendix 1, paragraph 16.

across its full suite of facilities; a position not least demonstrated by its facility at Ferrybridge (FM1) having achieved R1 status.

2.5.9 In regard to the final sentence made on page 4, and similar others made throughout KCC's representation [REP2-044], neither KCC, nor its advisors, can state authoritatively how NPS EN-3 was drafted; none of them were involved in writing any part of that policy document. By contrast, the waste planning advisor supporting WTI in this Application led the (very small) team that wrote the waste and biomass elements of NPS EN-3. This response can authoritatively state that paragraph 2.5.66 is simply a reflection of the standard process in planning decision making, a process that considers development proposals against policy.

2.5.10 On page 5, KCC turns to address KMWLP policy CSW4, presenting an overview of Article 16 of the Waste Framework Directive (2008/98/EC) similar to that which can be found at section 4 of the WHFAR. KCC's objection seems to be the *'intention to process waste from out of the county, this being contrary to the application of the proximity principle for mixed municipal waste arising from the source authorities*.' As explained from paragraph 22, Appendix 1, Applicant's response to WR [REP2-011], '*K3/WKN are, unashamedly, submitted as regional facilities; they are not focussed on only treating 'Kent's waste'*.' That response confirms that this approach is entirely consistent with both Article 16 of the Waste Framework Directive (2008/98/EC) (and as amended) and the Waste Regulation 2011, Schedule 1, Objective 4.

2.5.11 The Applicant's response to ExQ1A_1.2 demonstrates that policies of net self-sufficiency are similar across the authorities within the Study Area and that none of the recycling targets posited by those local authorities exceed that assumed within the WHFAR [APP-086]. The WHFAR appropriately addresses the test set at NPS EN-3 (paragraph 2.5.70) to demonstrate that K3/WKN are of an appropriate type and scale and will not prejudice either national or local waste management policy.

2.5.12 The Allington Facility referenced on page 8, is substantially full. It predominantly receives local authority collected waste generated in Kent, but also from other authorities across the south east and east of England and London, including Surrey, Thurrock and Norfolk. The Applicant is also aware that FCC Environment, the operator of the Allington Facility, intends to submit an application for development consent pursuant to Section 37 of the Planning Act 2008 for an extension to the Allington Facility. This demonstrates that WTI is not alone in recognising the market demand for additional residual waste treatment capacity.

2.5.13 On page 8, KCC references the Kent Waste Consultation Response Summary. Submissions made by WTI to that consultation have been provided to the ExA in response to ExQ1A-1.46.

2.5.14 KCC states that there is 'direct conflict' between the datasets underpinning the EPR (the Waste Need Assessment 'WNA' prepared by BPP for KCC) and that used in the WHFAR [APP-086]. In reality, they are just two sets of numbers that have been derived using incomplete data sets, future predictions and assumptions. There is, and probably will remain, disagreement over the waste tonnages; this is often the case in development proposals for waste management facilities. The Applicant's response to ExQ1A_1.20 references the recently approved REP DCO[5] . In coming to his decision to recommend approval of that application, the Examining Authority[6] recognises that '*Projections are in their nature subject to uncertainty and, in my view, it is prudent to consider a range of outcomes as the Applicant has done*.' (paragraph 5.2.34)

2.5.15 WTI made no objection to KCC's planning policy, other than the intention to no longer pursue a Sites Waste Plan. The disagreement between KCC and WTI is essentially limited to a set of numbers, which themselves are based on incomplete data sets, future predictions and assumptions.

2.5.16 On page 9, KCC questions the veracity of the WHFAR, referring to its own analysis at Annex 1 of its Deadline 1 submission [REP1-009].

2.5.17 The analysis presented by KCC at Appendix 1 [REP1-009] is incorrect. **Appendix A** to this Statement presents the summary of the WHFAR analysis (Table 3.10 [APP-086]) alongside KCC's [REP1-009] analysis and the correct calculation of the 2018 WDI data.

2.5.18 They key differences between the BPP Sensitivity and WTI's review of the 2018 WDI data can be seen in rows a and b, WTI has tried to replicate the 'BPP Sensitivity' figures but cannot. This early divergence leads to a difference of some 520,000 to 590,000 tonnes. At row e, the BPP Sensitivity has simply subtracted the recycling tonnage calculated in the WHFAR. This fails to apply the percentage properly to the BPP Sensitivity tonnages such that KCC's analysis results in an excessive deduction (i.e. 27% of its upper and lower ranges would only be 562,436 to 447,779 tonnes). In any event, recycling has, happily, increased in 2018 such that in simple terms to reach 65% would require an additional 24% of wastes to be recycled (reduced from the 27% calculated at WHFAR paragraph 3.4.20. This is the percentage applied to the WTI calculation for 2018.

2.5.19 Appendix A does show a reduction in fuel availability, but this is in no way as substantial as suggested by KCC in its Appendix 1 analysis. Indeed, a correct

[5] Application for the Riverside Energy Park Generating Station Order, Letter from Secretary of State for Business, Energy and Industrial Strategy, 9 April 2020.
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010093/EN010093-001388-Final%20Decision%20Letter%20-%20Riverside%20Energy%20Park%20PA08%20Application.pdf

[6] Riverside Energy Park Examining Authority's Report of Findings and Conclusions and Recommendation to the Secretary of State for Business, Energy and Industrial Strategy, 9 January 2020.
https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010093/EN010093-001043-Riverside%20Energy%20Park%20recommendation%20report%20final%20version.pdf

calculation of the 2018 WDI data shows that there still remains a substantial need for new residual treatment capacity, even after K3/WKN.

2.5.20 Further, this analysis does not consider those wastes generated within the Study Area but disposed to landfill beyond it. In 2018, nearly 330,000 tonnes of Household/Industrial/Commercial wastes were disposed to landfill, or nearly 260,000 tonnes of the shortlisted waste types. These are wastes generated within the Study Area and disposed to landfill in addition to those identified in Appendix A.

2.5.21 Consideration of the EPR commences on page 9 of the KCC response. Policy CSW7 states that waste management capacity that assists Kent in continuing to be net self-sufficient will be granted planning permission provided that certain criteria are met, the first three are relevant and addressed below:

1. it moves waste up the hierarchy

K3/WKN are demonstrated, not least by the WHFAR [APP086] to be moving waste up the hierarchy. The Proposed Developments would accept residual wastes, i.e. those that are generated even after waste minimisation/prevention has occurred and which remain after recycling. The WHFAR only considers those wastes that are either landfilled or exported as refuse derived fuel ('RDF'); these wastes are those that remain after all other waste handling activities have occurred. RDF is an entirely appropriate fuel, it has been processed for the purpose of being combusted to recover energy.

2. recovery of by-products and residues is maximised

The incinerator bottom ash ('IBA') that results from the combustion process will be sent off-site for processing, where secondary materials can be recovered: metals and glass have various end destination; and ash that can be used in construction materials. The air pollution control residues (APCR) will be also be treated off-site, at a destination to be confirmed but it will not be on the Isle of Sheppey. This is potentially a recyclable material.

3. energy recovery is maximised (utilising both heat and power)

Energy recovery is maximised to the extent that is viable and appropriate at this site. There is no requirement in the policy to utilise all of the energy recovered for heat; simply to maximise it. This has been done.

2.5.22 Policy CSW7 of the EPR is met.

2.5.23 Similarly, K3/WKN complies with the amended policy (and its supporting text) CSW8, in that the facilities have been '*designed to harness the maximum practicable quantity of energy produced'*; this is being achieved both as steam and electricity. On page 6 (referring to policy CSW9, but meaning CSW8) KCC suggests that there is '*little or no prospect of the WKN plant heat being utilised even on a back-up basis … and would not be in compliance with this policy*.' This statement is incorrect in as far as WKN will be able to provide back-up capability to provide steam to the papermill in the event that K3 is in either in a planned or unplanned shutdown. The other energy from waste facility at Ridham is the MVV Biomass plant. As far as the Applicant is aware, this facility does not supply steam to the papermill via a pipeline.

2.5.24 At page 10, KCC introduces the Residual Non-Hazardous Waste Management Needs Assessment (the 'WNA') prepared to inform preparation of the EPR, which identifies no further need for 'Other Recovery' capacity in Kent. As was made clear at paragraph 12, Appendix 1 Applicant's response to WR [REP2-011], WTI has demonstrated a number of errors within this work. WTI notes that ExQ1A_1.47 has sought a response on this matter.

2.5.25 On page 10, KCC suggests that there is an expectation within NPS EN-3 for applicants to refer to Annual Monitoring Reports. Paragraph 2.5.68 of NPS EN-3 identifies only that *'it may be appropriate to refer to the Annual Monitoring Report …'*. It is not a requirement to do so. It was not appropriate in this case as more than one authority is considered within the WHFAR, which sources the Study Area wide data from Waste Data Interrogator, the official dataset managed by the Environment Agency.

2.5.26 This section ends by suggesting that the Annual Monitoring Report can be swapped out by reference to the WNA. WTI disagrees. The Annual Monitoring Report is an objective document, one that reports what has happened over the past year and the effect this has had on policy delivery. The WNA, as has been previously described, is reliant upon forecasting, using uncertain data and selected assumptions; it is not considered by the Applicant to be a reliable document in this case. The WNA and the Annual Monitoring Report are not interchangeable.

2.5.27 KCC's Deadline 2 submission presents an abridged version of WTI's representations to the EPR and Matter 2. WTI did object to KCC's intention not to pursue a Waste Sites Plan; not least on account of the flaws demonstrated within the WNA and the likelihood that future infrastructure needs in Kent had been underestimated. WTI's representation was not that the KMLWP '*should remain unchanged even though K3 SEP had been built*', but that the WNA should be reviewed and work undertaken to address the concerns that WTI had raised. The approach of the EPR, to underestimate future capacity needs and not deliver a Waste Site Plan would mean that it failed to recognise the benefits to be gained from the incineration of residual waste; an approach still being pursued by KCC.

2.5.28 WTI's representations to the EPR (properly read) and the case made in the DCO Application are consistent. Further, WTI believes both are correct. K3/WKN remains demonstrated to be compliant with policies CSW2, CSW4, CSW7 and CSW8.

ExQ1.1.2

2.5.29 The Applicant responded to Q1.1.2. at Deadline 2 and reiterates that response. K3 is an NSIP by definition of its generating capacity and is therefore to be determined in accordance with the relevant National Policy Statements. WKN is not an NSIP but has been accepted by the Secretary of State as being nationally significant and EN-1 and EN-3 and the matters they address are important and relevant in the consideration of the WKN. However due regard has also been had within the application to relevant local planning policies and national planning policy and guidance within the NPPF and NPPG.

ExQ1.1.3

2.5.30 The Applicant notes that the requested SEWPAG Memorandum of Understanding has been provided at Deadline 2 and does not have any further comments specifically on that document which are not addressed in the comments provided in respect of other ExQ1 responses.

ExQ1.1.4

2.5.31 The Applicant's response to this question is set out at Appendix 1, Applicant's Responses to ExQ1 [APP2-009]. The Applicant has also responded to the ExQ1A in relation to net self-sufficiency.

2.5.32 KCC's table (from page 14) presents the commitment to net self-sufficiency expressed by each of the authorities within the Study Area. As is generally expressed in planning policy, this commitment is made where practicable, and recognising that waste will move across authority boundaries. This confirms that there is no planning policy that expressly prohibits the movement of waste between authorities. The very concept of net self-sufficiency builds in the expectation that wastes will move across administrative boundaries.

Ex Q1.1.6

2.5.33 The Applicant's response to this question is set out at Appendix 2, Applicant's Responses to ExQ1 [APP-009]. The Applicant has also responded to the ExQ1A in relation to net self-sufficiency.

2.5.34 As identified, not least by KCC in its response to ExQ1.1.4, each of the authorities considered within the WHFAR expect waste to move across administrative boundaries. As planning authorities, they are not responsible for providing waste management capacity, simply for providing a strategic policy framework that will enable the market to bring forward appropriate development. Some of the authorities will be waste management authorities (collection or disposal) and they will have responsibility to provide waste management infrastructure. However, this is limited to local authority collected waste and, has been seen elsewhere in the UK, capacity may be procured that lies outside of the authority area. K3/WKN presents no unique or unusual development; it does not distort plans, strategies or markets. It is an appropriate development, demonstrated to deliver both national and local policy.

2.5.35 The proximity principle is addressed by the Applicant in both the WHFAR [APP-086] at section 4, and Appendix 1, Applicant's Responses to WR [APP-011]. In short, K3/WKN are properly demonstrated to be one of the nearest appropriate installations to treat residual wastes, diverting them from landfill and recovering energy and secondary materials; the Proposed Development is fully in accordance with National Planning Policy for Waste.

ExQ1.4

2.5.36 The revised dDCO submitted by the Applicant at Deadline 2 reflected the changes to Requirement 20 requested by KCC in their Written Representation (2nd March 2020).

2.5.37 The Applicant notes the further amendments recommended by KCC in respect of preliminary works, specifically for Requirement 20 within the dDCO to be amended to read "*No authorised development or permitted preliminary works (unless agreed with the relevant planning authority) shall commence ….".* The Applicant does not object to that proposed amendment and intends to include that within the draft DCO to be submitted at Deadline 4.

ExQ1.6

2.5.38 On page 17, KCC quotes lightly from the Brittaniacrest Appeal, failing to take full account of the Inspector's further consideration on this matter. The Inspector actually goes on to conclude that '*It appears to me that dealing with the residual waste in an energy from waste facility on site rather than exporting the RDF to a similar facility in continental Europe would be likely to provide transport related carbons savings, which would help to mitigate climate change in keeping with the aims of the Framework and local policies …*' (paragraph 90). K3/WKN would perform better than the Britanniacrest Appeal in that it would provide both an in-country solution for RDF, avoiding its need to be exported overseas, and divert significant quantities of waste from landfill.

2.5.39 Paragraph 92 makes clear that the Inspector considered the Britanniacrest facility to '*be likely to deliver carbon savings when a wider view is taken. I conclude that the proposal would be likely to help to mitigate the impact of climate change, in keeping with the aims of the Development Plan and the Framework*.' The Inspector merely gives this little weight because of the number of uncertainties around the scale of any such benefits; he rightly recognises that there are a number of different factors at play and the overall benefit is what should be considered. The National Policy Statements were given little weight, primarily because the Appeal scheme is not a nationally significant infrastructure project. This is entirely in accordance with the standard planning regime.

2.5.40 On page 17 of its Deadline 2 response, KCC asserts that the WHFAR [APP-086] refers to local plan policy '*as something of an afterthought'*, again limiting its reference only to the Executive Summary of the WHFAR. The Executive Summary is necessarily short. Section 4.3 of the WHFAR is devoted to local plan policy, as is much of the Planning Statement [APP-082]. K3 is an NSIP and WKN has been accepted as being nationally significant and consequently the NPS take primacy in the case of K3 and remain equally important and relevant to the determination of WKN; however, local plan policy is wholly adequately addressed.

2.5.41 On page 18, KCC again asserts that the Applicant has made a '*knowingly unfounded assertion'*. It has not; KCC has simply misunderstood the representations made by WTI to the EPR. KCC is correct, the primary policy for K3/WKN to demonstrate is that set out in the National Policy Statements, this is made clear at paragraph 1.1.1 of NPS EN-1 '*For such applications this NPS, when combined with the relevant technology-specific energy NPS, provides the primary basis for decisions by the IPC*.' However, as demonstrated in the WHFAR, the Planning Statement and in the Applicant's Deadline 2 submissions, K3/WKN also comply with local plan policy, including that of the emerging EPR.

2.5.42 KCC's interpretation of the Britanniacrest Appeal at paragraph 91 is also wrong, as it fails to take into account the relevant context of the development. The Inspector discounts the comparison of waste to landfill and waste to recovery because a) waste going to landfill would be contrary to the waste hierarchy and b) it would be more likely to be exported for recovery than being sent to landfill.

2.5.43 This latter conclusion leads from evidence presented within the Britanniacrest Appeal:

- at paragraph 7, the existing facility operating at the site is clearly described as exporting RDF to continental Europe;
- at paragraph 12 the appellant indicates that 155,000 tpa of RDF is exported to continental Europe;
- at paragraph 20 the '*appellant has indicated that residual active waste arising from the process stream of which the existing appeal site operation forms part, is converted to RDF and exported to continental Europe for recovery, as is much of the residual waste arising within the catchment for the proposed facility'*; and
- at paragraph 90, the '*appellant has indicated that at present, residual active waste arising from the process stream of which the existing appeal site operation forms part, is converted to RDF and exported to continental Europe for recovery*.'

2.5.44 There is no reference to residual wastes being disposed to landfill.

2.5.45 The position demonstrated in the WHFAR is very different. Table 3.10 of the WHFAR identifies between 1.5 to 2 million tonnes of residual waste disposed to landfill within the Study Area, alongside approximately 1 million tonnes of RDF exported. K3/WKN will deliver the waste hierarchy by taking those wastes out of landfill and making domestic use of a renewable/low carbon fuel. The Proposed Developments will deliver both the carbon, economic and environmental benefits of recovering energy from those residual wastes, and (delivering core policy objectives of NPS EN-1) retain that energy within the UK, contributing to the urgent domestic need.

2.5.46 In determining the REP DCO, the ExA and Secretary of State also had to contend with objections made to the proposal on account of the carbon balance and comparisons being made with other energy generators. The Applicant in that case submitted a document titled Carbon Assessment (Document Reference 8.02.08[7] provided at **Appendix B** to this document. The Carbon Assessment demonstrated that the energy recovery facility incorporated within the REP DCO is most likely to displace generation from combined cycle gas turbines, gas engines and diesel engines. By contrast, other renewable/low carbon energy sources including nuclear, wind or solar can be expected to run all the time, as the marginal operating costs are low and likely to be supported by public subsidies that are generally not available to facilities such as the Proposed Developments. Consequently, energy recovery facilities such as that within the REP DCO and K3/WKN are unlikely to affect their operation and the grid would continue to receive renewable/low carbon energy from these sources, alongside that generated by energy from waste facilities. Further detail on this point is provided at Section 3.1 of the Carbon Assessment (8.02.08).

2.5.47 Consequently, KCC's conclusions are misplaced. K3/WKN will accept residual wastes (those that remain after recycling or which are the product of processing to make a product designed for combustion) diverting them from landfill or being exported overseas, to recover renewable/low carbon energy (in the form of both heat/steam and power/electricity) and secondary materials. K3/WKN are wholly in accordance with national and local policy expectations, in relation to both energy generation and waste management.

2.5.48 KCC refer in their response to the Court of Appeal judgement on the proposed Heathrow expansion. The Heathrow decision concerned judicial review of whether the Secretary of State had complied with the specific statutory duty to take into account "Government policy" on climate change mitigation and adaptation when designating the Heathrow National Policy Statement. It is of very narrow application to the exercise of powers under section 5(8) of the Planning Act 2008. It is not a relevant or proper consideration with respect to the impact of carbon emissions in the determination of development consent applications.

[7] https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010093/EN010093-000457-Cory%20Environmental%20Holdings%20Limited%20-%208.02.08%20Carbon%20Assessment.pdf

ExQ1.11.

2.5.49 "WTI to provide evidence of time controls within waste contracts" - The applicant claimed that the peak hours would be avoided, due to such time controls being in place. KCC would like to see evidence of such clauses in the contracts, so be able to assess this properly.

2.5.50 The Applicant will continue to liaise with KCC regarding the provision of vehicle movement data from Ferrybridge and regarding KCC's request of similar data from the Allington Waste to Energy site.

ExQ1.12

2.5.51 KCC have confirmed that surface water would be adequately managed and the Applicant therefore has no further comments at this stage.

Additional Submission regarding the proposed Ridham Dock IBA facility

2.5.52 The Applicant notes the submission made by KCC regarding the proposed Ridham Dock IBA facility and has provided responses to the specific questions raised by the ExA regarding that submission in Document 11.2 – Responses to ExQ1A, specifically in respect of Q1A.11.5, 11.6 and 11.7.

2.6 SEWPAG

ExQ1.1.2

2.6.1 The Applicant does not agree with the statement that the WKN application should be approached as though it were a proposal for a non-nationally significant waste management facility. The S35 Direction issued by the Secretary of State confirms that WKN has been directed as required Development Consent on the basis that it is considered to be nationally significant. The approach to the relevant NPS's within the application has been documented in the Applicant's response to ExQ1.1.2 and in any event, the whole suite of relevant local plan policies have been considered within the submitted documents and are available to the ExA in preparing his recommendation to the Secretary of State.

ExQ1.1.3

2.6.2 The Applicant notes that the requested SEWPAG Memorandum of Understanding has been provided at Deadline 2 and does not have any further comments specifically on that document which are not addressed in the comments provided in respect of other ExQ1 responses.

ExQ1.1.4

2.6.3 The Applicant's response to this question is set out at Appendix 1, Applicant's Responses to ExQ1 [REP2-009].

2.6.4 The submitted DCO Application is entirely open that K3/WKN are intended as regional capacity, not to be restricted to those wastes arising in Kent only. However, SEWPAG simply reasserts its position that this will result in the waste hierarchy consequently being prejudiced, it provides no evidence that this would be the case. Indeed, a recent appeal relied upon by KCC in its submission, the Britanniacrest Appeal , makes clear (at paragraph 16) that little weight should be given to '*the concern raised that the provision of energy from waste capacity may result in waste being managed further down the Waste Hierarchy than would otherwise be the case*' and (at paragraph 112) that no condition is required in relation to this matter.

2.6.5 SEWPAG is correct to identify that the latest waste need assessments prepared by KCC for the Early Partial Review of the Minerals and Waste Local Plan are not considered within the Waste Hierarchy and Fuel Availability Report [APP-086, the 'WHFAR'].

2.6.6 It is not necessary to do so and, as previously identified, the WNA is not considered to be a robust analysis of waste management needs within Kent. Further, K3/WKN are proposed as strategic facilities, to consider the waste management needs within but also beyond Kent. This has been done within the WHFAR. The recycling targets that will be sought across the Study Area have been incorporated into the WHFAR through inclusion of the Circular Economy Package (the 'CEP') sensitivity, which considered the effect on waste tonnages should the level of recycling be increased to 65%.

ExQ1.1.6

2.6.7 The Applicant's response to this question is set out at Appendix 2, Applicant's Responses to ExQ1 [REP2-009].

2.6.8 SEWPAG argues that the WHFAR [APP-086] does not consider each and every local plan or annual monitoring report prepared by all of the authorities within the Study Area. It is not necessary to take this approach; it is not required by the National Policy Statements.

2.6.9 The WHFAR relies upon relevant, Study Area wide data from the Waste Data Interrogator, the official dataset managed by the Environment Agency. The WHFAR incorporates the Circular Economy Package sensitivity, which builds in an expectation that increased recycling will be achieved across the Study Area. The level of recycling assumed to be achieved is 65%, which is greater than existing performance and higher than some policy aspirations. There remains substantial amounts of residual waste either to be diverted from landfill or otherwise retained in the UK as RDF. This work demonstrates that the effect on the plans of the other authorities within the Study Area has been considered.

The WHFAR has undertaken an assessment to satisfy NPS EN-3 paragraph 2.5.66 and demonstrates that K3/WKN 'is in accordance with the waste hierarchy and of an appropriate type and scale so as not to prejudice the achievement of local or national waste management targets …'. (NPS EN-3, paragraph 2.5.70)

2.6.10 Further, the Applicant's response to ExQ1A_1.2 demonstrates that policies of net self-sufficiency are similar across the authorities within the Study Area and that none of the recycling targets posited by those local authorities exceed that assumed within the WHFAR [APP-086]. The WHFAR appropriately addresses the test set at NPS EN-3 (paragraph 2.5.70) to demonstrate that K3/WKN are of an appropriate type and scale and will not prejudice either national or local waste management policy.

2.7 Royal Mail Group Limited (8th March 2020)

2.7.1 The Applicant notes the comments by the Royal Mail Group and has provided a response to the points raised by way of a response to Q1A.14.2 within Document 11.2, submitted at Deadline 3.

Appendix A

Summary of WHFAR July 2019, BPP Sensitivity and WDI 2018 update

Document 11.2 - Appendix A - Summary of WHFAR July 2019, BPP Sensitivity and WDI 2018 update

		WHFAR July 2019 (Table 3.10)		**BPP Sensitivity** (KCC WR REP01_009, Annex 1m, Appendix 1)		**WDI 2018** (WTI calculation)		
Assessment	**Ref**	**Calculated range using 2017 data (tonnes)**		**2018 data**		**2018 data**		**Row**
		Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	
HIC waste disposed to landfill within Study Area	Table 3.2 (row h)	1,981,358		1,194,029		1,781,213		a
Shortlisted waste types disposed to landfill within Study Area	Table 3.4 (row t)		1,508,860		769,372		1,289,794	b
RDF removed from facilities in the Study Area and exported	Table 3.6 (row h)	1,018,592	1,018,592	889,067	889,167	889,224	889,224	c
Total fuel		**2,999,950**	**2,527,452**	2,083,096	1,658,439	**2,670,437**	**2,179,018**	d
Additional 27% recycling to achieve CEP 2035 target	paragraph 3.4.21	809,986	682,412	809,986	682,412	640,905	522,964	e
Remaining fuel		**2,189,963**	**1,845,040**	1,273,110	976,027	**2,029,532**	**1,656,054**	f
Comparable future capacity likely to be delivered	Table 3.9 (row h)	852,500	852,500	852,500	852,500	852,500	852,500	g
Remaining fuel		**1,337,463**	**992,540**	420,610	123,527	**1,177,032**	**803,554**	h
Proposed capacity of K3/WKN	paragraph 1.6.8	497,000	497,000	497,000	497,000	497,000	497,000	i
Remaining level of need		**840,463**	**495,540**	-76,390	-373,473	**680,032**	**306,554**	j
Other factors due consideration								
Wastes originating within the Study Area but disposed to landfill outside the Study Area		447,714	398,686			328,456	259,292	k

Appendix B

Riverside Energy Park – Carbon Assessment

Riverside Energy Park

Carbon Assessment

VOLUME NUMBER:

08

PLANNING INSPECTORATE REFERENCE NUMBER:

EN010093

DOCUMENT REFERENCE:

8.02.08

May 2019 | Revision 0 (Deadline 2) | APFP Regulation 5(2)(q)

Planning Act 2008 | Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

CORY RIVERSIDE ENERGY

Contents

Tables

Appendices

This page is intentionally blank

1 Executive Summary

1.1.1 Cory Environmental Holdings Limited (trading as Cory Riverside Energy (Cory or "the Applicant")) has considered the climate change benefits of Riverside Energy Park (REP) in **Appendix K.2** to the **Environmental Statement (ES)** (**6.3; APP-095**). In that appendix, the Applicant referred to a peer-reviewed carbon assessment for the existing Energy Recovery Facility (ERF) (referred to as Riverside Resource Recovery Facility (RRRF)) and stated that the benefit of the ERF element of REP (known in this Assessment as the REP ERF) would be similar to or greater than the benefit of RRRF.

1.1.2 Questions have been raised about the RRRF carbon assessment in relevant representations, notably United Kingdom Without Incineration Network (RR-006). Therefore, the carbon benefits of the REP ERF have been assessed in this new carbon assessment.

1.1.3 The assessment compares the releases of greenhouse gases for two scenarios:

a. Processing residual waste in the REP ERF, generating electricity and heat for export; and

b. Sending that same residual waste to landfill and generating electricity from the recovery of landfill gas.

1.1.4 The base case for the assessment shows that the benefit of REP is about 137,000 tonnes of CO_2-equivalent per year, or about 229 kg CO_2e per tonne of waste processed, compared to sending the same waste for disposal in a landfill site. This is based on the following key assumptions.

a. The residual waste for the REP ERF has the same composition as the residual waste currently being supplied to RRRF.

b. Electricity generated by REP (or landfill gas engines) displaces electricity generated from gas-fired power stations.

c. The landfill site in the comparison scenario is a typical large UK landfill site.

1.1.5 If heat is exported, this benefit increases to 157,000 t CO_2e or 263 kg CO_2e per tonne of waste processed.

1.1.6 The assessment has considered the sensitivity of the assessment to changes in waste composition, changes in landfill gas recovery rates and changes in the source of displaced electricity. In all cases, the REP ERF continues to have a benefit over landfill.

1.1.7 A term not defined expressly in this Assessment can be found in the **Applicant's Glossary** (**1.6; APP-006**).

2 Introduction

2.1 Background

2.1.1 Cory Environmental Holdings Limited (trading as Cory Riverside Energy (Cory or "the Applicant")) is applying to the Secretary of State under the Planning Act 2008 (PA 2008) for powers to construct, operate and maintain an integrated Energy Park, to be known as Riverside Energy Park (REP). The principal elements of REP comprise complementary energy generating development and an associated Electrical Connection (together referred to as the 'Proposed Development'). As the generating capacity of REP will be in excess of 50 MWe capacity, it is classified as a Nationally Significant Infrastructure Project (NSIP) under sections 14 and 15 of the PA 2008 and therefore requires a Development Consent Order (DCO) to authorise its construction and operation.

2.1.2 REP would comprise an integrated range of technologies including: waste energy recovery, anaerobic digestion, solar panels and battery storage. The main elements of REP would be as follows:

a. Energy Recovery Facility (ERF): to provide thermal treatment of Commercial and Industrial (C&I) residual (non-recyclable) waste with the potential for treatment of (non-recyclable) Municipal Solid Waste (MSW);

b. Anaerobic Digestion facility: to process food and green waste. Outputs from the Anaerobic Digestion facility would be transferred off-site for use in the agricultural sector as fertilizer or, as an alternative and where appropriate, used as a fuel in the ERF to generate electricity;

c. Solar Photovoltaic Installation: to generate electricity. Installed across a wide extent of the roof of the Main REP Building;

d. Battery Storage: to store and supply additional power to the local distribution network at times of peak electrical demand. This facility would be integrated into the Main REP building;

e. On Site Combined Heat and Power (CHP) Infrastructure: to provide an opportunity for local district heating for nearby residential developments and businesses. REP would be CHP Enabled with necessary on site infrastructure included within the REP site.

2.1.3 The REP site would be constructed on land immediately adjacent to Cory's existing ERF (referred to as Riverside Resource Recovery Facility (RRRF)) situated at Norman Road in Belvedere, within the London Borough of Bexley (LBB). The underground Electrical Connection would run from the REP site and terminate at the Littlebrook substation in Dartford.

2.1.4 Fichtner Consulting Engineers (Fichtner) has been commissioned by the Applicant to prepare a quantitative greenhouse gas emissions assessment of the REP ERF. This is to expand on the Qualitative Greenhouse Gas Emissions Assessment included in **Appendix K.2** to the **Environmental Statement (ES)** (**6.3; APP-095**) and to respond, in part, to the relevant representation made by United Kingdom Without Incineration Network (UKWIN) (RR-006).

2.2 Purpose

2.2.1 The purpose of this assessment is to compare the relative carbon impact of processing residual waste in the REP ERF compared to sending the same waste to landfill. The carbon benefits of the other elements of REP (i.e. the anaerobic digestion facility and the solar panels) are not considered in this assessment as they are already considered in **Appendix K.2** and have not been disputed.

2.2.2 The sensitivity of the relative carbon impact to changes in the assumptions has also been considered.

3 Calculations

3.1 Energy from Waste

3.1.1 The combustion of waste generates direct emissions of carbon dioxide. It also produces emissions of nitrous oxide and methane, which are potent greenhouse gases. However, exporting energy to the grid offsets greenhouse gas emissions from the generation of power in other ways.

3.1.2 The following sections provide detail of the calculation of the carbon burdens and benefits associated with the REP ERF. Unless otherwise specified, all values presented are on an annual basis.

Waste throughput and composition

3.1.3 As explained in **paragraph 3.3.5** of the **Environmental Statement (ES)** (**6.1; Rev 1**), "*the ERF would be able to treat a likely upper throughput of waste up to 805,920 tpa, whilst the nominal design throughput is likely to be lower (c. 655,000 tpa)*." The nominal design throughput is based on the REP ERF operating for 8,000 hours, processing 32.75 tonnes per hour of waste with a net calorific value (NCV)[1] of 9 MJ/kg. The actual waste throughput would vary depending on the calorific value of the waste and the operating hours. This is because the REP ERF will have a maximum thermal input. If the calorific value of the waste is higher, then the REP ERF will process a lower waste throughput and vice versa.

3.1.4 In order to consider the sensitivity of the assessment to waste composition, four waste compositions have been included. In all four cases, the thermal input into the REP ERF has been kept constant, so that the throughput is higher if the calorific value of the waste is lower, and the operating hours have been set at 8,000 per year.

a. RRRF waste – taken from the carbon emission assessment prepared for the RRRF[2] (Appendix A), this is the measured composition of waste currently processed at RRRF. The NCV in this scenario is 9.85 MJ/kg.

b. Design waste – this is based on RRRF waste but with some of the plastics removed to reduce the NCV to 9 MJ/kg.

c. Reduced food – this is based on RRRF waste but with 50% of the putrescible waste removed to take account of a significant increase in separate collection of food and garden waste. The NCV in this scenario is 10.79 MJ/kg.

[1] Net calorific value is the amount of heat evolved when a unit weight of fuel is completely burnt and water vapor leaves with the combustion products without being condensed.

[2] https://www.coryenergy.com/carbon-efficiency/less-carbon/

d. Future waste – this is also based on RRRF waste but with 50% plastics, 50% food and 20% metals removed to model a significant increase in source segregation. The NCV in this scenario is 9.56 MJ/kg.

3.1.5 The waste composition and the key parameters needed for the carbon assessment are shown below.

Table 1 –Waste Composition Data

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Waste Fraction:					
Paper/Card	%	27.83%	29.59%	32.07%	35.62%
Plastic Film	%	8.51%	5.75%	9.81%	5.45%
Dense Plastic	%	7.77%	5.25%	8.95%	4.97%
Textiles	%	3.43%	3.65%	3.95%	4.39%
Combustibles	%	9.55%	10.15%	11.00%	12.22%
Non-combustibles	%	5.39%	5.73%	6.21%	6.90%
Glass	%	4.52%	4.81%	5.21%	5.79%
Putrescibles	%	26.44%	28.11%	15.23%	16.92%
Ferrous Metal	%	1.58%	1.68%	1.82%	1.62%
Non-Ferrous Metal	%	1.00%	1.06%	1.15%	1.02%
Fines	%	2.77%	2.94%	3.19%	3.55%
Hazardous	%	1.21%	1.29%	1.39%	1.55%
Net Calorific Value	**MJ/kg**	**9.85**	**9.00**	**10.79**	**9.56**
Throughput	**tpa**	**598,491**	**655,000**	**546,226**	**616,791**
Carbon Content	**% waste**	**26.72%**	**25.18%**	**28.65%**	**26.49%**
Biocarbon content	**% carbon**	**57.25%**	**64.58%**	**54.05%**	**64.92%**

Direct Emissions

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

3.1.7 For this assessment, only carbon dioxide emissions from fossil sources need to be considered, as carbon from biogenic sources has a neutral carbon burden.

3.1.8 ERFs have high burnout rates and operate with an excess of oxygen in the combustion chamber. Therefore, it is assumed that all of the carbon in the fuel is converted to carbon dioxide in the combustion process. The mass of fossil derived carbon dioxide produced is determined by multiplying the mass of fossil carbon in the fuel by the ratio of the molecular weights of carbon dioxide (44) and carbon (12) respectively.

3.1.9 The process of recovering energy from waste releases a small amount of nitrous oxide and methane, which contribute to climate change. The impact of these emissions is reported as CO2e emissions, and is calculated using the Global Warming Potential (GWP) multiplier. In this assessment the GWP for 100 years has been used.

3.1.10 Emissions of nitrous oxide and methane depend on combustion conditions. Nitrous oxide emissions also depend on flue gas treatment. These details are based on the final design of REP, which is not available at this stage. Therefore, default emissions factors from the IPCC have been used to determine the emissions of these gases, as shown in Table 2.

Table 2 –N2O and Methane Assumptions

Parameter	Unit	Value	Source
N20 emission factor	kg N_2O/TJ	4	IPCC Guidelines for Greenhouse Gas Inventories, Vol 2, table 2.2 Default Emissions Factors for Stationary Combustion in the Energy Industries, Municipal Wastes (non-biomass) and Other Primary Solid Biomass (Appendix B)
CH_4 emission factor	kg CH_4/TJ	30	
GWP - N2O to CO2	kg CO2e/kg N2O	298	United Nations Framework for Climate Change Global Warming Potentials, from IPCC AR4 (2007) (Appendix C)
GWP– CH4 to CO2	kg CO2e/kg CH4	25	

3.1.11 The REP ERF will be equipped with auxiliary burners, which would burn gasoil and will have a capacity of about 70% of the boiler capacity, or 71.64 MWth per line. It is assumed that these will only be used for start-up and shutdown. The ERF will have 6 periods of start-up and shutdown per annum per stream. Each sequence of start-up and shutdown will take a total of 18 hours. Therefore, each stream of the ERF will be in start-up and shutdown for approximately 102 hours per annum. Hence, the total fuel consumption would be: 71.64 x 102 x 2 = 14,615 MWh.

3.1.12 Each MWh of gasoil releases 0.25 tonnes of carbon dioxide, so the emissions associated with auxiliary firing would be 14,615 x 0.25 = 3,654 t CO2e. This is the same for all four waste composition cases considered.

3.1.13 The direct emissions from these sources are shown in below.

Table 3 –Direct Emissions from ERF

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Fossil carbon in input waste	t C	68,381	58,427	71,917	57,328
Fossil derived carbon dioxide emissions	**t CO_2**	**250,729**	**214,233**	**263,694**	210,201
N_2O emissions	t N_2O	24	24	24	24
Equivalent CO2 emissions	**t CO_2e**	7,027	7,027	7,027	7,027
CH_4 emissions	t CH_4	177	177	177	177
Equivalent CO2 emissions	**t CO_2e**	4,421	4,421	4,421	4,421
Burner emissions	**t CO_2e**	**3,654**	3,654	3,654	3,654
Total emissions	**t CO_2e**	**265,831**	**229,335**	**278,796**	**225,303**

Offset for electricity and heat generation

3.1.14 The REP ERF will generate electricity for export to the grid.

3.1.15 The Department for the Environment Farming and Rural Affairs (DEFRA) report titled ‘Energy from Waste – A guide to the debate 2014’ (herein referred to as ‘The Guide to the debate’) (Appendix D to this document) provides support for the use of CCGT as a comparator for electricity generated from the combustion of waste. Footnote 29 on page 21 states that:

> *‘A gas fired power station (Combined Cycle Gas Turbine – CCGT) is a reasonable comparator as this is the most likely technology if you wanted to build a new power station today.’*

3.1.16 It is important to understand why this is the case. The Applicant considers that building an ERF will have no effect on how nuclear, wind or solar plants operate. If a nuclear plant is built it will run all the time, as the marginal operating costs are low. Wind and solar plants run whenever they can, as their marginal operating costs are even lower and they are supported by generous subsidies in many cases which REP is not eligible to receive.

3.1.17 It is worth noting that ERFs have been bidding into the capacity market, where they are competing with, primarily, CCGTs, gas engines and diesel engines. The capacity market has developed over the last few years, with the first delivery year starting on 1 October 2017, and while it is currently on hold due to a legal challenge, the government and industry expect that it will restart in due course. The net effect is that electricity from ERFs is most likely to displace generation from CCGTs, gas engines and diesel engines. This means that CCGT is the correct comparator.

3.1.18 The Department for Business Energy and Industrial Strategy (DBEIS) publish fuel mix tables which identify the quantities of carbon dioxide equivalents from the combustion of different fuel types. The Fuel Mix Disclosure data table dated 01 April 2017 to 31 March 2018, which was revised on 24 August 2018, states that carbon dioxide emissions from the combustion of natural gas to generate power are 357 g/kWh[3] (Appendix E).

3.1.19 Therefore, for the purposes of this assessment, it is assumed that power generated by REP will displace power from a CCGT and that the carbon dioxide emissions from a CCGT power station is equivalent to 357 g/kWh (or 0.357 t/MWh).

3.1.20 It is intended that the REP ERF will also export heat. We have excluded this from the primary assessment, in order to be conservative, but we have considered the export of heat and assumed that any heat exported would displace heat generated by natural gas boilers with an efficiency of 90%. This is then converted to a carbon dioxide offset by multiplying the amount of natural gas displaced by the grid displacement factor for natural gas of 0.20437 kg CO_2e/kWh[4].

3.1.21 As explained earlier, the thermal input into the REP ERF is the same for all four waste compositions. Hence, the power generated will also be the same.

3.1.22 In the electricity-only base case, 63.9 MW would be exported, giving annual export of 511,200 MWh (63.9 MW x 8,000 hours of operation) and displacing 182,498 tCO_2e (511,200 MWh x 0.357 t CO_2e/MWh.

3.1.23 According to Table 10 of the Combined Heat and Power Assessment (5.4; APP-035), the anticipated network heat load is 13.9 MWth, reducing electricity export to 62.0 MWe. This gives annual heat export of 111,200 MWh (13.9 MW x 8,000 hours), displacing 25,251 tCO_2e (111,200 MW x 0.20437 t CO_2e/MWh), and annual electricity export of 496,814 MWh (62 MW x 8,000 hours), displacing 177,363 tCO_2e (496,814 x 0.357 t CO_2e/MWh.

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/737451/fuel-mix-disclosure-data-2018-revised-2.pdf accessed on 16/05/2019.

[4] BEIS Greenhouse gas reporting: conversion factors 2018

3.2 Landfill

3.2.1 When waste is deposited in landfill, some of the biogenic carbon in the waste degrades over time to produce landfill gas, which is a mixture of carbon dioxide and methane. Methane is a potent greenhouse gas. Three things can happen to this landfill gas.

a. Some will be released to atmosphere directly. The carbon dioxide in landfill gas is biogenic and so can be ignored in this assessment, but the methane must be accounted for.

b. Some will be captured and burned in flares. This converts the methane to carbon dioxide, which is again biogenic, and so this can be ignored in this assessment.

c. Some will be captured and burned in gas engines to produce electricity. Some of the methane passes through unburnt and so must be accounted for, but the rest is converted to carbon dioxide, which is again biogenic, and so can be ignored. The electricity generated in the landfill gas engines will displace other sources of electricity and so this benefit should be considered. For consistency with the EfW calculation, it is assumed that CCGTs are displaced with a carbon intensity of 357 g/kWh.

3.2.2 The primary source of information on performance of UK landfills is the report "Review of Landfill Methane Emissions Modelling" (herein referred to as the Landfill Emissions Modelling report), published by Golders Associates (Golders) for DEFRA in November 2014 (Appendix F to this document). This report was produced after the DEFRA report "Energy recovery for residual waste - A carbon based modelling approach" (herein referred to as the Carbon Modelling report), which was published in February 2014. The Landfill Emissions Modelling report is more detailed than the Carbon Modelling report with a clearer evidence base. Therefore, we consider that the Landfill Emissions Modelling report supersedes the Carbon Modelling report.

3.2.3 The key assumptions made are set out in Table 4 below, with explanations for some of the values below the table. All values are taken from the Landfill Emissions Modelling report and can be found in the executive summary, which is attached as Appendix F to this document.

Table 4 –Landfill Modelling Assumptions

Parameter	Unit	Value
Calorific value of methane	MJ/kg	50
Percentage of biogenic carbon which is converted to landfill gas.	%	50
Methane content of landfill gas (a)	%	57

Fraction of landfill gas recovered (b)	%	68
Oxidisation of landfill gas in cap	%	10
Fraction of recovered landfill gas used in engines (c)	%	92
Methane slippage through landfill gas engine	%	1.5
Landfill gas engine efficiency (d)	%	36

a. The more common assumption for the methane content of landfill gas is 50%. Golders reviewed an extensive dataset from UK landfill sites and concluded that the correct figure is 57%. This figure is then used throughout the Landfill Emissions Modelling report to derive the other figures.

b. The Landfill Emissions Modelling report states the estimated landfill gas collection efficiency for a subset of 43 large modern landfills as 68%. For all UK landfills, the figure would be 52%. A more conservative figure of 75% has been considered for sensitivity purposes.

c. The Carbon Modelling report assumes that, over the life of a landfill site, about 50% of the landfill gas collected is used to generate electricity. Within the Landfill Emissions Modelling report, it is estimated at active sites with landfill gas engines, 92% of the landfill gas would be used to generate electricity. This does not take account of sites which do not have gas engines, but should be representative of the 43 large, modern landfills for which the collection efficiency figure was derived.

d. The Carbon Modelling report uses an engine efficiency of 41%, based on the gross generation efficiency of new landfill gas engines. The Landfill Emissions Modelling report agrees with this figure for new engines but takes account of parasitic loads and other losses to estimate a net export efficiency of 36%. Given that, for the ERF, we are using net electricity exported, it is reasonable to use the same type of efficiency for landfill gas engines.

3.2.4 The greenhouse gases released to atmosphere and the offset due to power generation are shown in Table 5.

Table 5 –Greenhouse Gas Emissions from Landfill

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Biogenic carbon in waste	tonnes	91,561	106,525	84,580	106,088

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Total carbon converted to LFG	tonnes	45,781	53,263	42,290	53,044
CH_4 in LFG	tonnes	34,793	40,480	32,140	40,314
CH_4 released to atmosphere directly	tonnes	10,020	11,658	9,256	11,610
CH_4 slippage through engines	tonnes	327	380	302	378
CO_2e released to atmosphere	**t CO_2e**	**258,675**	**300,949**	**238,951**	**299,715**
Methane captured	tonnes	23,659	27,526	21,855	27,413
Methane used in gas engines	tonnes	21,440	24,944	19,805	24,842
Fuel input to gas engines	GJ	1,072,011	1,247,206	990,270	1,242,093
Power generated	MWh	107,201	124,721	99,027	124,209
CO_2e offset through CCGT displacement	**t CO_2e**	**38,271**	**44,525**	**35,353**	**44,343**
Net CO_2e emissions	**t CO_2e**	**220,404**	**256,424**	**203,598**	**255,372**

3.3 Transport

ERF Assumptions

3.3.1 The waste for the REP ERF would mainly be delivered by river. The Applicant is proposing a DCO Requirement to limit the HGV deliveries of waste to 90 per day. This assessment assumes that the maximum permitted HGV movements would take place each day (i.e. 90 x 365 = 32,850), with the remaining waste being delivered by river. The incinerator bottom ash (IBA) produced by the ERF would also be transported by river, while the Air Pollution Control Residues (APCR) would be transported by road to Suffolk.

3.3.2 The assumptions used in the transport carbon calculation are shown below.

Table 6 –ERF Transport Assumptions

Parameter	Unit	Value	Source

RCV load size (for deliveries to ERF)	t	7	ES chapter 6
Articulated lorry load size	t	20	ES chapter 6
Articulated Lorry CO2 Factor - 100% Loaded	kg CO2/km	0.9683	Department for Business , Energy and Industrial Strategy (BEIS) "Greenhouse gas reporting: conversion factors 2018"
Articulated Lorry CO2 Factor - 0% Loaded	kg CO2/km	0.64923	BEIS "Greenhouse gas reporting: conversion factors 2018"
Road transport distance, waste to ERF	km	10	Applicant estimate for local deliveries.
Road transport distance, APCr	km	140	Distance to Brandon, Suffolk
River transport fuel consumption	l/t	1.6	RRRF Carbon report
GHG emission factor for marine gas oil	kg CO2e/litre	2.77479	BEIS "Greenhouse gas reporting: conversion factors 2018"

Landfill Assumptions

3.3.3 It is assumed that all of the waste which would be processed at the REP ERF would otherwise be transported by road to landfill using articulated lorries, travelling 70km, and that these lorries would return empty.

Calculation

3.3.4 Table 7 shows the transport emissions for each waste composition. For all road transport, the vehicle distance is multiplied by the CO_2 factors for articulated lorries above, assuming that each lorry travels the full distance loaded and then returns the full distance unloaded.

Table 7 –GHG Emissions from Transport

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Waste throughput	t	598,491	655,000	546,226	616,791
Number of loads (20 t per load)		29,925	32,750	27,312	30,840
Total vehicle distance (70 km each way)	km	2,094,750	2,292,500	1,911,840	2,158,800

GHG emissions, transport to landfill	**t CO_2e**	**3,388**	**3,708**	**3,092**	**3,492**
Waste transported by road to ERF	t	229,950	229,950	229,950	229,950
Number of loads (7 t per load)		32,850	32,850	32,850	32,850
Total vehicle distance (10 km each way)	km	328,500	328,500	328,500	328,500
GHG emissions	**t CO_2e**	**531**	**531**	**531**	**531**
APCr transported by road	t	22,144	24,235	20,210	22,821
Number of loads (20 t per load)		1,108	1,212	1,011	1,142
Total vehicle distance (140 km each way)	km	155,120	169,680	141,540	159,880
GHG emissions	**t CO_2e**	**251**	**274**	**229**	**259**
Waste transported by river to ERF	t	368,541	425,050	316,276	386,841
IBA transported by river from ERF	t	143,638	157,200	131,094	148,030
Marine oil required (1.6 l/t transported)	l	819,487	931,600	715,793	855,792
GHG emissions	**t CO_2e**	**2,274**	**2,585**	**1,986**	**2,375**
Total GHG emissions for ERF transport	**t CO_2e**	**3,056**	**3,391**	**2,746**	**3,165**

4 Results

4.1 Electricity only

4.1.1 Combining the calculations from earlier, the results of the assessment for the electricity-only case are shown below in Table 8. There is a net benefit of between 107,000 and 213,000 tCO_2e per annum, or 197 to 345 $kgCO_2e$ per tonne of waste going to the REP ERF rather than landfill.

Table 8 –GHG Emissions Comparison, Electricity-Only

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Releases from landfill gas	t CO_2e	258,675	300,949	238,951	299,715
Transport of waste and outputs to landfill	t CO_2e	3,388	3,708	3,092	3,492
Offset of grid electricity from landfill gas engines	t CO_2e	-38,271	-44,525	-35,353	-44,343
Total landfill emissions	**t CO_2e**	**223,792**	**260,132**	**206,691**	**258,864**
Transport of waste to and outputs from ERF	t CO_2e	3,056	3,391	2,746	3,165
Offset of grid electricity with ERF generation	t CO_2e	-182,498	-182,498	-182,498	-182,498
Emissions from ERF	t CO_2e	265,831	229,335	278,796	225,303
Total ERF Emissions	**t CO_2e**	**86,389**	**50,227**	**99,044**	**45,969**
Net Benefit of ERF	**t CO_2e**	**137,403**	**209,905**	**107,647**	**212,895**
	t CO_2e/t waste	**0.230**	**0.320**	**0.197**	**0.345**

4.2 CHP

4.2.1 Combining the calculations from earlier, the results of the assessment for the CHP case are shown below in Table 9. There is a net benefit of between 128,000 and 233,000 tCO_2e per annum, or 234 to 378 $kgCO_2e$ per tonne of waste going to the REP ERF rather than landfill.

Table 9 –GHG Emissions Comparison, CHP

Parameter	Unit	RRRF Waste	Design Waste	Reduced Food	Future Waste
Releases from landfill gas	t CO_2e	258,675	300,949	238,951	299,715
Transport of waste and outputs to landfill	t CO_2e	3,388	3,708	3,092	3,492
Offset of grid electricity from landfill gas engines	t CO_2e	-38,271	-44,525	-35,353	-44,343
Total landfill emissions	**t CO_2e**	**223,792**	**260,132**	**206,691**	**258,864**
Transport of waste to and outputs from ERF	t CO_2e	3,056	3,391	2,746	3,165
Offset of natural gas usage with ERF heat	t CO_2e	-25,251	-25,251	-25,251	-25,251
Offset of grid electricity with ERF generation	t CO_2e	-177,363	-177,363	-177,363	-177,363
Emissions from ERF	t CO_2e	265,831	229,335	278,796	225,303
Total ERF Emissions	**t CO_2e**	**66,273**	**30,112**	**78,928**	**25,854**
Net Benefit of ERF	**t CO_2e**	**157,519**	**230,020**	**127,762**	**233,011**
	t CO_2e/t waste	**0.263**	**0.351**	**0.234**	**0.378**

4.3 Sensitivity Assessment

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

a. UKWIN considers that the long-run marginal generation-based emissions factor for 2021 should be used, which is 0.258 g/kWh. While the Applicant does not accept this position, the effect of varying this value is presented in Table 10.

b. As noted earlier, the Landfill Emissions Modelling report states that the collection efficiency for large, modern landfill sites was estimated to be

68% and the collection efficiency for the UK as a whole was estimated to be 52%. In the Carbon Modelling report, it is suggested that a conservative figure of 75% should be used. As the Landfill Emissions Modelling report post-dates the Carbon Modelling report, we consider that its figure is more suitable, but the sensitivity of the results to this assumption has also been assessed below.

4.3.2 Table 10 shows the estimated net benefit of the REP ERF compared to landfill, operating in electricity-only mode, in tonnes of carbon dioxide equivalent emissions per annum, for different combinations of grid displacement factor and landfill gas capture rate. This is shown for all four waste compositions. The base case is highlighted in bold.

4.3.3 It can be seen that there is a benefit in all cases, with the benefit ranging from 14,000 tCO_2e to 362,000 tCO_2e per annum.

Table 10 –Sensitivity Calculations

Grid Displacement Factor	**Landfill Gas Capture Rate**			
RRRF Waste				
	75%	68%	60%	52%
0.357	79,504	**137,403**	203,574	269,744
0.32	64,965	122,455	188,159	253,863
0.258	40,601	97,408	162,329	227,251
Design Waste				
	75%	68%	60%	52%
0.357	142,544	**209,905**	286,889	363,873
0.32	128,719	195,605	272,046	348,488
0.258	105,553	171,643	247,175	322,706
Reduced Food				
	75%	68%	60%	52%
0.357	54,163	**107,647**	168,772	229,896
0.32	39,289	92,396	153,090	213,784
0.258	14,367	66,842	126,813	186,784

Future Waste				
	75%	68%	60%	52%
0.357	145,810	**212,895**	289,564	366,232
0.32	131,965	198,576	274,704	350,832
0.258	108,764	174,583	249,805	325,027

4.3.4 The lowest predicted benefit is 14,367 tCO_2e. This case is based on the following conservative assumptions:

a. The waste supplied to the REP ERF will be the same as the waste supplied to RRRF except that half of the putrescible waste has been removed and no plastics has been removed.

b. The REP ERF exports no heat.

c. The REP ERF displaces power at the long run marginal rate, which is incorrect.

d. All of the waste processed at the REP ERF would otherwise be processed in landfill sites which have very high landfill gas collection and utilisation rates throughout their life.

4.3.5 We have used global warming potential figures from the IPCC fourth Assessment Report (2007), as these are used for national reporting. However, the figures were updated in the fifth Assessment Report (2013) from 298 to 265 for nitrous oxide and from 25 to 28 for methane. These could be considered to present the latest scientific view. Using these figures for GWP, the benefit of the REP ERF increases by around 30,000 to 35,000 tCO_2e in the base case. In the most conservative case, the benefit increases by 23,000 tCO_2e to 37,000 tCO_2e.

5 Conclusion

5.1.1 A carbon assessment has been carried out for the REP ERF.

5.1.2 The base case for the assessment shows that the benefit of the REP ERF compared to landfill is about 137,000 tonnes of CO_2-equivalent per year, or about 229 kg CO_2e per tonne of waste processed. This is based on the following key assumptions.

a. The residual waste for the REP ERF has the same composition as the residual waste currently being supplied to RRRF.

b. Electricity generated by REP (or landfill gas engines) displaces electricity generated from gas-fired power stations.

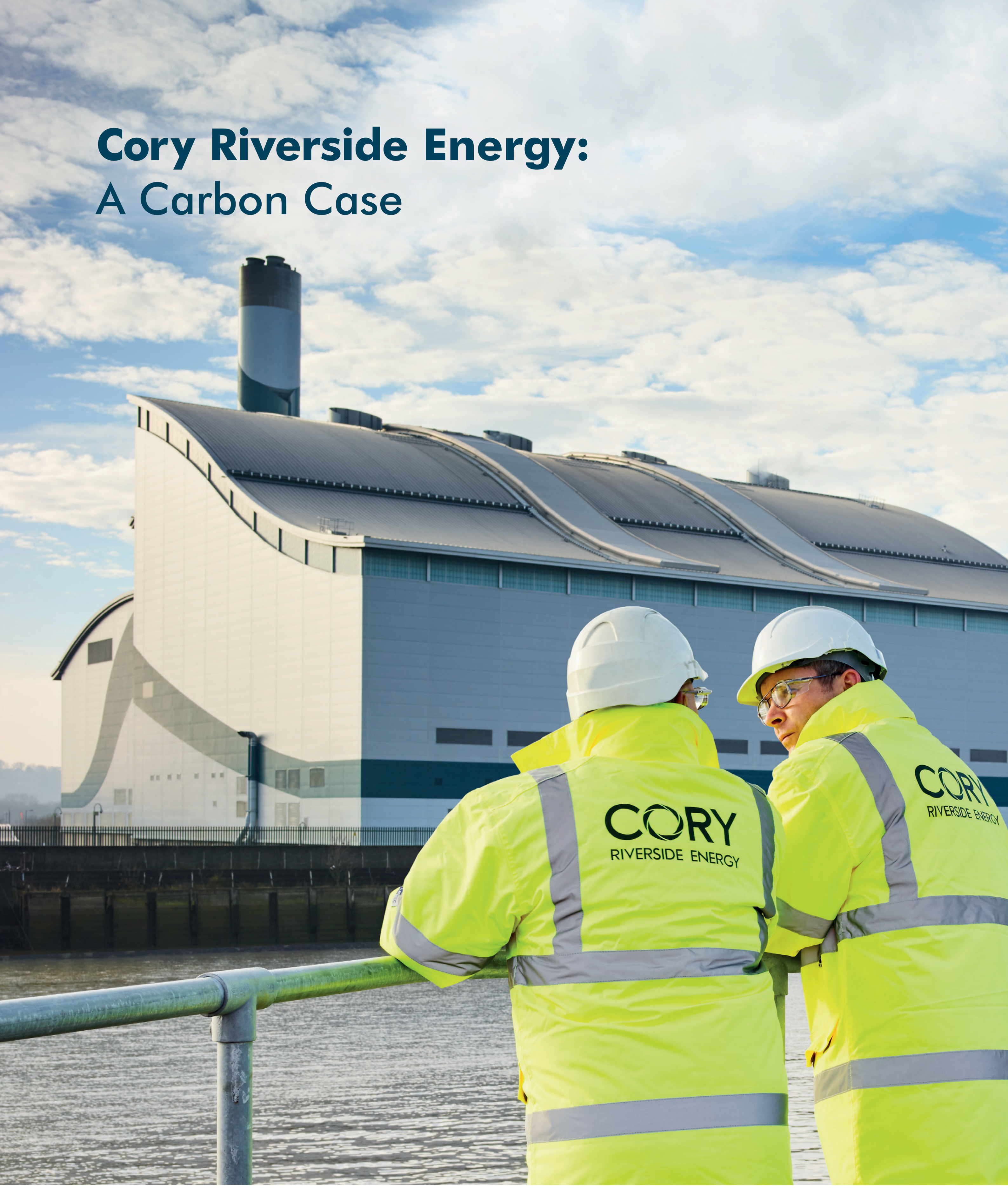
c. The landfill site in the comparison scenario is a typical large UK landfill site.

5.1.3 If heat is exported, this benefit increases to 157,000 t CO_2e or 263 kg CO_2e per tonne of waste processed.

5.1.4 The assessment has considered the sensitivity of the assessment to changes in waste composition, changes in landfill gas recovery rates and changes in the source of displaced electricity. In all cases, the REP ERF continues to have a benefit over landfill.

Appendix A RRRF Carbon Assessment – cover and p.16

Cory Riverside Energy:
A Carbon Case



CORY
RIVERSIDE ENERGY

2.3 Energy from Waste

2.3.1 WASTE COMPOSITION

The composition of waste received by Riverside EfW is measured annually via sample data taken from waste stream. This reporting is conducted by a third party on behalf of Cory. Reporting uses Ofgem's methodology to calculate the percentage of waste entering Riverside that is derived from biogenic sources.

CARBON CONTENT

In 2015, chemical analysis revealed 27% of the waste entering Riverside EfW contains carbon (C) by weight. This result is higher than the 23% used in the Defra carbon modelling study, but within the typical range of municipal solid waste in the UK (20-30%)[21]. Calorific value and therefore energy produced is highly correlated to carbon content; this model uses calorific value as a proxy for carbon content.

BIOGENIC CONTENT

Table 4 summarises the composition of waste by: % weight of total sample; % of CV of energy recovery process; biogenic content; non-biogenic content. This allows quantification of the biogenic and non-biogenic proportion in the waste stream. Results highlight: 54.10% of the waste is biogenic in origin; 45.90% of waste is of fossil fuel origin. For the purpose of calculating CO_2 emissions from EfW, only emissions from waste of fossil fuel are considered.

21 See Carbon Balances 2006, Energy Impacts of the Management of UK Waste Streams, here

Waste Composition	By Weight %	By CV %	Biogenic Content %	Non Biogenic %	Qualifying Renewable %	Fossil Carbon %
Paper and card	27.83	27.80	100	0	27.8	0
Plastic film	8.51	18.67	0	100	0	18.67
Dense plastic	7.77	17.28	0	100	0	17.28
Textiles	3.43	5.25	50	50	2.625	2.62
Misc. Combustible	9.55	12.26	50	50	6.13	6.13
Misc. Non-Combustible	5.39	0.00	50	50	0	0
Glass	4.52	0.00	0	100	0	0
Putrescibles	26.44	16.35	100	0	16.35	0
Ferrous Metal	1.58	0.00	0	100	0	0
Non-ferrous Metal	1.00	0.00	0	100	0	0
Hazardous	1.21	0.00	0	100	0	0
Fines	2.77	2.39	50	50	1.195	1.19
Total	**100%**	**100%**	–	–	**54.10%**	**45.90%**

Table 4 *Waste Composition*

Appendix B IPCC Guidelines for Greenhouse Gas Inventories - cover and p. 2.16-2.17

CHAPTER 2

STATIONARY COMBUSTION

TABLE 2.2
DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN THE ENERGY INDUSTRIES
(kg of greenhouse gas per TJ on a Net Calorific Basis)

Fuel		CO_2			CH_4			N_2O		
		Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper
Crude Oil		73 300	71 100	75 500	r 3	1	10	0.6	0.2	2
Orimulsion		r 77 000	69 300	85 400	r 3	1	10	0.6	0.2	2
Natural Gas Liquids		r 64 200	58 300	70 400	r 3	1	10	0.6	0.2	2
Gasoline	Motor Gasoline	r 69 300	67 500	73 000	r 3	1	10	0.6	0.2	2
Gasoline	Aviation Gasoline	r 70 000	67 500	73 000	r 3	1	10	0.6	0.2	2
Gasoline	Jet Gasoline	r 70 000	67 500	73 000	r 3	1	10	0.6	0.2	2
Jet Kerosene		r 71 500	69 700	74 400	r 3	1	10	0.6	0.2	2
Other Kerosene		71 900	70 800	73 700	r 3	1	10	0.6	0.2	2
Shale Oil		73 300	67 800	79 200	r 3	1	10	0.6	0.2	2
Gas/Diesel Oil		74 100	72 600	74 800	r 3	1	10	0.6	0.2	2
Residual Fuel Oil		77 400	75 500	78 800	r 3	1	10	0.6	0.2	2
Liquefied Petroleum Gases		63 100	61 600	65 600	r 1	0.3	3	0.1	0.03	0.3
Ethane		61 600	56 500	68 600	r 1	0.3	3	0.1	0.03	0.3
Naphtha		73 300	69 300	76 300	r 3	1	10	0.6	0.2	2
Bitumen		80 700	73 000	89 900	r 3	1	10	0.6	0.2	2
Lubricants		73 300	71 900	75 200	r 3	1	10	0.6	0.2	2
Petroleum Coke		r 97 500	82 900	115 000	r 3	1	10	0.6	0.2	2
Refinery Feedstocks		73 300	68 900	76 600	r 3	1	10	0.6	0.2	2
Other Oil	Refinery Gas	n 57 600	48 200	69 000	r 1	0.3	3	0.1	0.03	0.3
Other Oil	Paraffin Waxes	73 300	72 200	74 400	r 3	1	10	0.6	0.2	2
Other Oil	White Spirit and SBP	73 300	72 200	74 400	r 3	1	10	0.6	0.2	2
Other Oil	Other Petroleum Products	73 300	72 200	74 400	r 3	1	10	0.6	0.2	2
Anthracite		98 300	94 600	101 000	1	0.3	3	r 1.5	0.5	5
Coking Coal		94 600	87 300	101 000	1	0.3	3	r 1. 5	0.5	5
Other Bituminous Coal		94 600	89 500	99 700	1	0.3	3	r 1. 5	0.5	5
Sub-Bituminous Coal		96 100	92 800	100 000	1	0.3	3	r 1.5	0.5	5
Lignite		101 000	90 900	115 000	1	0.3	3	r 1. 5	0.5	5
Oil Shale and Tar Sands		107 000	90 200	125 000	1	0.3	3	r 1. 5	0.5	5
Brown Coal Briquettes		97 500	87 300	109 000	n 1	0.3	3	r 1. 5	0.5	5
Patent Fuel		97 500	87 300	109 000	1	0.3	3	n 1. 5	0.5	5
Coke	Coke Oven Coke and Lignite Coke	r 107 000	95 700	119 000	1	0.3	3	r 1. 5	0.5	5
Coke	Gas Coke	r 107 000	95 700	119 000	r 1	0.3	3	0.1	0.03	0.3
Coal Tar		n 80 700	68 200	95 300	n 1	0.3	3	r 1. 5	0.5	5
Derived Gases	Gas Works Gas	n 44 400	37 300	54 100	n 1	0.3	3	0.1	0.03	0.3
Derived Gases	Coke Oven Gas	n 44 400	37 300	54 100	r 1	0.3	3	0.1	0.03	0.3
Derived Gases	Blast Furnace Gas	n 260 000	219 000	308 000	r 1	0.3	3	0.1	0.03	0.3
Derived Gases	Oxygen Steel Furnace Gas	n 182 000	145 000	202 000	r 1	0.3	3	0.1	0.03	0.3
Natural Gas		56 100	54 300	58 300	1	0.3	3	0.1	0.03	0.3

TABLE 2.2 (CONTINUED)
DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN THE ENERGY INDUSTRIES
(kg of greenhouse gas per TJ on a Net Calorific Basis)

Fuel		CO_2			CH_4			N_2O		
		Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper
Municipal Wastes (non-biomass fraction)		n 91 700	73 300	121 000	30	10	100	4	1.5	15
Industrial Wastes		n 143 000	110 000	183 000	30	10	100	4	1.5	15
Waste Oils		n 73 300	72 200	74 400	30	10	100	4	1.5	15
Peat		106 000	100 000	108 000	n 1	0.3	3	n 1.5	0.5	5
Solid Biofuels	Wood / Wood Waste	n 112 000	95 000	132 000	30	10	100	4	1.5	15
Solid Biofuels	Sulphite lyes (Black Liquor)[a]	n 95 300	80 700	110 000	n 3	1	18	n 2	1	21
Solid Biofuels	Other Primary Solid Biomass	n 100 000	84 700	117 000	30	10	100	4	1.5	15
Solid Biofuels	Charcoal	n 112 000	95 000	132 000	200	70	600	4	1.5	15
Liquid Biofuels	Biogasoline	n 70 800	59 800	84 300	r 3	1	10	0.6	0.2	2
Liquid Biofuels	Biodiesels	n 70 800	59 800	84 300	r 3	1	10	0.6	0.2	2
Liquid Biofuels	Other Liquid Biofuels	n 79 600	67 100	95 300	r 3	1	10	0.6	0.2	2
Gas Biomass	Landfill Gas	n 54 600	46 200	66 000	r 1	0.3	3	0.1	0.03	0.3
Gas Biomass	Sludge Gas	n 54 600	46 200	66 000	r 1	0.3	3	0.1	0.03	0.3
Gas Biomass	Other Biogas	n 54 600	46 200	66 000	r 1	0.3	3	0.1	0.03	0.3
Other non-fossil fuels	Municipal Wastes (biomass fraction)	n 100 000	84 700	117 000	30	10	100	4	1.5	15

(a) Includes the biomass-derived CO_2 emitted from the black liquor combustion unit and the biomass-derived CO_2 emitted from the kraft mill lime kiln.
n indicates a new emission factor which was not present in the 1996 Guidelines
r indicates an emission factor that has been revised since the 1996 Guidelines

Appendix C IPPC AR4 WG1 Chapter 2 - cover and p. 121

2

Changes in Atmospheric Constituents and in Radiative Forcing

Coordinating Lead Authors:

Piers Forster (UK), Venkatachalam Ramaswamy (USA)

Lead Authors:

Paulo Artaxo (Brazil), Terje Berntsen (Norway), Richard Betts (UK), David W. Fahey (USA), James Haywood (UK), Judith Lean (USA), David C. Lowe (New Zealand), Gunnar Myhre (Norway), John Nganga (Kenya), Ronald Prinn (USA, New Zealand), Graciela Raga (Mexico, Argentina), Michael Schulz (France, Germany), Robert Van Dorland (Netherlands)

Contributing Authors:

G. Bodeker (New Zealand), O. Boucher (UK, France), W.D. Collins (USA), T.J. Conway (USA), E. Dlugokencky (USA), J.W. Elkins (USA), D. Etheridge (Australia), P. Foukal (USA), P. Fraser (Australia), M. Geller (USA), F. Joos (Switzerland), C.D. Keeling (USA), R. Keeling (USA), S. Kinne (Germany), K. Lassey (New Zealand), U. Lohmann (Switzerland), A.C. Manning (UK, New Zealand), S. Montzka (USA), D. Oram (UK), K. O'Shaughnessy (New Zealand), S. Piper (USA), G.-K. Plattner (Switzerland), M. Ponater (Germany), N. Ramankutty (USA, India), G. Reid (USA), D. Rind (USA), K. Rosenlof (USA), R. Sausen (Germany), D. Schwarzkopf (USA), S.K. Solanki (Germany, Switzerland), G. Stenchikov (USA), N. Stuber (UK, Germany), T. Takemura (Japan), C. Textor (France, Germany), R. Wang (USA), R. Weiss (USA), T. Whorf (USA)

Review Editors:

Teruyuki Nakajima (Japan), Veerabhadran Ramanathan (USA)

This chapter should be cited as:

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. *In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table 2.14. *Lifetimes, radiative efficiencies and direct (except for CH_4) GWPs relative to CO_2. For ozone-depleting substances and their replacements, data are taken from IPCC/TEAP (2005) unless otherwise indicated.*

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W m^{-2} ppb^{-1}$)	Global Warming Potential for Given Time Horizon			
				SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]1.4×10^{-5}	1	1	1	1
Methane[c]	CH_4	12[c]	3.7×10^{-4}	21	72	25	7.6
Nitrous oxide	N_2O	114	3.03×10^{-3}	310	289	298	153
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
CFC-113	CCl_2FCClF_2	85	0.3	4,800	6,540	6,130	2,700
CFC-114	$CClF_2CClF_2$	300	0.31		8,040	10,000	8,730
CFC-115	$CClF_2CF_3$	1,700	0.18		5,310	7,370	9,990
Halon-1301	$CBrF_3$	65	0.32	5,400	8,480	7,140	2,760
Halon-1211	$CBrClF_2$	16	0.3		4,750	1,890	575
Halon-2402	$CBrF_2CBrF_2$	20	0.33		3,680	1,640	503
Carbon tetrachloride	CCl_4	26	0.13	1,400	2,700	1,400	435
Methyl bromide	CH_3Br	0.7	0.01		17	5	1
Methyl chloroform	CH_3CCl_3	5	0.06		506	146	45
HCFC-22	$CHClF_2$	12	0.2	1,500	5,160	1,810	549
HCFC-123	$CHCl_2CF_3$	1.3	0.14	90	273	77	24
HCFC-124	$CHClFCF_3$	5.8	0.22	470	2,070	609	185
HCFC-141b	CH_3CCl_2F	9.3	0.14		2,250	725	220
HCFC-142b	CH_3CClF_2	17.9	0.2	1,800	5,490	2,310	705
HCFC-225ca	$CHCl_2CF_2CF_3$	1.9	0.2		429	122	37
HCFC-225cb	$CHClFCF_2CClF_2$	5.8	0.32		2,030	595	181
Hydrofluorocarbons							
HFC-23	CHF_3	270	0.19	11,700	12,000	14,800	12,200
HFC-32	CH_2F_2	4.9	0.11	650	2,330	675	205
HFC-125	CHF_2CF_3	29	0.23	2,800	6,350	3,500	1,100
HFC-134a	CH_2FCF_3	14	0.16	1,300	3,830	1,430	435
HFC-143a	CH_3CF_3	52	0.13	3,800	5,890	4,470	1,590
HFC-152a	CH_3CHF_2	1.4	0.09	140	437	124	38
HFC-227ea	CF_3CHFCF_3	34.2	0.26	2,900	5,310	3,220	1,040
HFC-236fa	$CF_3CH_2CF_3$	240	0.28	6,300	8,100	9,810	7,660
HFC-245fa	$CHF_2CH_2CF_3$	7.6	0.28		3,380	1030	314
HFC-365mfc	$CH_3CF_2CH_2CF_3$	8.6	0.21		2,520	794	241
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	15.9	0.4	1,300	4,140	1,640	500
Perfluorinated compounds							
Sulphur hexafluoride	SF_6	3,200	0.52	23,900	16,300	22,800	32,600
Nitrogen trifluoride	NF_3	740	0.21		12,300	17,200	20,700
PFC-14	CF_4	50,000	0.10	6,500	5,210	7,390	11,200
PFC-116	C_2F_6	10,000	0.26	9,200	8,630	12,200	18,200

Table 2.14 (continued)

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency ($W\ m^{-2}\ ppb^{-1}$)	Global Warming Potential for Given Time Horizon			
				SAR‡ (100-yr)	20-yr	100-yr	500-yr
Perfluorinated compounds *(continued)*							
PFC-218	C_3F_8	2,600	0.26	7,000	6,310	8,830	12,500
PFC-318	c-C_4F_8	3,200	0.32	8,700	7,310	10,300	14,700
PFC-3-1-10	C_4F_{10}	2,600	0.33	7,000	6,330	8,860	12,500
PFC-4-1-12	C_5F_{12}	4,100	0.41		6,510	9,160	13,300
PFC-5-1-14	C_6F_{14}	3,200	0.49	7,400	6,600	9,300	13,300
PFC-9-1-18	$C_{10}F_{18}$	>1,000[d]	0.56		>5,500	>7,500	>9,500
trifluoromethyl sulphur pentafluoride	SF_5CF_3	800	0.57		13,200	17,700	21,200
Fluorinated ethers							
HFE-125	CHF_2OCF_3	136	0.44		13,800	14,900	8,490
HFE-134	CHF_2OCHF_2	26	0.45		12,200	6,320	1,960
HFE-143a	CH_3OCF_3	4.3	0.27		2,630	756	230
HCFE-235da2	$CHF_2OCHClCF_3$	2.6	0.38		1,230	350	106
HFE-245cb2	$CH_3OCF_2CHF_2$	5.1	0.32		2,440	708	215
HFE-245fa2	$CHF_2OCH_2CF_3$	4.9	0.31		2,280	659	200
HFE-254cb2	$CH_3OCF_2CHF_2$	2.6	0.28		1,260	359	109
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	5.2	0.34		1,980	575	175
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	7.1	0.25		1,900	580	175
HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$	0.33	0.93		386	110	33
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$	3.8	0.31		1,040	297	90
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	0.77	0.3		207	59	18
HFE-43-10pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$	6.3	1.37		6,320	1,870	569
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$	12.1	0.66		8,000	2,800	860
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	6.2	0.87		5,100	1,500	460
Perfluoropolyethers							
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	800	0.65		7,620	10,300	12,400
Hydrocarbons and other compounds – Direct Effects							
Dimethylether	CH_3OCH_3	0.015	0.02		1	1	<<1
Methylene chloride	CH_2Cl_2	0.38	0.03		31	8.7	2.7
Methyl chloride	CH_3Cl	1.0	0.01		45	13	4

Notes:

[a] The CO_2 response function used in this report is based on the revised version of the Bern Carbon cycle model used in Chapter 10 of this report (Bern2.5CC; Joos et al. 2001) using a background CO_2 concentration value of 378 ppm. The decay of a pulse of CO_2 with time t is given by

$$a_0 + \sum_{i=1}^{3} a_i \cdot e^{-t/\tau_i}$$

Where $a_0 = 0.217$, $a_1 = 0.259$, $a_2 = 0.338$, $a_3 = 0.186$, $\tau_1 = 172.9$ years, $\tau_2 = 18.51$ years, and $\tau_3 = 1.186$ years.

[b] The radiative efficiency of CO_2 is calculated using the IPCC (1990) simplified expression as revised in the TAR, with an updated background concentration value of 378 ppm and a perturbation of +1 ppm (see Section 2.10.2).

[c] The perturbation lifetime for methane is 12 years as in the TAR (see also Section 7.4). The GWP for methane includes indirect effects from enhancements of ozone and stratospheric water vapour (see Section 2.10.3.1).

[d] Shine et al. (2005c), updated by the revised AGWP for CO_2. The assumed lifetime of 1,000 years is a lower limit.

[e] Hurley et al. (2005)

[f] Robson et al. (2006)

[g] Young et al. (2006)

Appendix D Energy from Waste – A Guide to the debate - cover and p. 21

Department
for Environment
Food & Rural Affairs

www.gov.uk/defra

Energy from waste

A guide to the debate

February 2014 (revised edition)

DEPARTMENT OF
ENERGY
& CLIMATE CHANGE

greenhouse gas emissions, (usually expressed as carbon dioxide equivalents[25]), is generally placed higher in the waste hierarchy.

38. To illustrate such a comparison of greenhouse emissions let us consider the potential fate of a current typical 'black bag' of residual waste – one route where it is sent to landfill and another when it is used in energy recovery.

39. A typical black bag of residual waste will contain a mixture of different things, such as paper, food, plastic, clothes, glass and metal. Some of these wastes, e.g. food, will originally have come from biological sources, i.e. plants, and the carbon stored in them is known as biogenic carbon. Some of the waste materials, e.g. plastics, will have been made from fossil fuels such as oil and the carbon stored in them is known as 'fossil carbon'. Some of the wastes, e.g. clothes, will contain a mixture of biogenic and fossil carbon (e.g. cotton/polyester mixes) while other wastes will contain little or no actual carbon (e.g. metals). We need to understand if the carbon in the waste is biogenic or fossil in origin for two reasons: (i) they behave differently in landfill (plastic does not generally decompose) and (ii) biogenic and fossil carbon are counted differently in terms of how they are calculated to contribute to global warming[26]. Of the waste in our typical black bag, currently[27] somewhere between one half and two thirds will contain biogenic carbon.

40. Considering the energy from waste route, if our black bag of waste were to go to a typical combustion-based energy from waste plant, nearly all of the carbon in the waste would be converted to carbon dioxide[28] and be released immediately into the atmosphere. Conventionally the biogenic carbon dioxide released is ignored in this type of carbon comparison as it is considered 'short cycle', i.e. it was only relatively recently absorbed by growing matter. In contrast, the carbon dioxide released by fossil-carbon containing waste was absorbed millions of years ago and would be newly released into the atmosphere if combusted in an energy from waste plant.

41. The energy from waste plant will generate some energy (in addition to whatever it uses to run itself). This energy substitutes for energy that would otherwise need to be generated by a conventional gas-fired power station[29], thereby saving the fossil carbon dioxide that would have been released by that power station. This means that in our comparison some of the fossil carbon dioxide released by the energy from waste plant can be offset by the saving from the gas fired power station, reducing the

[25] Carbon dioxide equivalents are used as a way of comparing the effect of different gasses. Carbon dioxide is given a global warming potential of one, while a given unit of methane will be 25 carbon dioxide equivalents.

[26] The atmosphere cannot distinguish between CO_2 released from a biogenic source versus a fossil source. However, in terms of considering overall climate impacts it is important they are accounted for and treated differently to avoid double counting. The IPCC have agreed conventions for doing this which are applied here.

[27] The composition of waste changes over time as consumption patterns, reuse, recycling and separate collection practices change.

[28] <3% would remain in the ash.

[29] 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. When conducting more detailed assessments the energy offset should be calculated in line with DECC guidance using the appropriate marginal energy factor https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Appendix E BEIS Fuel Mix Disclosure Table

Department for Business, Energy & Industrial Strategy

Fuel Mix Disclosure Data Table
The information below constitutes the 'fuel mix disclosure data table' as defined in The Electricity (Fuel Mix Disclosure) Regulations 2005. The data are for the disclosure period 01/04/2017 – 31/03/2018.

See related documents for Electricity (Fuel Mix Disclosure) Regulations 2005 issued by BEIS and, under 'External Links', guidance from Ofgem about Fuel Mix Disclosure (*).

For the 2017/18 Publication the residual calculation method has changed. See the 2018 Methodology document for more details.

1. Transmission and distribution loss factor (not to be applied to embedded generation)

1.12020

2. Residual Fuel mix (relevant to Paragraph 10 of the Regulations)

Energy Source	%
Coal	11.8
Natural Gas	62.6
Nuclear	19.0
Renewables	2.6
Other Fuels	4.0

Residual Fuel Mix revised 24 August 2018[1]

[1] Residual fuel mix figures were updated due to an error in the calculation method. For reference, the residual fuel mix originally published was coal 11.7%, natural gas 59.4%, nuclear 18.0%, renewables 7.3% and other fuels 3.6%. This is superseded by the revised mix above.

3. Environmental impact (relevant to Paragraph 11 of the Regulations)

Carbon Dioxide Emissions

Revised 24 August 2018[1]

Energy Source	g/kWh
Coal	918
Natural Gas	357
Nuclear	0
Renewables	0
Other	691
Overall average	225

High-level radioactive waste

0.007 g/kWh

4. UK fuel mix (for comparison)

Revised 31 August 2018[2]

Energy Source	%
Coal	7.64
Natural Gas	41.24
Nuclear	20.01
Renewables	29.04
Other	2.07

(*) *Note that under the new licences introduced on 1 August 2007, Fuel Mix Disclosure is supply licence condition 21 in place of licence condition 30A quoted in the Guidelines.*

Page updated on 31 August 2018

[2] UK fuel mix figures updated to 2 decimal places to address rounding.

Appendix F Landfill Emissions Report - cover and exec. summary

November 2014

DEPARTMENT OF THE ENVIRONMENT, FOOD AND RURAL AFFAIRS

Review of Landfill Methane Emissions Modelling

Authors: Robert Gregory, Julia Stalleicken, Richard Lane, Samantha Arnold, David Hall

Submitted to:
Department of the Environment,
Food and Rural Affairs
Nobel House
17 Smith Square
London
SW1P 3JR

Photograph used with permission of Infinis plc

REPORT

Report **Number** 13514290381.506/A.1

Distribution:

DEFRA - 2 copies (1 pdf and 1 Word format)
Golder Associates (UK) Ltd - 1 copy

Golder Associates

Executive Summary

The Department for Environment, Food and Rural Affairs (Defra) considers that waste management accounts for 3% of the United Kingdom's (UK's) greenhouse gas emissions, with the majority being emitted from landfills. Current practice is to model these emissions rather than measure them directly. The estimates for methane emissions from landfills come from computer models. For national emissions MELMod is used and for site specific and Pollution Inventory (PI) reporting estimates the model is usually GasSim. Whilst there has been a substantial investment programme in methane capture technology over the last two decades, the precise rate of methane capture remains uncertain. Defra and the Environment Agency (EA) along with the Department of Energy and Climate Change (DECC) have been working together to address this uncertainty.

The aim of this project is to provide Defra with an up-to-date, robust figure for the methane capture rate from landfill that can be used to inform policy decisions. Also, the project aims at achieving accurate and defensible reporting of emission from the waste sector in the European greenhouse gas inventory.

Golder Associates (Golder) has approached this task by developing a methodology for assessing the methane capture rate for the UK portfolio of large modern landfills with comprehensive gas collection specified as category Type 3 landfill in MELMod. This category of landfills contains all the UK organic waste emplaced since 1979, when the MELMod Type 4 landfills were considered to have ceased filling. Golder quantified the various elements of methane generation and emission for the year of 2011, the latest year for which MELMod reported methane emission estimates. As part of the process, Golder consulted with UK and international landfill gas experts, reviewed research undertaken under the umbrella of the Defra/DECC/EA Methane Capture Project, data made available by the EA as well as peer-reviewed literature. A bibliography detailing relevant articles is appended to the report.

This assessment entailed a review of methane generation factors to be used in MELMod to establish the 2011 methane generation from Type 3 landfills including Degradable Decomposable Organic Carbon Content (DDOC) for different waste fractions, waste degradation rates and methane content in landfill gas. Subsequently, the different terms of the managed methane capture were quantified including methane utilised in landfill gas engines, methane flared and methane slippage from engines. Finally, the uncontrolled methane emissions were assessed and estimates were derived for the quantities of methane fugitive emissions from landfill and methane oxidised in the cover soils. The summary of our findings are given below:

- MELMod and GasSim should continue to use current values of the parameter describing available degradable organic content under anaerobic conditions (DDOC).

- The half-lives of waste degradation for a large portfolio of Type 3 UK landfill sites are most realistically represented currently by GasSim "wet" waste degradation rates. This should be kept under review as landfill management practices evolve in the future. Further consideration is also required as to the relative allocation of waste fractions and DDOC to rapid, medium and slowly degrading organic materials (RDO, MDO and SDO) with the various models to better understand their comparability.

- The ratio of methane to carbon dioxide measured in UK landfill gas is calculated to be 57:43% rather than the 50:50% landfill gas production ratio which is the International Panel for Climate Change (IPCC, 2006) default value. Further review of existing research is recommended to investigate these differences.

- Review of the current mix of engine types across the UK portfolio has resulted in an average gross engine efficiency estimate of 40%. It has been assumed that parasitic and other losses are encompassed in a 4% loss factor leading to a net electrical efficiency assumption of 36%. The MELMod model needs to recognise these improvements in electrical efficiency for the UK's modern landfill portfolio.

- The total methane combusted in 2011 in the UK has been calculated as 1,325,427 tonnes. This is comprised of the following components:
  - The quantum of methane utilised in landfill gas engines is calculated be 1,012,501 tonnes for 2011.
  - The quantum of methane that is flared from operational sites with landfill gas utilisation is estimated to be 1/11th of the methane utilised in gas engines. The total estimate for 2011 is 92,242 tonnes.
  - The quantum of methane that is flared from sites with only flaring as gas control is actually very difficult to quantify. In the absence of representative data for the UK, Golder has suggested a methodology to determine this value, which we estimate is 220,685 tonnes. Additional research is required to refine this value.
- The quantum of methane which passes through landfill gas engines unburnt is calculated to be 1.5% of the gas supplied to gas engines in any one year. For 2011, this is calculated to be 14,836 tonnes of methane.
- The fugitive emissions estimate for 2011 is 1,286,251 tonnes. This is based on a limited and potentially unrepresentative data set. It is recommended that the results of further measurements are made at UK landfill sites, such as during the GAUGE project (2014) which is yet to report, and that these are analysed as they become available to refine this estimate.
- Calculations made on differential absorption lidar (DIAL) emissions measurement datasets suggest an overall methane oxidation value similar to the IPCC default value of 10%. Again, until further field measurements are available for analysis it is recommended that the IPCC default value for methane oxidation of 10% is retained.

Golder used these findings to calculate the 2011 methane capture rate for the Type 3 landfill portfolio. This whole life collection efficiency is calculated to be 52% using a methodology based on MELMod methane generation predictions. A second, model independent methodology was employed to validate these findings. This slightly more conservative approach arrived at an estimated methane capture rate of 48%. Applying the latter methodology to a subset of 43 large, operational, modern UK landfills resulted in an estimated instantaneous capture rate of 68% which is close to the median of the range of UK expert's assumptions for current operational sites of 55-85%.

The report includes a detailed sensitivity analysis exploring the impacts of different assumptions for DDOC, waste degradation rates, landfill gas methane content, engine electrical efficiency and amount of flaring on sites that are only using flaring as gas control. The report concludes with recommendations on the calculation of separate collection efficiencies for different modern landfill types that will help to inform current regulatory policy, potential considerations for future updates to MELMod, as well as proposed future research to decrease uncertainty in those elements observed above that are currently quantified based on small data sets or unreliable estimates. Future research may include studies into: the allocation of DDOC to RDO, MDO and SDO between the various models; review of publications to explain the difference in methane content between the measured UK field data and the IPCC (2006) default production value; an historical check on electrical efficiencies; improved quantification of landfill gas flaring; analysis of flaring data with respect to flare types and methane slippage; and analysis of on-going methane emissions monitoring field programmes such as GAUGE to better inform fugitive emissions estimates.

Acknowledgements

Golder would like to thank: the independent peer reviewers for their time and considered comments made to Defra; the Landfill Gas Industry Group (LGIG) for sharing of data and their expertise; the consulted UK and international experts and industry representatives for their honest opinions and time; NPL for discussions regarding their DIAL field studies and assessments; and DEFRA, DECC and the EA for their joint interactions supporting the project.