REBUTTAL PROOF OF EVIDENCE TO NI4H PLANNING MR CHRISTOPHER LECOINTE

On behalf of Britaniacrest Recycling Limited

Rebuttal Proof of Evidence of Mr C Lecointe

Rebuttal Proof of Evidence
To Ni4H

October 2019

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1 INTRODUCTION

1.1 This is a rebuttal Proof of Evidence to address one section in the planning evidence prepared by Maureen Darrie on behalf of Ni4H, dated 1st October 2019.

1.2 I do not seek to deal with all matters raised the Ms Darrie's proof as most can be dealt with during the normal course of the Inquiry. However, I do address section 9 – Greenhouse Gas Emissions, as to rebut this largely technical argument I must rely, in part, upon technical evidence by others if I am to draw correct policy conclusions. In particular, my evidence relies on an additional technical appraisal undertaken by Mr Dan Smyth of RPS, found at Appendix 1 of this proof. This also deals with this electrical output of the facility.

2 REBUTTAL TO NI4H

2.1 Ms Darrie, on behalf of Ni4H, makes a case in summary that:

> *" The assessment carried out by Only Solutions concludes that the EfW plant would emit significant quantities of fossil* CO_2*, the energy generated would be 'high carbon', and that if the Appeal is upheld, the EfW would result in the release of more GHG than sending the same waste directly to landfill, contrary to both national and local planning policy."*

2.2 Her case does not deal with the renewable component of the appellants facility but instead is focused on the carbon issue. It is predicated upon the need to define the level of carbon being produced by the appellants proposed facility, and to demonstrate that it is not *'low carbon'* and indeed that the scheme is *'high carbon'*. Having developed that argument she then concludes that as such *" the electricity that would be generated by the proposed EfW plant would hamper efforts to decarbonise the electricity supply*" and, therefore, "*would be contrary to the Policies 24 and 36 of the Local Plan, and Policy W12 of the Waste Local Plan, para 1 of the National Planning Policy for Waste, and the NPPF*".

2.3 In summary my response to these points are set out below:

a. Ms Darrie does not deny that the appellant's facility will accept waste that is at least partially from renewable sources, and therefore, is able to supply low carbon renewable energy that is urgently needed and supported by Government policy. To the extent that low carbon renewable energy is produced from the facility, it will not '*hamper'* the Government's policy of decarbonising the electricity supply. National Grid is responsible for managing and balancing supply from various sources and they are obliged to progressively move towards, and in effect favour, low carbon sources where these are available, over fossil based sources – on that basis electricity produced by the appellants facility will be preferred over fossil fuel generating stations.

As Ms Darrie is silent on the facility's obvious low carbon renewable energy benefits, she does not weigh this important benefit into the planning balance nor therefore into her conclusion.

b. That the term 'Low Carbon' (or indeed Ni4H's reference to 'High Carbon') as referred to in policy is not defined. There is no numerical threshold level of carbon above or below which one can or should judge the acceptability of EfW's in planning terms. This is so given that national planning policy does not require a carbon assessment to be undertaken or be 'measured' for such schemes; that the factors affecting such an assessment rely on assumptions, not certainty's, and so a degree of caution is required to ensure one does not imply a level of accuracy that does not exist; and, that to the extent that an EfW's general carbon credentials are relevant, they are but one measure against which the scheme should be judged, not least because such facility's perform not just a vital energy function but also a key waste management function to. The scheme is compliant with relevant policy;

c. The logical conclusion to be drawn from Ms Darrie's evidence is that the waste that is already permitted to be supplied to the appeal site should instead be sent to landfill or continue to export it, as she sees no benefits from treating waste in the way proposed by the appellant nor in producing renewable energy from the facility.

2.4 I explore each of these points further below (note, any bold text is my emphasis).

The Renewable issue

2.5 Ms. Darrie's proof is silent on the point of whether the appellants proposal qualifies as being renewable. I assume, based on her experience, and that she ultimately accepts that the facility will achieve R1 status, that she also accepts the appellants scheme is indeed one that will produce low carbon renewable energy and is on that basis in accordance with national and local planning policy. In my view significant weight should be attached to this policy compliant benefit and that the appellants scheme should be allowed on this basis alone.

Carbon Issue

2.6 In her paragraph 9.4.10 she states that 'low carbon' is defined in the glossary to the NPPF (Feb 2019) as follows:

> *"Low carbon technologies are those that can help reduce emissions (compared to conventional use of fossil fuels)".*

2.7 I have no issue with that and would make a number of observations.

2.8 In terms of measuring this low carbon policy goal, there is no express threshold to be met on a case by case basis, nor on a wider basis, for EfW facilities. Instead it is the direction of travel that is significant and to that end policy seeks to encourage planning authorities to support a range of technologies that assist in this transition. Indeed, in NPS EN1, paragraph 2.5.38 the Government even recognise that CO_2 emissions may be significant from '*biomass/waste combustion plant'* but that the policies set out in section 2.2 of EN-1 mean that the Secretary of State *"…does not, therefore, need to assess individual applications in terms of carbon emissions against carbon budgets…"*

2.9 The definition of low carbon, in the context of EfW schemes (or other non-traded emission sectors), is not defined numerically in terms of how and to what extent such technologies should deliver low carbon outcomes. That they make some contribution is accepted and enough in policy terms.

2.10 I accept that in addition to the many planning benefits that the appellants facility will bring, the facility planned will also produce CO_2 emissions. However, the level of those emissions depends upon very many factors and assumptions – many if not all cannot easily be controlled. In the case of EfW, it very largely depends on the composition of the waste streams that the plant will receive – and that is uncertain and is likely to remain uncertain throughout the life of the project.

2.11 Such uncertainty is, in my view, why planning policy does not *require* applicants to calculate this when submitting applications for such factifies or *prescribe* CO_2 emission levels above which they must not go. In my opinion, the requirement for a specific carbon intensity threshold for EfW has deliberately not been included within policy because it is not practical to do so - some waste is low carbon; other waste is high carbon and the plant will deal with a mix of both.

2.12 Other than in very general terms, as per the definition in the NPPF to which Ms Darrie refers, I am not aware of any clear consensus on the subject of what constitutes 'low carbon' in any numerical sense. Many of the documents in Ms Darrie's evidence are research papers and through those the debate continues to advance, but these are documents that are only precursors to policy – they test and challenge policy, but they are **not** policy. Many also pre-date current planning policy.

2.13 I accept though, it is common practise for applicants, or consultants on their behalf, to attempt to undertake carbon or greenhouse gas calculations to demonstrate the likely carbon savings or climate change impact, when compared to conventional use of fossil fuels. Fundamentally though, this process implies a level of certainty that simply does not exist.

2.14 Mr Smyth's note on carbon attached to my proof, and the additional note to appendix 1 of this rebuttal proof, demonstrates that with different assumptions, which we believe on the balance of probability are more likely in terms of carbon outputs, show that the scheme is low carbon when measured against coal, and is preferential to landfilling. We accept that a comparison against coal as a fuel and landfill as a disposal route have limited relevance as these two options are fast closing down as realistic options. That being the case, there is no better alternative (that is policy compliant), than to make a comparison of the level of carbon emitted by a similar facility elsewhere.

2.15 The above debate, of course, ignores the other function that EfW performs; that of disposal of our residual waste and the renewable energy supply this generates.

2.16 I would also add that EfW is a very small proportion of UK carbon budgets (<1%) and that emissions in this sector (non-traded emissions sector including commercial, public sector, agriculture and waste, currently contributing 38% to non traded emissions), are predicted to fall by 32% by 2035 (Updated Energy and Emissions Projections 2016, DBEIS, May 2017, page 16. CD (XX)).

2.17 I accept the legitimacy of a debate around CO_2 emissions, but only if that carries enough force relating to the relevance and direction of current policy, should it then be considered by Government, and then policy adjusted, or not, as the case may be. This Inquiry, however, is not the forum to debate nor change current policy.

2.18 We have seen already a similar policy debate in the recent Drax decision (see new Core Document XX)) issued on 4 October 2019.

2.19 Here, the Examining Authority (ExA) argued that the policies of the NPS should be interpreted with up-to-date information. Key extracts from the ExA report are set out below.

> *"**5.2.22**. It is clear that underpinning NPS EN-1 is a road map and a direction of travel for future energy generation sources. As such, the passage of time between the publication of the energy NPSs in 2011 and this Application in 2018-19, is a matter for consideration. Crucially, it is acknowledged throughout*

NPS EN-1 that there is an expectation to reduce over time, the dependence on fossil fuels to meet the overarching need for energy generation. Related to this point, the need to progressively increase dependence on low carbon technology to meet the commitment to reduce GHG emissions is also acknowledged throughout NPS EN-1. ***The ExA considers that both these matters have become increasingly significant due to the passage of time since the publication of NPS EN suite****.*

5.2.23*. The ExA concludes that while the principle of need for energy NSIPs in general is not for debate****, it is entirely correct that the SoS assesses the need for this Proposed Development,*** *in light of the evidence submitted in this examination. Adopting this approach is in our view, in line with the inter-relationship between paragraphs 3.2.3 and 3.1.4 of NPS EN-1.* ***Crucially, this approach is required to take account of the changes in energy generation since the publication of NPS EN-1.***

5.2.24*. Evidence submitted by IPs throughout the Examination demonstrates that energy generation in the UK is moving to lower carbon sources, which is in line with the policy objective in the NPS EN-1 requiring transition to a low carbon economy over time. It follows that requirements from each energy NSIPs must too continually change with time, to reflect the transitioning energy market. As such, the ExA also concludes that the assessment of need for the Proposed Development must take into account current information regarding energy generation submitted in to the Examination.*

2.20 So, in the ExA's report, they had reasoned the applicant <u>does</u> have to demonstrate need on a project-specific level, contrary to the NPS; concluded there is no clear need for the Drax CCGTs due to existing consented capacity in the planning system; concluded that it would cause high-carbon lock in (against NPS objective to decarbonise) and increase total emissions (against CA 2008, Paris etc goals); and concluded that this all weighs strongly enough in the planning balance to recommend against the development. Sections 5.2, 5.3 and paras 7.3.14-16.

2.21 However, the SoS in her decision, rejected the ExA's attempt to look at need on a project level, ruled out the ExA's attempt to consider climate change as an impact in the planning balance, and falls back on standard position from the NPS EN-1 that says (a) need for energy NSIPs is already demonstrated by the NPS and (b) that in light of the NPS', the SoS must not consider climate change impacts of a project.

2.22 In paragraph 4.7 she notes that "…*the ExA's findings on these matters led it to conclude that the Development would not be in accordance with the relevant National Policy Statements for the purposes of section104(3) of the 2008 Act [ER 7.3.6] and would undermine the Government's commitment to cut GHG emissions as set out in the Climate Change Act 2008 ("the CCA"). Furthermore, when considering the planning balance for the purposes of section104(7) of the 2008 Act, the ExA gave no positive weight to the contribution of the Development towards meeting identified need gave considerable negative weight in the planning balance to both the adverse effects of the Development's GHG emissions on climate change (see paragraphs 4.21 – 4.28 below) and the and perceived conflict with the NPSs' overarching decarbonisation objective."*

2.23 At paragraph 4.9 the secretary of State states:

4.9 The Secretary of State takes the view that the relevant National Policy Statements are clear in setting out the policies which apply for this purpose**. Paragraph 3.1.1 of EN-1 states that: "[T]he UK needs all the types of energy infrastructure covered by this NPS in order to achieve energy security at the same time as dramatically reducing greenhouse gas emissions". Further, paragraph 3.1.3 sets out that: "[T]he IPC [the decision-taker] should therefore **assess all applications for development consent for the types of infrastructure covered by the energy NPSs on the basis that the

Government has demonstrated that that there is a need for those types of infrastructure and that the scale and urgency of that need is as described for each of them in this part.*”*

2.24 In paragraph 4.11 she states:

4.11 *Finally, paragraph 4.1.2 of EN-1 states that, "Given the level and urgency of need for infrastructure of the types covered by the energy NPSs set out in part 3 of the NPS….the [decision-maker] should* ***start with a presumption in favour of granting consent to applications for Energy NSIPs. That presumption applies unless any more specific and relevant policies set out in the relevant NPSs clearly indicate that consent should be refused****."*

2.25 Later in paragraph 4.15 the secretary of State states that:

- *"..****4.15*** *However, in line with paragraph 4.13 above, the Development's impacts on decarbonisation must, in the first instance, be assessed by reference to the specific policies on carbon emissions from energy NSIPs which are contained in the relevant NPSs and which reflect the appropriate role of the planning system in delivering wider climate change objectives and meeting the emissions reduction targets contained in the CCA. In this regard, the Secretary of State has noted that section 2.2 of EN-1 explains how climate change and the UK's GHG emissions reduction targets contained in the CCA have been taken into account in preparing the suite of Energy NPSs. She has also noted the policy contained in paragraph 5.2.2 of EN-1 which sets out (underlining added):*

  "CO2 emissions are a significant adverse impact from some types of energy infrastructure which cannot be totally avoided (even with full deployment of CCS technology). However, given the characteristics of these and other technologies, as noted in Part 3 of this NPS, …… Government has determined that CO2 emissions are not reasons to prohibit the consenting of projects which use these technologies or to impose more restrictions on them in the planning policy framework than are set out in the energy NPSs (e.g. the CCR and, for coal, CCS

requirements). Any ES [Environmental Statement] on air emissions will include an assessment of CO2 emissions, but the policies set out in Section 2, including the EU ETS, apply to these emissions. The [decision-maker] does not, therefore need to assess individual applications in terms of carbon emissions against carbon budgets and this section does not address CO2 emissions or any Emissions Performance Standard that may apply to plant."

2.26 In paragraph 4.15 the Secretary of State states that:

4.16 *This policy is also reflected in paragraph 2.5.2 of EN-2. It is the Secretary of State's view, therefore, that,* ***while the significant adverse impact of the proposed Development on the amount of greenhouse gases that will be emitted to atmosphere is acknowledged, the policy set out in the relevant NPSs makes clear that this is not a matter that that should displace the presumption in favour of granting consent.***

4.17 In light of this, the Secretary of State considers that the Development's adverse carbon impacts do not lead to the conclusion that the Development is not in accordance with the relevant NPSs or that they would be inconsistent with the CCA*. The Secretary of State notes the need to consider these impacts within the overall planning balance to determine whether the exception test set out in section104(7) of the 2008 Act applies in this case. The ExA considers that the Development will have significant adverse impacts in terms of GHG emissions which the Secretary of State accepts may weigh against it in the balance.* ***However, the Secretary of State does not consider that the ExA was correct to find that these impacts, and the perceived conflict with NPS policy which they were found to give rise to, should carry determinative weight in the overall planning balance once the benefits of the project are properly considered, including in particular its contribution towards meeting need as explained below.***

__4.18__ The ExA's views on the need for the Development and how this is considered in the planning balance have also been scrutinised by the Secretary of State. As set out above, paragraphs 3.1.3 of EN-1, and the presumption in favour of the Development already assume a general need for CCR fossil fuel generation. Furthermore, paragraph 3.1.4 of EN-1 states: "the [decision maker] should give substantial weight to the contribution which projects would make towards satisfying this need when considering applications for development consent". The ExA recommends that no weight should be given to the Development's contribution towards meeting this need within the overall planning balance. This is predicated on its view that EN-1 draws a distinction between the need for energy NSIPs in general and the need for any particular proposed development. The Secretary of State disagrees with this approach. The Secretary of State considers that applications for development consent for energy NSIPs for which a need has been identified by the NPS should be assessed on the basis that they will contribute towards meeting that need and that this contribution should be given significant weight.

2.27 This decision therefore, underscores the tension in the current debate on carbon and climate change, but provides a clear direction on how policy should be interpreted. In light of the above, the only certainty we have is the current expression of planning policy and it is against planning policy, not research papers or the passing of time and any changed circumstances, that planning decisions must be made. Unless or until these policy reviews and academic debates finally reach a consensus and manage to influence current planning policy, they should not in my opinion be used to unduly influence proper planning judgements.

2.28 Current policy states that EfW facilities using residual waste do **generate renewable energy and this is urgently required**.

2.29 Current policy (NPS EN 1 July 2011, para 3.3.10) states that as part of the UK's need to diversify and **decarbonise** electricity generation, the Government is committed to increasing dramatically the amount of renewable generation capacity. In the short to medium term, much of this new capacity is likely to be onshore and offshore wind, **but increasingly it may include plant powered by the combustion of biomass and waste** and the generation of electricity from wave and tidal power.

2.30 Then at paragraph 3.4.3 it clearly states that "…***Future large-scale renewable resources is likely to come from the following sources"…..".Energy from Waste*** *(EfW) - the principal purpose of the combustion of waste, or similar processes (for example pyrolysis or gasification) is to reduce the amount of waste going to landfill in accordance with the Waste Hierarchy and to recover energy from that waste as electricity or heat. Only waste that cannot be re-used or recycled with less environmental impact and would otherwise go to landfill should be used for energy recovery. The energy produced from the biomass fraction of waste is renewable…"*

2.31 Current policy states (EN-3 page 17 paragraph 2.5.38) that CO2 emissions may be a significant adverse impact of biomass/waste combustion plant. Although an ES on air emissions will include an assessment of CO2 emissions, the policies set out in Section 2.2 of EN-1 will apply. The IPC **does not, therefore need to assess individual applications in terms of carbon emissions against carbon budgets and this section does not address CO2 emissions or any Emissions Performance Standard that may apply to plant.**

2.32 Current policy (NPS EN1 para 2.2.19) states that while the Government may choose to influence developers in one way or another to propose to build particular types of infrastructure, it remains a matter for the market to decide where and how to build, as market mechanisms will deliver the required infrastructure most efficiently. Against this background of possibly changing market structures, developers will still need development consent for each proposal. Whatever incentives, rules or other signals developers are responding to, the Government believes that the NPSs set out planning policies which both respect the principles of sustainable development and are capable of facilitating, for the foreseeable future, the consenting of energy infrastructure on the scale and of the types and mix necessary to help us maintain safe, secure, affordable and increasingly low carbon supplies of energy.

2.33 Current policy in NPS-EN1 makes it clear that **a broad and diverse range of technologies with differing renewable and low carbon characteristics are required**, and that **decision makers should not consider the relative advantages of one technology over another**. Paragraph 3.3.5 of NPS EN-1 states that "*The UK is choosing to largely decarbonise its power sector by adopting low carbon sources quickly. There are likely to be advantages to the UK of maintaining a diverse range of energy sources so that we are not overly reliant on any one technology (avoiding dependency on a particular fuel or technology type). This is why Government would like industry to bring forward many new low carbon developments (renewables, nuclear and fossil fuel generation with CCS) within the next 10 to 15 years to meet the twin challenge of energy security and climate change as we move towards 2050*."

2.34 To the extent that calculating precise carbon benefits are possible or indeed determinative to the planning outcome of this appeal, I say the appeal scheme will lead to a reduction of CO_2 and greenhouse emissions when compared to fossil fuels and is still preferential to landfilling.

2.35 Notwithstanding the above, Ms Darrie, specifically refers to non-compliance with polices 24 and 36 of the Horsham District Planning Framework 2015, and a number of other policies with which I deal below.

2.36 The first point I would make that Horsham District were fully consulted throughout the course of both the first and second of the appellants applications and they did not raise any express concerns about climate change or that the appellants scheme would give raise to a material planning objection. In their letter dated 1 May 2018, they state in conclusion that:

*" HDC acknowledges that the site is allocated for the proposed use, however on the basis of the information submitted the Council retains some reservations over the impact of the proposed facility in terms of air quality, landscape impact and the potential impact on the North Horsham development. However, **while the Council does not believe that these are sufficient enough to formally object to the application** on material planning grounds, **it will be essential for all of these matters to be suitably addressed and/or controlled by way of conditions or through the Environmental Permit procedures, if permission is granted.** In particular, it is considered essential that conditions are attached which limit the number and times of trips and routes used by heavy goods vehicles accessing the site, secure a high quality level of finish and landscape improvement, provide considerable mitigation of the negative visual impact, ensure air quality is protected, and that any noise impact of the facility is appropriately minimised and managed."*

2.37 So the competent authority in this case, taking their Development Plan as a whole, found no grounds sufficient to object to the appellants application. This could possibly be that paragraph 10.6 in the plan states that:

*" **The development of renewable and low carbon energy is a key means of reducing the district's contribution to climate change.** "*

2.38 And that in the next paragraph (10.7) is states that

*" **Renewable and low carbon energy can encompass a wide range of technologies including combined heat and power (CHP)**; combined cooling, heat and power (CCHP); district heating, **energy from waste**, wind (large and small scale), biomass, solar (thermal and photovoltaics) and heatpumps."*

2.39 In other words the appellants scheme is compliant with these policy references.

2.40 Ms Darrie refers to Policies 24 (which uses the phrase ‘minimise greenhouse gases’) and Policy 36 (uses the phrase ‘maximise the potential for carbon reduction’)) in the Horsham Planning Framework 2015. She does not mention Policy 35 in that Plan but this explicitly refers to Climate Change and amongst the measures set out to minimise climate change impacts it refers to ‘*Measures which reduce the amount of biodegradable waste being sent to landfill..”.*

2.41 Ms Darrie also refers to Policy W12 of the Waste Local Plan, para 1 of the National Planning Policy for Waste, and the NPPF. Again, these policies contain very similar messages in respect of carbon emissions i.e. including mitigating against, or minimising or helping to reduce.

2.42 I see no conflict with these policies. The appellants proposals will minimise/help to reduce carbon emissions when compared to fossil fuels, it is to be preferred over landfill, and the contribution it makes in terms of renewable energy is regarded as low carbon, and this is sufficient in policy terms.

2.43 Finally, I can find no reference in any policy document that states that EfW is a technology that should be rejected in terms of its ability to deliver a valuable source of low carbon renewable electricity, also important to our security of energy supply, nor that it is an inappropriate means for disposing of our residual waste stream. On the contrary, in my opinion there is clear policy support for these policy goals.

The Alternative to EfW - Landfill?

2.44 Ms Darrie concludes at paragraph 9.6.6 of her proof that:

“ The assessment also concludes that, even when the benefits that arise from the recovery of metals and IBA are taken into account, the proposed EfW plant is estimated to be 49,101 tonnes of CO_2e per year worse than sending the same waste to landfill, which equates to the proposed EfW plant being more than 1.47 million tonnes of CO_2e worse than landfill over 30 years of operation.

2.45 The logical conclusion one would draw from this paragraph is that Ni4H are proposing that, in the circumstances of this case, and presumably every other similar EfW facility in the UK, the waste should be sent to landfill.

2.46 If one were to ban EfW as a legitimate means of disposing of residual waste what are the alternatives and consequences? If one were to revert to landfill, this would not policy compliant (at the bottom of the waste hierarchy), it would still generate methane which is 25 times more harmful as a GHG compared to CO2, it would undermine and be contrary to government policy in terms of using our residual waste stream to generate renewable energy, and would mean that we would continue to export the waste, as currently happens, to other countries with all the carbon effects such transport entails, for it then to be used by those countries to be placed in landfill or incinerated for *them* to benefit from the recovery the energy from that waste. Such actions would also undermine what most people regard as the proximity principle, and would undermine WSCC objective of becoming self-sufficient and free from landfill by 2030.

2.47 Landfilling as an alternative is clearly contrary to established Government policy in terms of the waste hierarchy and other planning policies that are geared to securing management of waste according to the hierarchy.

2.48 Then at paragraph 9.6.7, Ms Darrie seems to entice the reader with the possibility that:

> *" Whilst the assessment has been made on the basis that the waste would otherwise go directly (untreated) to landfill, that is not to say that the discarded material might not otherwise be biostabilised prior to landfill or indeed that it might be reduced, re-used, recycled or composted. Therefore, the relative CO2 impact of sending waste to the proposed EfW plant could be significantly worse than modelled,"*

2.49 This is obviously speculation, and whilst in theory these treatment processes are possible, in my opinion (over and above those that are already being provided by the appellant (recycling)), they are not likely (as they would have come forward by the market before now if they were viable or otherwise commercially attractive treatment options), nor able to be deployed at sufficient scale or speed to deal with the problem that faces West Sussex and the Country. Such alternatives would deny the UK the benefits of another low carbon renewable energy resource and additional energy security.

2.50 To speculate about the potential role of other treatment process, when none have come forward in any significant way since the County signalled its willingness to encourage appropriate treatment processes since 2014, is not a realistic way to manage waste arisings in the region, hoping that that at some point the market will develop a solution that is acceptable to Ni4H.

2.51 Also, Government policy reminds us that it remains a matter for the market to decide where and how to build waste management facilities and what technology to use, as market mechanisms will deliver the required infrastructure most efficiently (NPS EN 1).

2.52 Linked to this, Ms Darrie then finally concludes at 10.1.7, that

"…Landfill sits at the bottom of the hierarchy, with 'other recovery'…"

2.53 I assume this is an oversight as clearly 'other recovery' sits above landfill in the hierarchy. The appellants' facility therefore sits above what Ni4H appear to advocate i.e. landfilling. This waste hierarchy which emerged with the Waste Framework Directive, is a tool to show how, depending on where one sits in the hierarchy, one fares in relation to making an effective positive impact on climate change. The appellants scheme with integrated recycling and recovery makes a positive contribution, as intended by this policy.

2.54 So, whilst it can be argued that the advantages of EfW are not *as* attractive as they once were in terms of CO_2 emissions compared to landfilling and when measured against fossil fuel energy generation, they are, still justified, more attractive than the alternative, and still supported in policy terms.

3 CONCLUSION

3.1 In this rebuttal I have addressed the policy issues arising out of the Ni4H position in respect of Greenhouse gases, Ms Darrie’s section 9 in her main proof.

3.2 I have relied upon technical support from Mr Daniel Smyth and his submission at Appendix 1. Also relevant to this issue is the Secretary of State’s decision in the Drax Power station DCO. This gives a clear and current view on how policy should be interpreted in the context of energy facilities and how the carbon debate needs to be dealt with.

3.3 There are other matters that I have not offered a view on in this rebuttal, but these will be dealt with in the normal course of the Inquiry.

APPENDICES

Appendix 1

Additional technical rebuttal note on carbon and electricity generation issues.

A1 Response to NI4H Proof of Evidence Appendix A – "Evaluation of the Climate Change Impacts of the Energy from Waste Plant Proposed for Wealden Brickworks, Horsham – Only Solutions September 2019"

A1.1 Appendix A of Miss Darrie's evidence has been prepared by Messrs Shlomo and Josh Dowen who also operate the UK Without Incineration Network (UKWIN). UKWIN was founded in March 2007 to help individuals and groups to develop the case against incineration. UKWIN is dedicated to helping local groups and individuals campaigning to prevent the building, expansion or ongoing operation of incinerators anywhere in the UK. It is an anti-incineration special protest group.

A1.2 The evidence presented by Miss Darrie is almost identical with that presented in opposition to the Appellant at the appeal enquiry APP/U3935/W/18/3197964 (Land at Thornhill Road, Keypoint Industrial Estate, South Marston, Swindon, SN3 4RY), with the same conclusions being reached.

A1.3 The technical evidence that Miss Darrie relies upon could be applied equally to any energy from waste scheme anywhere in the UK. The carbon intensity of the energy produced by any energy from waste plant depends on the waste it processes, not on the technology. The waste that would be treated at Wealden Works will be a mix of municipal and commercial/ industrial and not significantly different to that treated in many other energy from waste plants across the country. There is nothing site or project specific that makes this argument different or unique to the Wealden 3Rs application.

A1.4 The Appellant has advised the main parties that there was a numerical error in the assessment presented with the planning application, which was corrected and is attached to Mr LeCointe's proof of evidence.

A1.5 The carbon assessment presented by the Appellant makes it clear that the waste composition presented in its calculation is an assumption, as it is bound to be. The carbon intensity of the electricity produced depends on the biogenic composition of the residual waste received by the facility. This is not under the control of the Appellant. The carbon intensity for electricity generation alone is lower than power generation using coal as a fuel, higher than the most efficient CCGT in baseload operation and better than the carbon intensity of OCGT, CCGT operating in peaking mode and gas peaking plants. Its primary function is to recover value from residual waste, as opposed to generating electricity from fossil fuel.

A1.6 The Appellant's calculation makes a comparison with landfill, the assumption being that this was located at Redhill, Surrey. This is one of two operational landfills in the South of England and input to it is restricted. Most of the residual waste arising within the catchment of the 3Rs Facility is now exported to energy from waste facilities in Holland and Germany for processing in energy recovery plants not dissimilar to that proposed for the 3Rs Facility. The effect of developing the 3Rs Facility will be to considerably reduce the vehicle miles travelled in transporting the waste, with attendant benefits in environmental terms, as indicated in the Appellant's calculation. Disposing of the waste arising in West Sussex to landfill is not a practical option, particularly at the site which is the subject of this application.

Waste Composition

A1.7 Waste is heterogeneous and its composition varies between loads, different contracts and seasonally. The actual composition of the waste received will be unknown until it arrives at the facility and can only then be calculated by sampling. Different collection, recycling and treatment schemes make the composition of residual waste more uncertain.

A1.8 In the case of commercial and industrial (C&I) waste, the composition depends heavily on the business of the waste producers from whom the waste is collected, and it cannot be characterised in the same way as MSW. Any calculations will always depend on the waste composition assumed. Only Solutions (OS) have assessed a reduced compostable waste composition, which has the effect of removing biogenic material from the waste stream and increases the relative proportion of fossil derived waste. This has the effect of increasing the carbon intensity of the process. If the reduced compostable waste is achieved via MBT and anaerobic digestion (AD) with energy recovery, that would mean that the biogenic carbon content available from the AD process would have been combusted in a gas engine to generate electricity, thus recovering this energy and releasing biogenic CO2 in an additional, separate step. OS do not include the effect of electricity recovered in this way within their system boundary.

A1.9 The Applicant has obtained chemical compositions and the calorific values (CVs) of sampled waste currently being exported to Europe. It is anticipated that if consented, the 3Rs Facility will be treating waste similar to this. Appendix 1 presents data on the CVs measured.

A1.10 The data presented in Appendix 1 indicate that the average net CV (as received) of the municipal waste is 11.5MJ/kg with a range of 8.6 – 17MJ/kg, and the CV of commercial/ industrial waste is 10.5MJ/kg with a range of 6.1 – 13.6MJ/kg.

A1.11 Waste is bulked up and mixed in large quantities in the waste-fuel bunker to even out the variations in samples supplied, and contracts are monitored to assess the composition of waste-refuse derived fuel supplied to the facility. This ensures that sufficient embodied energy is provided to deliver the electricity output stated by the Appellant. While the 3Rs Facility will have a design point of 23 tonnes per hour at an NCV of 11.5 MJ/kg, the plant throughput can be varied to maintain electrical output of up to 18MW.

A1.12 The furnace control software of such plants can modulate the grate to ensure a constant release of energy to the boiler. This is achieved by increasing the speed of the grate. This provides a constant supply of steam at the pre-set temperature and pressure supplied to the steam turbine and thereby constant electricity production. The net output of the plant of at least 18 MW net (after the parasitic load is deducted) for export will be guaranteed by the plant supplier.

Methodology and landfill comparison

A1.13 The methodology adopted by OS i.e. “Energy recovery for residual waste. A carbon based modelling approach. February 2014” was developed by DEFRA to examine trends. It was not intended to be applied to a specific situation as it has been applied by Miss Darrie. The document itself suggests caution and forewarns at paragraph 202:

As with all modelling the results should be used with a suitable degree of caution. The scenarios have been developed to understand likely trends and should not be considered predictions. There are uncertainties in many of the assumptions and while the model’s sensitivity to these has been examined one should avoid placing too much weight on exact figures but rather focus on the general trends they exemplify.

A1.14 When it comes to the asserted comparison with landfill, OS has drawn heavily from the approach and data in the Defra study. However, OS comes to a different conclusion from Defra, presenting figures that suggest landfilling waste causes far less CO_2e to be emitted per tonne of waste than EfW. This is a reversal of the Defra report conclusions[1], and is clearly a matter for concern in considering the weight to be attached to the OS material.

A1.15 The Defra report is a balanced study, carefully considering the various parameters and uncertainties to which carbon calculations are highly sensitive and looking at the combination of resulting scenarios. It shows in Tables 17-19 that a modern EfW with good efficiency commissioned now or in the near future would have carbon savings compared to landfill in the majority of scenarios. Even in the more pessimistic scenario, the difference would be small: less than 0.1 tCO_2e per tonne of waste treated and well within the uncertainties overall. Taking into account potential biogenic carbon sequestration in landfill, which is described in the study as highly uncertain, an EfW would again still perform comparably in climate change terms with

[1] And similar conclusions about the positive comparison of EfW with landfill reached by consultancy Eunomia

when setting a 2017 emissions performance standard for waste management in London, including considering biogenic carbon sequestration. Eunomia, 2017. Greenhouse Gas Emissions Performance Standard for London’s Local Authority Collected Waste – 2017 Update. https://www.london.gov.uk/sites/default/files/gla_eps_update_2017_final.pdf

Extract in Appendix 3

landfill (Charts 15 and 16) with an increase in biogenic content of the waste over time (achieved, for example, with more separation and recycling of plastics) or with an efficiency improvement that could be offered by Combined Heat and Power.

A1.16 By contrast, OS has taken the Defra study data and repeated its calculations while cherry-picking only the assumptions that most favour landfill in a comparison with EfW.

A1.17 It is also relevant to note that in paragraphs 9.4.8-10, Miss Darrie treats the BEIS marginal carbon intensity factor as a “fossil fuelled generation” factor, which is incorrect. Miss Darrie’s conclusion in 9.4.10 is therefore also strictly incorrect. While the use of this factor provides a comparison with the potential future average carbon intensity of the grid taken as a whole, which is of interest, it does not provide a comparison with fossil fuelled generation, i.e. coal, oil or gas fired power generation, which are all pure fossil fuel generation techniques. The emission factors for coal and gas are in the range 0.786 – 0.990 kg/kWh (coal) as shown in Appendix 2. The efficiency of gas fired power generation is not as good in intermittent operation where gas is used to facilitate the transition to renewables, particularly including wind. These factors are balanced by National Grid to ensure security of power supply. The role of energy from waste in this system is very small, representing less than 1% of UK national CO_2 emissions from combustion in 2015[2].

A1.18 It should of course also be noted that an EfW does not only generate electricity like a wind turbine, solar PV or CCGT, it effectively treats residual waste, which these other technologies do not do. Therefore comparing its carbon intensity with other electricity generators on gross combustion emissions - as Miss Darrie has done - rather than the net waste management greenhouse gas balance, is only part of the process. Additional value is derived from the recovery of both ferrous and non-ferrous metals and secondary aggregate from bottom ash, each of which displaces energy and CO_2 from primary processing and, in the case of metals, from smelting activities.

A1.19 The degree of biogenic sequestration of carbon in landfill is highly uncertain and OS’s use of an assumption of 50% sequestration is at the top of the plausible range. This assumption is described in the Defra report whose methodology OS relies upon as “*a very high level of sequestration (around 50%) which could be considered to be an upper limit*” (p58) and a factor that greatly increases the uncertainty of the analysis. The choice of this assumption very much favours landfill but is not supported by robust information – as acknowledged in the Defra study.

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[2] Latest year available. UK national communication to the UNFCCC. https://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/19603845_united_kingdom-nc7-br3-1-gbr_nc7_and_br3_with_annexes_(1).pdf

And data tables at https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/submissions/national-inventory-submissions-2017#fn1

Extracts in Appendix 4

Consequently, Miss Darrie is wrong to conclude with any confidence in paragraph 9.6.1 that the EfW "would" result in more GHG emissions than the same waste to landfill.

A1.20 Landfill sits at the bottom of the waste hierarchy and the calculation of emissions from landfill is highly uncertain, but methane and other gases are generated and are difficult to capture. Landfill is technically much less advanced and inherently far less reliable than energy from waste technology.

A1.21 The OS report uses a figure at the optimistic end of the range for landfill gas capture rate. It models landfill gas capture at 75% (implying that only 25% is released to the atmosphere) over the entire lifetime of the landfill, including its early filling stages when the landfill cells are not yet capped through to the 100-150 years of its gas-generating phase.

A1.22 Assuming a lifetime landfill gas capture rate of 75%, which the Defra study describes as "a likely maximum under current best practice" that does "depend on continuing maintenance of the extraction system for decades after the economic incentive has ceased" (p63 and p64) favours landfill in a comparison with EfW but is not a performance figure that can be effectively monitored or guaranteed.

A1.23 A further detailed review of waste management in UK landfills published by Golder Associates for Defra in 2014[3] suggested lower rates of lifetime gas capture of around 50-70% were likely (see section 5) and that the CH_4:CO_2 ratio is likely to be 57:43 rather than 50:50 as assumed by OS, both of which factors would increase the GHG emissions assumed for waste in landfill.

A1.24 The biogenic proportion can only be estimated unless the waste composition is known but the total emissions can be calculated with confidence - as can the carbon dioxide equivalent emissions from the recovery of metals and secondary aggregate and for fossil fuelled power generation. It is also true that all of these factors are changing as electricity production is progressively decarbonised. There will always be residual waste that needs to be treated. If more capacity is provided than is needed, this capacity will either not be developed or not operated.

A1.25 It is much more difficult to calculate emissions from the landfill of waste, because the degree of biogenic sequestration of carbon is highly uncertain, as is the quantity of methane generated and the methane capture rate.

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[3] Gregory, R. *et al*., 2014. Review of Landfill Methane Emissions Modelling. Golder Associates, for Defra. http://randd.defra.gov.uk/Document.aspx?Document=12439_WR1908ReviewofMethaneEmissionsModelling.pdf

Extract in Appendix 5

A1.26 Methane has a much higher global warming potential (GWP) than carbon dioxide, around 28 times higher over a 100-year period and 84 times higher over the first 20 years[4] (the most critical period, given the pressing need to mitigate temperature rises that are locked in by current and near future emissions).

A1.27 The effective energy from an energy from waste plant can be increased significantly where there is a use or a use can be attracted for its waste heat. All modern energy from waste plants are able to achieve the R1 index in electricity only mode. To fully demonstrate this, operational data are required, which will only become available when a plant is operational. A design stage R1 application was submitted to the Environment Agency on 8 August 2019. A response from the EA is anticipated in October 2019.

Conclusion

A1.28 It is true that there are emissions of carbon dioxide from an energy from waste plant as in any other combustion process, but its primary purpose is to treat waste and in the process to also recover energy (usually in the form of electricity but also waste heat where there are or may be heat customers). There is a good prospect of heat usage local to Wealden Works, but in the absence of a planning permission for the facility, it is premature to hold realistic commercial discussions.

A1.29 Mr LeCointe addresses government policy but landfill is at the bottom of the waste hierarchy and energy from waste meeting the R1 index sits above landfill and below recycling, reuse and minimisation in the waste hierarchy. Energy from waste represents a very small proportion of UK greenhouse gas emissions and treats waste in a way that electricity generation techniques are unable to do, while recovering useful energy in the process. It is not low carbon like wind, solar or nuclear power, but those technologies do not treat residual waste.

A1.30 Comparing the carbon intensity of electricity generation from EfW with conventional fossil fuelled power generation, EfW is lower than coal, higher than the most efficient base load CCGT but comparable with or lower than less efficient OCGT or CCGT and gas engines operated as peaking plant, depending on fuel composition.

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[4] Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Extract in Appendix 6

A1.31 This is not an appropriate comparison, however, because EfW recovers value from metals and bottom ash and treats waste, which other forms of power generation do not do. EfW represents less than 1% of the UK's carbon dioxide emissions. The 3Rs facility would be less than 2% of the EfW sector emissions.

A1.32 The majority of studies, including the Defra study that OS and in turn Miss Darrie rely upon, conclude that EfW has lower greenhouse gas emissions than landfill. This conclusion is dependent on the study assumptions. The greatest uncertainty is associated with landfill gas generation and leakage rates and assumptions on biogenic sequestration. OS make assumptions that favour the conclusion they reach that landfill is better than energy recovery.

A1.33 Waste composition can be managed to ensure sufficient embodied energy is provided to deliver the electricity output stated by the Appellant. While the 3Rs Facility will have a design point of 23 tonnes per hour at an NCV of 11.5 MJ/kg, the plant throughput can be varied to maintain electrical output of 18MW.

Appendix 1

RDF from Horsham MBT

Sample ID	Sampling Date	Moisture %	Gross CV (as received) MJ/Kg	Gross CV (dry) MJ/Kg	Gross CV (dry ash free) MJ/Kg	Net CV (as received) MJ/Kg	Net CV (dry) MJ/Kg	Ash (as received) %	Ash (dry) %	Volatile Matter (as received) %	Volatile Matter (dry) %	Volatile Matter (dry ash free) %	Total Carbon (as received) %	Total Carbon (dry basis) %	Total Carbon (dry ash free) %
18-12833	08/05/18	40.5	13.9	23.4	27.7	11.9	21.7	9.3	15.6	44.9	75.5	89.4	31.3	52.7	62.4
18-15358-1	19/06/18	44.4	12.3	22.2	29.7	10.4	20.7	14.0	25.2	40.6	73.0	97.6	29.2	52.6	70.4
18-16395	02/07/18	41.8	13.3	22.8	28.3	11.4	21.4	11.2	19.3	42.7	73.4	91.0	30.8	53.0	65.6
18-17057	12/07/18	42.7	13.4	23.3	27.2	11.7	22.2	8.3	14.4	43.7	76.2	89.1	26.1	45.5	53.1
18-17649	18/07/18	29.3	15.3	21.6	25.2	13.5	20.1	10.1	14.3	52.5	74.2	86.5	38.5	54.5	63.5
18-18250	23/07/18	38.2	12.7	20.5	24.1	11.0	19.3	9.3	15.0	46.0	74.5	87.6	25.4	41.1	48.4
18-18870	26/07/18	32.0	15.1	22.2	27.6	13.5	21.0	13.3	19.6	50.5	74.3	92.4	29.0	42.6	53.0
18-19389	06/08/18	33.4	13.3	20.0	28.7	11.6	18.6	20.3	30.4	45.2	67.8	97.4	29.9	44.8	64.4
18-19951	13/08/18	39.4	11.2	18.5	24.0	9.5	17.3	13.9	22.9	43.2	71.3	92.4	26.7	44.1	57.2
18-20558	21/08/18	34.4	11.8	18.0	22.3	10.1	16.7	12.7	19.4	46.9	71.4	88.6	28.2	43.0	53.4
18-22178	10/09/18	41.0	12.6	21.4	28.1	10.9	20.2	14.0	23.8	41.0	69.6	91.3	29.8	50.6	66.3
18-25058	22/10/18	36.4	13.1	20.6	25.7	11.5	19.4	12.5	19.7	46.9	73.7	91.8	25.5	40.1	49.9
18-22178	10/09/18	41.0	12.6	21.4	28.1	10.9	20.2	14.0	23.8	41.0	69.6	91.3	29.8	50.6	66.3
18-26934	03/11/18	38.3	13.2	21.4	24.6	11.6	20.3	8.1	13.1	46.3	75.0	86.3	32.8	53.2	61.2
18-26937	29/10/18	39.9	15.5	25.9	29.3	14.1	25.0	7.1	11.8	47.4	78.9	89.4	25.2	41.9	47.4
18-28757	24/11/18	45.5	13.7	25.1	29.8	11.7	23.4	8.7	16.0	41.8	76.7	91.3	29.1	53.3	63.5
18-28757	01/12/18	45.5	15.3	28.0	31.2	13.2	26.2	5.5	10.1	45.7	83.9	93.3	33.3	61.1	68.0
18-28757	05/12/18	42.9	13.4	23.5	30.7	11.5	21.9	13.4	23.4	41.6	72.8	95.1	30.1	52.8	68.9
19-00324	06/12/18	42.7	15.0	26.1	30.8	13.2	24.9	8.7	15.2	44.2	77.2	91.0	33.2	57.9	68.3
19-00324	10/12/18	33.1	14.4	21.5	25.5	12.7	20.2	10.4	15.5	50.6	75.7	89.6	34.8	52.0	61.6
19-00324	20/12/18	46.3	12.2	22.8	26.1	10.4	21.4	6.8	12.7	41.3	76.9	88.1	28.7	53.5	61.3
19-00324	24/12/18	42.4	15.1	26.2	31.3	13.3	25.0	9.4	16.3	46.9	81.4	97.2	30.0	52.1	62.3
19-00324	02/01/19	42.8	14.4	25.2	29.0	12.5	23.7	7.5	13.1	45.7	79.9	91.9	31.4	54.9	63.2
19-02334	02/01/19	44.5	12.8	23.0	31.1	10.8	21.4	14.3	25.8	38.8	69.8	94.1	29.8	53.7	72.4
19-03311	30/01/19	37.5	15.5	24.8	30.0	13.5	23.1	10.8	17.3	46.7	74.8	90.5	36.0	57.6	69.7
19-03722	12/02/19	34.4	15.6	23.9	28.6	13.8	22.4	10.9	16.7	51.0	77.8	93.4	35.4	54.0	64.8
19-04460	25/02/19	41.6	14.1	24.1	28.4	12.3	22.8	8.8	15.1	44.9	76.8	90.5	30.6	52.5	61.8
19-06088	25/03/19	42.6	12.4	21.5	27.4	10.4	19.9	12.4	21.5	42.1	73.4	93.5	31.2	54.3	69.3
19-06088	26/03/19	43.2	10.8	18.9	26.0	9.0	17.7	15.5	27.3	40.2	70.8	97.4	25.0	43.9	60.5
19-07248	17/04/19	46.5	12.3	23.0	27.8	10.4	21.5	9.2	17.1	38.7	72.3	87.3	28.5	53.2	64.2
19-07796	19/04/19	19.6	18.5	23.0	28.7	17.0	21.7	16.0	19.9	59.0	73.4	91.6	35.7	44.4	55.5
19-07796	25/04/19	35.3	14.1	21.8	27.0	12.5	20.6	12.6	19.4	47.3	73.1	90.8	25.9	40.0	49.6
19-08576	29/04/19	45.2	12.2	22.2	30.2	10.1	20.4	14.6	26.6	38.5	70.2	95.7	34.7	63.4	86.4
19-08700	30/04/19	48.8	11.3	22.2	29.2	9.4	20.7	12.4	24.2	36.0	70.3	92.8	23.9	46.8	61.7
19-08700	04/05/19	47.7	12.1	13.5	30.0	10.2	21.8	12.0	23.0	38.4	73.4	95.2	22.5	42.9	55.7
19-08700	08/05/19	43.3	23.1	23.8	29.8	11.5	22.2	11.4	20.1	43.2	76.2	95.3	30.6	54.0	67.5
19-08899	27/04/19	41.5	13.5	23.1	27.7	11.8	21.8	9.7	16.6	43.2	73.9	88.6	33.1	56.5	67.8
19-09370	11/05/19	31.3	13.3	19.3	30.7	11.6	18.1	25.4	37.0	41.5	60.4	96.0	28.2	41.1	65.2
19-09370	14/05/19	46.6	10.6	19.8	27.3	8.8	18.7	14.5	27.2	34.1	63.8	87.7	25.7	48.1	66.1
19-09467	29/05/19	38.2	10.6	17.2	26.5	8.9	15.8	21.7	35.0	36.8	59.6	91.7	27.6	44.6	68.6
19-10980	07/06/19	40.7	13.0	21.9	27.6	11.1	20.5	12.2	20.5	39.4	66.5	83.7	30.7	51.8	65.2
19-10980	11/06/19	43.0	12.2	21.4	29.6	10.3	20.0	15.7	27.5	31.0	54.4	75.1	28.8	50.5	69.7
19-11462	14/06/19	52.1	10.5	21.8	25.9	8.6	20.5	7.5	15.5	35.5	74.1	87.8	21.9	45.7	54.1
19-15397	25/07/19	49.1	11.6	22.8	27.9	9.7	21.3	9.3	18.4	37.8	74.3	91.1	27.9	54.8	67.1
19-15397	26/07/19	48.1	12.2	23.5	28.0	10.2	21.9	8.4	16.1	39.2	75.5	90.0	29.0	55.8	66.6
19-15762	12/08/19	46.5	13.7	25.7	29.9	11.7	24.0	7.5	14.1	43.0	80.3	93.5	31.0	58.0	67.4
19-176664	04/09/19	22.1	18.6	23.9	33.0	17.0	22.5	21.6	27.7	53.5	68.7	95.0	35.3	45.3	62.6
Average		**40.5**	**13.6**	**22.3**	**28.2**	**11.5**	**21.1**	**12.0**	**20.0**	**43.3**	**72.9**	**91.2**	**29.7**	**50.2**	**63.0**
Maximum		**52.1**	**23.1**	**28.0**	**33.0**	**17.0**	**26.2**	**25.4**	**37.0**	**59.0**	**83.9**	**97.6**	**38.5**	**63.4**	**86.4**
Minimum		**19.6**	**10.5**	**13.5**	**22.3**	**8.6**	**15.8**	**5.5**	**10.1**	**31.0**	**54.4**	**75.1**	**21.9**	**40.0**	**47.4**

RDF from Britanicrest

Sample ID	Sampling Date	Moisture %	Gross CV (as received) MJ/Kg	Gross CV (dry) MJ/Kg	Gross CV (dry ash free) MJ/Kg	Net CV (as received) MJ/Kg	Net CV (dry) MJ/Kg	Ash (as received) %	Ash (dry) %	Volatile Matter (as received) %	Volatile Matter (dry) %	Volatile Matter (dry ash free) %	Total Carbon (as received) %	Total Carbon (dry basis) %	Total Carbon (dry ash free) %
116/912	21/01/16	26.3	11.97	16.24				20.70	28.00	47.90	65.00		28.40	38.50	
114/768	23/01/14	17.1	12.89			11.89		15.50	18.70	61.80	74.60	92.00	32.10	38.70	46.1
114/769	23/01/14	21.1	14.67			13.55		14.10	17.90	59.40	75.20	92.00	33.30	42.20	49.1
114/770	23/01/14	48.5	7.45			6.12		9.50	18.70	39.00	75.70	93.80	16.30	32.00	35.6
563577	22/01/18	40.0						9.70	16.00						
563578	22/01/18	50.0						9.00	18.00						
563579	22/01/18	12.0	13.10	14.90	16.30	12.50	14.30	7.60	8.80	66.00	75.00	82.00	32.00	36.00	60.0
724963	28/11/18	34.0	10.10	15.80	19.70	8.50	13.40	12.00	10.00	47.00	75.00	93.00	29.00	46.00	57.0
Average		**44.54**	**11.64**	**6.14**	**7.20**	**10.51**	**5.54**	**15.48**	**21.62**	**54.64**	**75.10**	**90.56**	**28.54**	**38.98**	**49.56**
Maximum		**50.0**	**14.7**	**16.2**	**19.7**	**13.6**	**14.3**	**20.7**	**28.0**	**66.0**	**75.7**	**93.8**	**33.3**	**46.0**	**60.0**
Minimum		**12.0**	**7.5**	**14.9**	**16.3**	**6.1**	**13.4**	**7.6**	**8.8**	**39.0**	**65.0**	**82.0**	**16.3**	**32.0**	**35.6**

Appendix 2

HOUSES OF PARLIAMENT
PARLIAMENTARY OFFICE OF SCIENCE & TECHNOLOGY

POSTNOTE UPDATE

Number 383 June 2011

Carbon Footprint of Electricity Generation

In 2006, POSTnote 268 outlined the "carbon footprints" of a variety of electricity generation technologies. Footprint data were scarce at that time, particularly peer-reviewed estimates. This POSTnote provides an updated overview of the evidence base in 2011, including estimates from more than 30 peer-reviewed studies.

Overview

- All electricity generation technologies emit greenhouse gases at some point in their life cycle and hence have a carbon footprint.
- Fossil-fuelled generation has a high carbon footprint, with most emissions produced during plant operation. "Carbon capture and storage" could reduce these significantly, though this is unproven at full scale.
- Nuclear and renewable generation generally have a low carbon footprint. Most emissions are caused indirectly, such as during the construction of the technology itself.
- Carbon footprints are sensitive to factors including the technology's operating conditions and country of its manufacture.
- Further studies for the UK would improve the evidence base.

Background

International negotiations and national targets seek to reduce greenhouse gas (GHG) emissions significantly and limit the risks of dangerous climate change. In the UK, the Climate Change Act (2008) requires a reduction in emissions of 80% by 2050 compared with 1990 levels. It also expects Parliament to set successive five-year "carbon budgets" to limit emissions along the way. The fourth budget equates to a reduction in annual emissions of 50% from 1990 levels for the period 2023-27.[1]

The electricity sector has a key role to play in meeting these budgets. Average emissions from electricity generation fell from 718 gCO_2eq/kWh in 1990 to 500 gCO_2eq/kWh in 2008 (Box 1).[2] The Committee on Climate Change (CCC) recommends a further reduction to just 50 gCO_2eq/kWh by 2030 to support achievement of the national budgets.[3]

These figures consider only the emissions caused directly at the point of electricity generation, such as when coal is burnt in a coal-fired power station. To provide a more complete picture of the emissions caused by generation technologies, all stages of their life cycles must be considered. These include their construction and maintenance; the extraction, processing and transport of their fuels (if applicable); and their ultimate decommissioning and disposal.

Box 1. Quantifying Greenhouse Gas (GHG) Emissions

The units 'gCO_2eq/kWh' are grams of carbon dioxide equivalent per kilowatt-hour of electricity generated. Carbon dioxide is the most significant GHG and is produced, for example, when fossil fuels are burnt. GHGs other than carbon dioxide, such as methane, are quantified as equivalent amounts of carbon dioxide. This is done by calculating their global warming potential relative to carbon dioxide over a specified timescale, usually 100 years.

Carbon Footprints

A *carbon footprint* aims to account for the total quantity of greenhouse gas emitted over the whole life cycle of a product or process. It is calculated by the method of *life cycle assessment* (POSTnote 268). In practice, it can be difficult to analyse the complete life cycle because some stages, such as end-of-life management, may be uncertain. The analysis nevertheless provides a more comprehensive view than considering only direct emissions in isolation.

This POSTnote describes the carbon footprints of a variety of electricity generation technologies. Box 2 describes how data have been selected and presented in the figures. Data generally refer to existing rather than future technology, and are international in their scope rather than specific to the UK. The footprints aim to consider all emissions up to and including the process of electricity generation, and ignore:

The Parliamentary Office of Science and Technology, 7 Millbank, London SW1P 3JA; Tel: 020 7219 2840; email: post@parliament.uk www.parliament.uk/post

- downstream emissions, such as those caused by the construction of transmission cables and consumer appliances, and;
- alternatives to direct electricity generation, such as heating technologies and combined heat-and-power plants. These offer further and sometimes alternative ways of providing energy services to consumers.

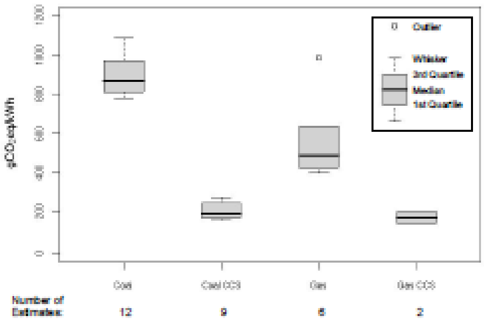
Box 2. Data Selection and Presentation
Carbon footprint estimates are influenced by the conditions and assumptions of each study, including:
- the scope and methodology of the analysis;
- the specific design of the technology within each broad category;
- the country of manufacture of the technology and its components;
- the operating conditions and lifetime of the technology.

These often vary between studies, making it difficult to compare and summarise results. With the aim of providing a pragmatic and impartial summary of the evidence:
- only footprint data from published, peer-reviewed studies were included in the main analysis summarised by the figures. Peer review does not guarantee integrity of results but does mean that studies have been formally and independently reviewed. The data search was international in scope due to a scarcity of peer-reviewed UK studies.
- the data are displayed as box plots[4] to show their spread and to indicate outliers. (Outliers are defined as estimates that reside further than 1.5 times the inter-quartile range from the median.[4]) The number of footprint estimates given in each figure is greater than the number of referenced studies because some studies consider multiple scenarios (e.g. different deployment conditions). The figures do not necessarily reflect true maximum or minimum values or any central tendency for conditions in the UK.
- where there was a lack of peer-reviewed data for the UK, non-peer reviewed studies are quoted in the text but excluded from the figures.

Fossil-Fuelled Technologies

Figure 1 gives carbon footprint data for coal and gas-fired electricity generation, with and without potential carbon capture and storage (CCS) technology. The footprints are dominated by the emissions produced directly as fuel is burnt during plant operation, as opposed to indirectly, such as those arising during construction. Direct emissions are influenced mainly by generating efficiency but also the specific type of fuel (e.g. lignite vs higher-grade coal).

Fig 1. International Carbon Footprints of Fossil-Fuel Electricity



Coal
Within the range of international carbon footprint estimates shown on Figure 1,[5,6,7,8,9,10,11,12] three studies give figures for existing UK plant of 786,[10] 846,[11] and 990[12] gCO_2eq/kWh. In general, the improved generation efficiencies of newer designs of plant (POSTnote 253) give footprints at the lower end of the range shown in Figure 1.

Gas
Figure 1 shows footprint estimates for six European gas generation scenarios from three studies.[7,8,13] The lowest carbon footprints are achieved by the most efficient generation technology – combined cycle gas turbines (CCGT) – which predominate in the UK. One UK study[8] gives a footprint of 488 gCO_2eq/kWh for a CCGT. More recent research from Imperial College London[14] and separately at the University of Manchester[15] is indicating that UK CCGT footprints can be as low as 365 gCO_2eq/kWh for modern technology, but these estimates are excluded from the figure because they have not yet been peer-reviewed and published.

The type and source of gas used for electricity generation can have a significant effect on the carbon footprint. Domestic supplies of North Sea gas are in decline and so imports are increasing, reaching 32% of UK supply in 2009. These come either by pipeline or, as liquefied natural gas (LNG), by ship. Research in the USA estimates that the footprint of electricity from imported LNG is 20-25% higher than from US-produced gas[16,17] due to the additional energy requirement and hence emissions associated with its processing and shipping. This is an active area of research in the UK: recent but unpublished estimates suggest that the use of 100% LNG would increase the footprint of modern CCGTs, though figures vary widely from 4%[14] to 31%.[15]

Natural gas is composed mainly of methane, which is itself a greenhouse gas (Box 3). The footprint of gas generation is influenced by the "fugitive" emissions of methane that arise during its production and transport, for example via pipeline leakages. Researchers have found fugitive emissions to be greater than previously thought in the USA, increasing the footprint of US natural gas.[18] They also found that the fugitive emissions and hence footprint of US "shale gas" (POSTnote 374) to be greater than those of "conventional" gas. Shale gas has gained much recent attention, including in the UK, following its major exploitation in the USA.[19]

Box 3. The Global Warming Potential of Methane
Methane is a more potent greenhouse gas than the CO_2 produced when it is burnt for electricity generation, but it also has a tenfold shorter residence time in the atmosphere so its effect reduces more rapidly.[18] The common practice is to quantify the global warming potential of GHGs relative to carbon dioxide over a one hundred year timescale (Box 1), reflecting the aim of minimising long-term climate change. In this case, the warming potential of methane is generally taken to be 25 times that of CO_2,[20] and each unit of methane is therefore counted as 25 units of CO_2 equivalent. (Recent modelling has suggested that the ratio should be as high as 33.[18]) By contrast, a shorter 20 year timescale gives a global warming potential of methane of 72[20] to 105[18] times that of CO_2.

Carbon Capture and Storage (CCS)
CCS technologies (POSTnote 335) have the potential to reduce emissions from fuel combustion considerably, but

Appendix 3

Table 4-2: Tonnages and Carbon Emissions from Waste Management in Target Years

	Waste Management Activity	Waste Managed (ktpa) in 2015/16	Associated Emissions (ktCO2e) in 2015/16	Waste Managed (ktpa) in 2020/21	Associated Emissions (ktCO2e) in 2020/21	Waste Managed (ktpa) in 2024/25	Associated Emissions (ktCO2e) in 2024/25	Waste Managed (ktpa) in 2030/31	Associated Emissions (ktCO2e) in 2030/31
Residual	Landfill (inc. residues)	707	132	508	100	485	97	444	90
	Incineration	1,530	177	1,635	219	1,594	240	1,653	291
	MBT	365	40	347	45	336	41	1	0
	Total Residual	**2,602**	**349**	**2,491**	**364**	**2,415**	**379**	**2,098**	**381**

Appendix 4

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			
	CO_2 (2)	CH_4	N_2O	CO_2 Amount captured
	(kt)			
1.A. Fuel combustion	393768.62	59.96	11.73	NO
Liquid fuels	160482.20	7.75	7.81	NO
Solid fuels	86099.10	8.21	1.47	NO
Gaseous fuels	143513.13	11.05	1.06	NO
Other fossil fuels(4)	3665.93	2.35	0.27	NO
Peat(5)	8.27	0.02	0.00	NO
Biomass(6)		30.58	1.12	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS			
	CO_2 (2)	CH_4	N_2O	CO_2 Amount captured
	(kt)			
Waste incineration with energy recovery included as:				
Biomass(6)	NE	NE	NE	NO
Fossil fuels(4)	3010.41	2.15	0.24	NO

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	EMISSIONS		
	CO_2	CH_4	N_2O
	(kt)		
1. Waste Incineration	269.93	0.07	0.17
Biogenic [(1)]	NO	0.07	0.15
Municipal solid waste	NO	NO	NO
Other *(please specify)*[(2)]	NO	0.07	0.15
Sewage Sludge	NO	0.07	0.15
Non-biogenic	269.93	0.00	0.02
Municipal solid waste	NO	NO	NO
Other *(please specify)*[(3)]	269.93	0.00	0.02
Clinical Waste	88.86	0.00	0.00
Other (please specify)	181.07	NO	0.02
Chemical waste	181.07	NO	0.02
2. Open burning of waste	11.92	0.29	NO,NE
Biogenic [(1)]	NO	NO	NO
Municipal solid waste	NO	NO	NO
Other *(please specify)*	NO	NO	NO
Non-biogenic	11.92	0.29	NE
Municipal solid waste	11.92	NE	NE
Other *(please specify)*	NE	0.29	NE
Accidental fires (vehicles)	NE	0.03	NE
Accidental fires (buildings)	NE	0.26	NE

5.0 THE 2011 LANDFILL METHANE COLLECTION EFFICIENCY ESTIMATE

5.1 Background

International research supports instantaneous collection efficiencies ranging from 29% to 99% depending on the landfill gas collection infrastructure and the type of landfill cover (Barlaz et al 2009; Barlaz 2012). A lot of theorisation around how many years at what collection efficiency for different stages of the landfill lifetime has been made, but there is no set answer for a landfill lifetime collection efficiency, as it depends on so many factors. As Oonk (2012) pointed out, estimated national average collection efficiencies vary from 45% to more than 70%.

International research findings are generally well aligned with the results of the DIAL studies undertaken in the UK (EA, 2012a). From both the initial and supplementary DIAL studies (Innocenti, 2012 and 2013), methane capture rates ranged between 23% and 91% (Figure 9 and Appendix C). Data from the more recent supplementary DIAL Studies (Sites J, K and L) reported Methane Capture Rates of between 71 and 91%); from the initial DIAL studies (Sites A to I) methane capture rates ranged between 23 and 85%. The categorisation of the Sites is explained below:

- Sites A-C are operational landfills;
- Sites D-I are closed landfills;
  - Site E, F and H are a subset which closed after 2001;
  - Sites D, G and I are a subset which closed before 2001; and
- Sites J-L are operational landfills investigated in the supplementary DIAL study programme with a more detailed meteorological measurement regime.

REVIEW OF LANDFILL METHANE EMISSIONS MODELLING

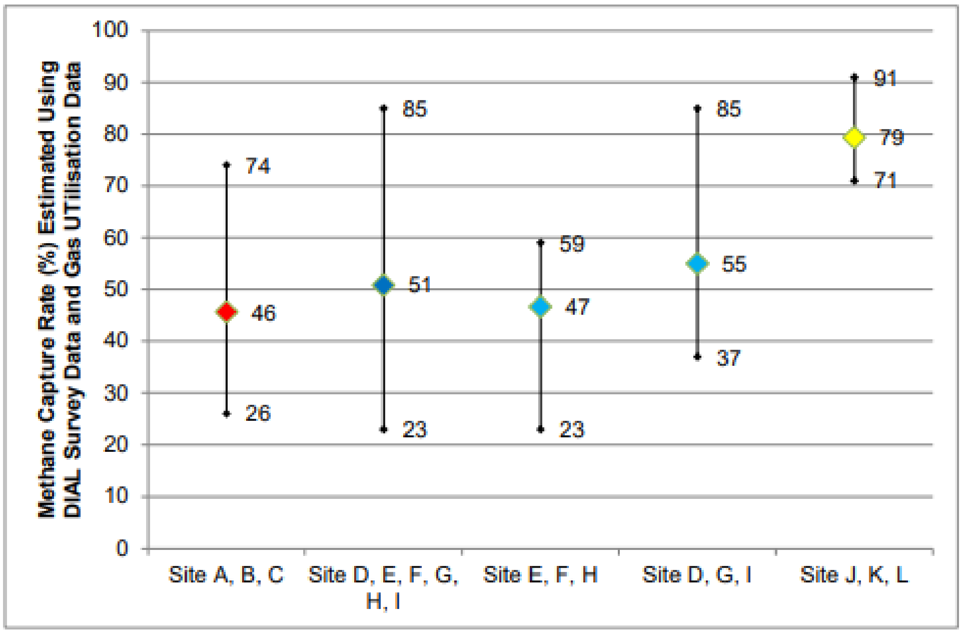


Figure 9: Methane Capture Rate Estimates from DIAL Studies, at Initial Sites (A-I) and Supplementary Sites (J-L)

These observations are generally in line with the UK landfill operators' views expressed during the expert seminar who estimated that once gas collection infrastructure had been installed, the collection efficiency of modern landfills was anticipated to range from 55 – 85% with a possible mean and median of 75% and 70%, respectively.

While the above values are instantaneous collection efficiencies, the aim of this report is to establish a defendable collection efficiency estimate for the Type 3 landfill portfolio within MELMod. This category of landfills contains all the UK organic (i.e. landfill gas producing) waste emplaced since 1979, when the MELMod Type 4 landfills were considered to have ceased filling.

Golder has not attempted to model a single landfill throughout its entire life cycle, and attribute collection efficiencies to each stage, although there is enough information available to do that for an individual site (e.g. Barlaz, 2012). Rather, Golder has taken the view that calibration against the 2011 gas generation estimates for all landfills in Type 3 will give a more realistic lifetime collection efficiency value, as there are many sites in this category and they will all be at different stages of their gassing lives. The collection efficiency Golder aims to establish is not therefore equivalent to the lifetime collection efficiency of a typical modern UK landfill.

Golder approached the aim of establishing the Type 3 portfolio collection efficiency by quantifying the various elements of methane generation and emission (see Figure 1) for the year of 2011, the latest year for which MELMod methane generation numbers are established. The quantification process for each element is described in Sections 2, 3 and 4 of this report. The results were used to establish the estimated collection efficiency as the quotient of methane combusted in engines and flares and the total methane generated by Type 3 landfill sites in 2011 as predicted by MELMod. This is indicated by the left pictogram in Figure 10.

In addition, Golder established the collection efficiency by replacing the MELMod predicted methane generation in 2011 with the sum of combusted methane, fugitive methane emissions and methane oxidised in the landfill cover soil. For the reasons detailed in Section 4.1, the deducted figure for UK fugitive landfill methane emissions is subject to significant uncertainty. This second approach which is not reliant on any methane generation modelling is therefore meant as a confirmatory tool only appraising the sensibility of the MELMod output based approach. This is indicated by the right pictogram in Figure 10.

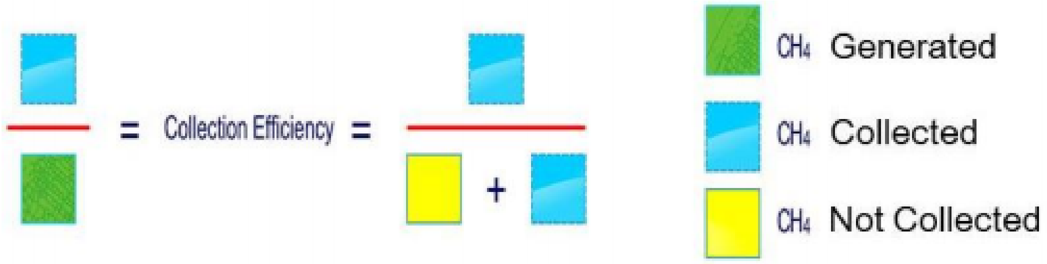


Figure 10: Golder Approach to Establishing 2011 Methane Collection Efficiency (see also Barlaz 2012)

5.2 Collection Efficiency based on MELMod Methane Generation

A theoretical collection efficiency was established as the quotient of the methane combusted in engine and flares in 2011 as derived in Section 3 and the MELMod predicted methane generation from Type 3 landfills in 2011.

This collection efficiency estimates establishes the base case for the sensitivity analysis undertaken in Section 6 is based on the following assumptions:

- MELMod default DDOC assumptions for different waste types;
- Wet degradation rate with k-values of 0.076, 0.116 and 0.694 for slow, moderately and fast degrading waste fractions;
- 57% methane content in landfill gas (if corrected for balance gas);
- A net landfill gas engine electrical efficiency of 36%;
- A flare to engine ratio at UK sites that both combust and flare methane, of 1:11; and
- An average flaring rate of 200 m^3/h at 466 estimated sites that only flare as means of gas control with 50% of the sites flaring continuously (apart from a 5% annual engine downtime), 25% of the sites flaring 50% of the time and 25% of the sites flaring 25% of the time only.

Based on the above assumption, the 2011 collection efficiency for Type 3 landfills in MELMod is 52% as detailed in Appendix E.

5.3 Collection Efficiency based on Area Emission Assumptions

The second approach is meant to provide an independent validation of the values derived above. It excludes any modelling assumptions, but uses the DIAL study findings. Collection efficiency is derived as the quotient of the methane combusted in engine and flares in 2011 (as derived in Section 3) and the sum of combusted methane and estimates for UK landfill area emissions and methane oxidation (as derived in Section 4). Due to the uncertainty surrounding these area estimates, this approach is used to confirm the modelling approach and is not proposed as an alternative methodology.

In line with the first approach the following assumptions are made:

- A net landfill gas engine efficiency of 36%;
- An flare to engine ratio at UK sites that both, combust and flare methane, of 1:11; and
- An average flaring rate of 200 m^3/h at 466 estimated sites that only flare as means of gas control with 50% of the sites flaring continuously (apart from a 5% annual engine downtime), 25% of the sites flaring 50% of the time and 25% of the sites flaring 25% of the time only.

In addition this approach assumes that:

- In the UK operational, temporary capped and permanently capped landfill areas cover 8,211,007 m^2, 12,052,504 m^2 and 562,467,104 m^2, respectively; and
- The emission rates from operational and capped landfill areas are 108 g/m^2/day and 5 g/m^2/day, respectively. These emissions estimates are based on the area weighted average of the Supplementary DIAL studies results for Sites J, K and L (Appendix C).

Based on the above assumption, the 2011 collection efficiency for Type 3 landfills in MELMod is 48% as detailed in Appendix E. Table 20 summarises the findings.

Table 20: Type 3 Landfill Portfolio Collection Efficiency Estimates 2011

Basis of Collection Efficiency Estimate	Collection Efficiency Estimate %
MELMod Methane Generation	52
UK Landfill Area Emission Assumptions	48

While the estimates based on MELMod methane generation predictions are slightly higher than estimates based on landfill area emission assumptions there is good convergence between both approaches. The slightly lower collection efficiency estimate based on landfill area emission assumptions may reflect an over-estimate of landfilled area as the shape files used to deduct them indicate the permitted area of landfills rather than the actual area of waste deposition (Appendix D).

5.4 Instantaneous Collection Efficiency of UK Large Modern Landfills based on Area Emissions Assumptions

The collection efficiency estimate of 52% for the Type 3 landfill portfolio in MELMod are at the lower end of collection efficiencies reported for modern landfills in international research; measured by DIAL in the supplementary survey; and estimated by the UK landfill experts during consultation. Golder therefore applied the methodology detailed above to a subset of 43 large modern UK landfills which generated approximately 30% of the entire electricity from landfill gas exported in 2011. Areas for these sites were estimated using the same methodology as detailed in Section 4 and Appendix D; however, as all sites are situated in England or Wales no scaling up was required. As the subset of sites assessed are highly managed and generating power, only the 1:11 flare to engine ratio was used to determine the flaring parameter associated with these sites.

The same limitations and uncertainties detailed above for Golder's independent validation approach using area emissions applies to this subset, and the findings should therefore be interpreted as a confirmation check against the UK landfill experts' estimates only. As the vast majority of sites in the analysed subset are operational, the estimated collection efficiency is indicative of the operational period of large modern UK landfills, which we propose in our recommendations should be classed as Type 5 landfills (see Section 7). Table 21 details the input parameters for this subset of the UK portfolio.

Table 21: Input Parameters for Sensitivity Test on Subset of UK Portfolio

Parameter	Value	Unit
Electricity generated 2011 from Portfolio Subset	1,605	GWh
Operational Area	2,678,391	m^2
Temporary Capped Area	3,931,468	m^2
Permanently Capped Area	22,076,816	m^2

Processing the above data in the same manner as the entire portfolio estimates based on landfill area emissions resulted in an estimated collection efficiency of 68%. As detailed above, this is a conservative estimate due to the limitations of the use of shape files to derive landfill areas.

Based on this assessment, the 2011 collection efficiency for a subset of modern, large landfill operations in the UK is 68%. This is within the range of the UK expert's assumptions for current operational landfills of 55-85% as detailed above and close to the expected median of 70%.

A collection efficiency of 68% indicates that this subset of 43 large, modern landfills, which producing a third of the electricity from landfill gas in the UK, only consumes approximately 20% of the methane generated in Type 3 landfills in MELMod. This underlines the role that modern, highly managed landfills in the UK play in reducing the overall methane emissions and increasing the UK's landfill portfolio collection efficiency. If a separate set of landfills, similar in design and performance to the subset examined here, were defined as Type 5 (see Section 7 below), according to the sites adopting the standards of IPPC regulations from 2002 onwards, then the collection efficiency of the remaining Type 3 landfills would be lower than the 52% calculated in this report.

While Oonk (2012) showed that estimated national average collection efficiencies vary from 45% to more than 70%, countries that measure their landfill gas collection including, Austria, Denmark, the Netherlands, Finland and Canada have generally much lower national averages in the range of 8 to 37%. Thus if comparing the presumed UK collection efficiency of 52% with these monitored figures, the UK still scores well.

Appendix 6

Table 8.7 | GWP and GTP with and without inclusion of climate–carbon feedbacks (cc fb) in response to emissions of the indicated non-CO_2 gases (climate-carbon feedbacks in response to the reference gas CO_2 are always included).

	Lifetime (years)		GWP_{20}	GWP_{100}	GTP_{20}	GTP_{100}
CH_4[b]	12.4[a]	No cc fb	84	28	67	4
		With cc fb	86	34	70	11
HFC-134a	13.4	No cc fb	3710	1300	3050	201
		With cc fb	3790	1550	3170	530
CFC-11	45.0	No cc fb	6900	4660	6890	2340
		With cc fb	7020	5350	7080	3490
N_2O	121.0[a]	No cc fb	264	265	277	234
		With cc fb	268	298	284	297
CF_4	50,000.0	No cc fb	4880	6630	5270	8040
		With cc fb	4950	7350	5400	9560

Notes:

Uncertainties related to the climate–carbon feedback are large, comparable in magnitude to the strength of the feedback for a single gas.

[a] Perturbation lifetime is used in the calculation of metrics.

[b] These values do not include CO_2 from methane oxidation. Values for fossil methane are higher by 1 and 2 for the 20 and 100 year metrics, respectively (Table 8.A.1).