Advice Note – Stack Height for an Alternative Waste Management Facility at the Rivenhall site

Essex County Council currently has before it a proposal to increase the height of the stack from 35m to 58m, to serve a (yet to be constructed) Integrated Waste Management Facility at the Rivenhall site.

The environmental permit granted in 2017 permits the operation of the following installation:

- a waste incineration plant processing up to 595,000tpa of non-hazardous refuse derived fuel (RDF) and solid recovered fuel (SRF);
- an anaerobic digestion facility with combustion of resultant biogas capable of processing up to 30,000 tpa
- a de-ink paper pulp facility capable of recycling up to 170,000 tpa

In addition the following activities are considered to be directly associated:

- mechanical and biological treatment (MBT) facility capable of treating up to 170,000 tpa;
- materials recycling facility (MRF) capable of processing 300,000 tpa; and
- a waste water treatment plant (WWTP).

The permit requires that a stack of no less than 108m AOD, which equates to 58m above natural ground levels; (henceforth this will be taken as the reference point for expressing stack heights) be provided to receive gaseous output from all parts of the facility, i.e. AD, MBT, de-ink paper pulp facility etc. There is more than one flue within the stack casing.

The detail of how this height has been arrived at is explained within the EA Environmental Permit applications. The first, reference EPR/KP3035RY/A001 which proposed the stack of the height approved by the extant planning consent, i.e. 35m, was refused a permit on the grounds of the proposal not representing Best Available Technique according to the EU Waste Incineration Directive BREF document, but the second EPR/FP3335YU/A001 was granted with a stack of a height 58m above ground level.

Clear Air Thinking has been asked by BPP Consulting to provide expert advice on the following questions:

1.Could a stack of 35m height be sufficient to allow the granting of an Environmental Permit for a CHP facility that could deal with 200,000tpa only? And, if not,

2. what would be the minimum required height of a stack for such a facility likely to be?

A. Introduction

The process of determining the stack height for an industrial installation which requires an Environmental Permit is driven mostly by consideration of the principle of Best Available Techniques, in which the optimal height is a trade off between the environmental benefits and costs. In addition, consideration is given by the Environment Agency to the following:

1. ensuring the relevant air quality standard are not exceeded at identified receptors;
2. any sensitive receptors which may require a greater level of protection and hence a lower level of exposure to be set;
3. the height of the building housing the combustion plant and any other structures of significant height in proximity;
4. operational considerations such as efficiency of heat capture affecting exit temperature of flue gas which in turns affects buoyancy of plume.

Each application is treated on its own merits, with regard to stack height determination. After establishing the minimum height at which air quality standards will not be breached, the principles of BAT are then applied to determine the optimum height, which will be the height at which further increases will bring insufficient benefit (expressed as reductions of pollutant concentrations), relative to the cost of the additional increases in stack height. This is best understood in the form of a graphical plot.

The principal variables in the determination are the mass release rate of the pollutant, NO_x in this case, coupled with thermal buoyancy of the plume, and the costs associated with constructing the stack. Although there is a relationship between waste throughput and the stack emission, it is indirect, being distorted by other factors, such as the calorific value of the waste, which will affect the volume of flue gases and hence buoyancy.

It follows from the existence of multiple factors that feed into the stack height determination process that there is likely to be non-uniformity in stack heights across facilities of a similar type, since the outcome of dispersion modelling will always reflect the site specific context.

B. Specific Application

The Permit Application submitted by Gent Fairhead contains a thorough analysis of the stack height determination process (as Annex 12)[1] from which the Figures in this note have been extracted. That document provides details of modelling carried out for the installation's emissions expressed as the maximum short-term and long-term concentrations of NO_2 applying varying stack heights. (This is the most critical pollutant for this exercise, being the one emitted at the greatest mass release rate.).

Given that regulatory requirements relating to emissions reductions are governed by the need to not impose excessive costs on facility operators, as reflected in the Best Available Techniques (BAT), the exercise included a comparison between the maximum annual mean NO_2 concentration and the 'marginal annualised cost' of constructing the stack to a certain height. This is expressed as a function of the increasing cost of reducing the NO_2 concentration by 0.4 μgm^{-3}, or 1% of the assessment level. The results are presented in Figure 4 of Annex 12 reproduced overleaf.

[1] Available at: http://wrren.co.uk/environmental-permit-application/

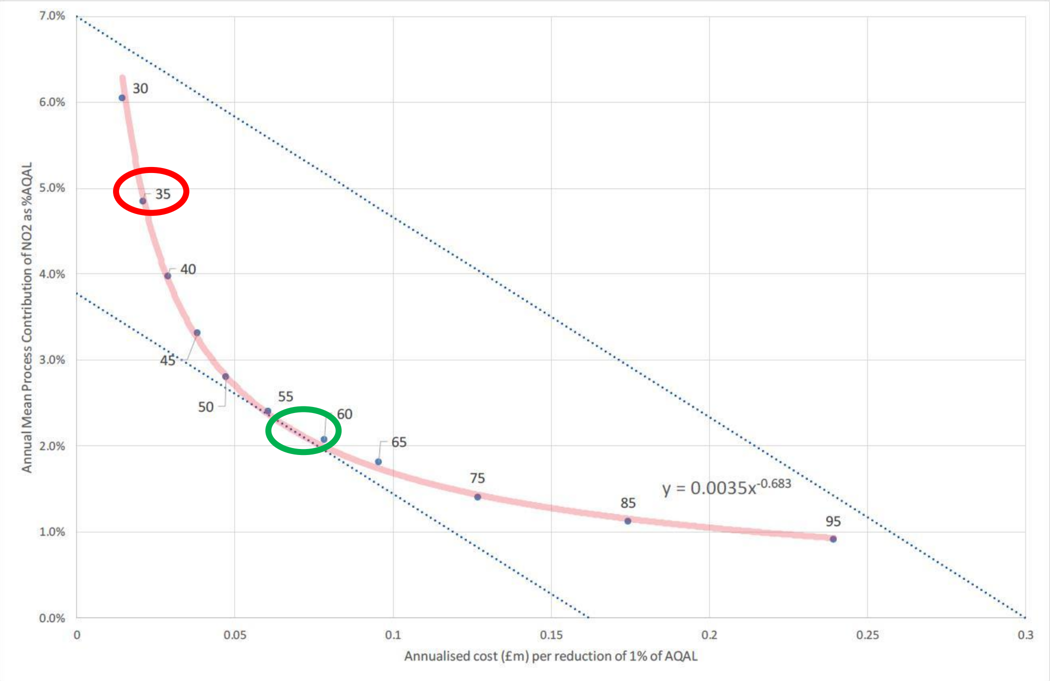

Figure 4 – Annual mean PC against Marginal Annualised Cost, showing interception with 45° line

In simple terms, it demonstrates that the marginal cost increases considerably as the stack height increases beyond 60m (where the curve leaves the dotted line to the right) with relatively little, i.e. marginal, additional benefit in terms of emissions reduction (aka process contribution - PC) . The analysis presented is considered to provide a reasonable justification for the proposed height of 58m. It also demonstrates that significant improvements in air quality impacts can be achieved by moving from the original height of 35m (red ring) to 58m (green ring) at relatively little additional cost.

It should be noted that this height is viable partly because the applicant conceded to adhere to a significantly lower emission limit for NO_x at it leaves the stack of 150 mg m^{-3} through adoption of selective non-catalytic reduction technology (SNCR) involving addition of ammonia/urea to the flue gas[2], at additional cost. If they had not conceded that and worked to the limit prescribed by the Industrial Emissions Directive of 200 mg m^{-3}, as applies to most similar facilities in the UK, the stack would have needed to be significantly taller still.

The Fichtner analysis provided a comparison of stack heights for 34 waste combustion facilities in the UK, presented as a function of throughput (in tonnes per annum) and in the form of a ‘scatter plot’. This appears as Figure 6 in Annex 12 reproduced overleaf. The Rivenhall proposal is shown as a red dot.[3] The purple diamonds represent three other facilities that are also partly below ground level (Hartlebury, Newhaven and Allington).

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[2] 150mg m^{-3} is considered to be the lowest level achievable through application of SNCR.

[3] While the Rivenhall stack has been designed to serve other permitted processes within the IWMF that may give rise to emissions it is considered that the CHP plant contribution will be overriding.

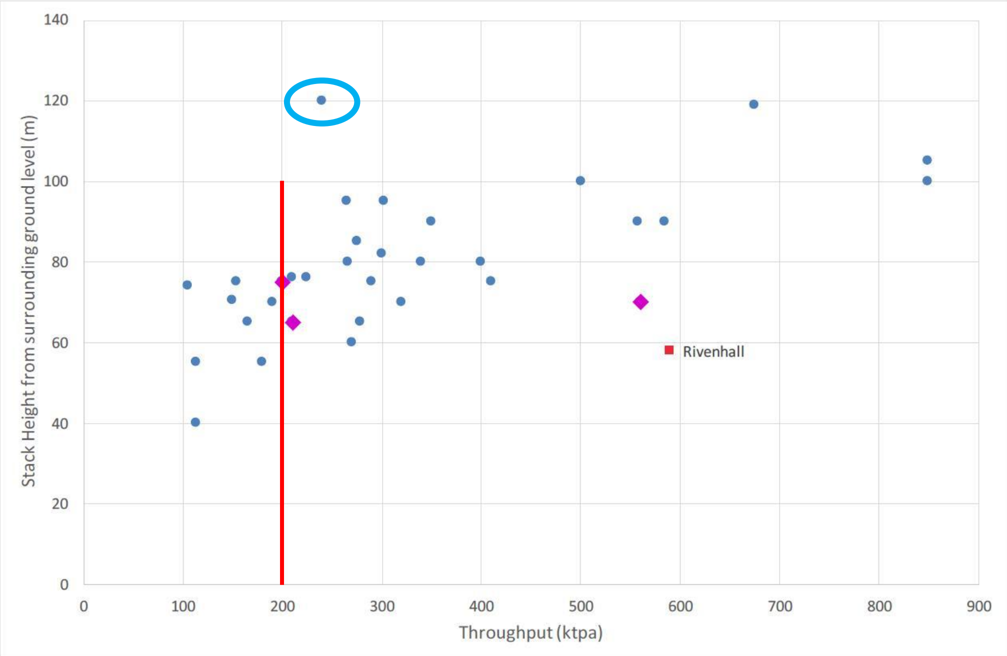

Figure 6 –Stack Height (above surrounding ground level) against Throughput

While, in general, stack height increases broadly with throughput, there is a large spread in the data. All these points in the graphical plot are for waste combustion facilities with an Environmental Permit. It is therefore considered that the principles of BAT are reflected in the approved stack heights, i.e. the cost-benefit considerations have been accounted for.

The fact that Rivenhall is shown as an outlier, i.e. has a significantly lower stack height than the majority of plants, reflects the decision to accept a lower emission limit for NO_x in the flue gas. Nearly all the other facilities included here have an emission limit of 200 mg m^{-3}. Other outliers reflect some particular local circumstances. For example, the plant ringed in blue is the Cornwall EfW plant which has a stack height of 120m, with a throughput of 240,000 tonnes per annum, because a nearby Special Area of Conservation required a greater level of protection from nitrogen deposition.

Figure 6 shows that for facilities with a throughput of 200,000 tonnes per annum (as indicated by the red line), stack heights are in a similar range to Rivenhall and above (c55-80 m). Adoption of a lower NO_x emission limit i.e. to 150 mg m^{-3} through adoption of SNCR would mean the stack height of these other plants could have been lower, although by how much is hard to determine given the scatter in the data points and the absence of a clear fit.

One of the factors that would typically influence the stack height determination is building height, since the building 'downwash' effect on the dispersing plume can increase ground level concentrations considerably. In the case of the current proposal, as for the stack, the building is partially sunk relative to the surrounding land. This reduction in building height relative to the stack is advantageous for dispersion and increases what might be referred to as the effective stack height. The Fichtner analysis has considered the relationship between stack height and building height. This is shown in Figure 7 reproduced overleaf. This shows that while the Rivenhall building/stack height relationship is broadly in line with that of other facilities around the country, the stack is somewhat taller than might be expected for a building of the height proposed.

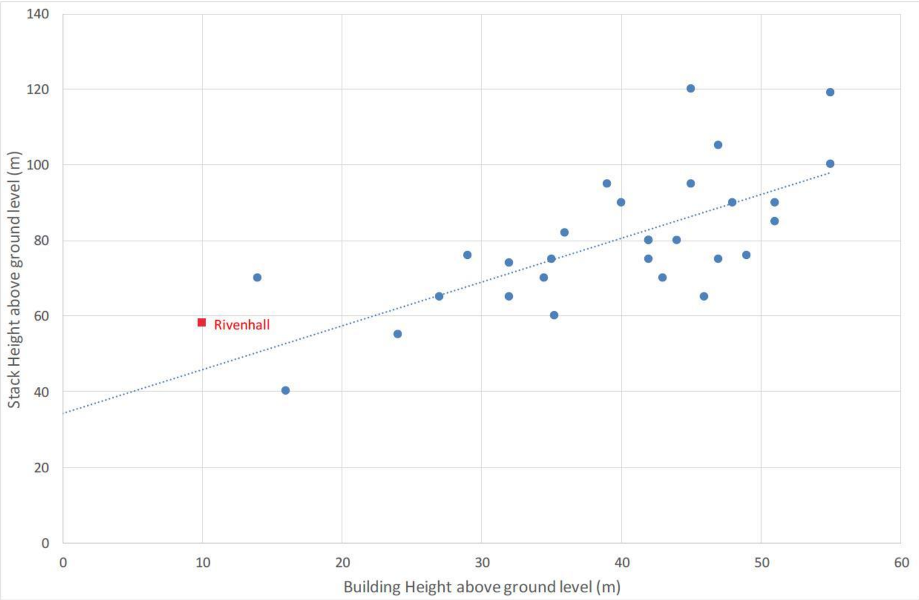

Figure 7 – Stack Height against Building Height above ground level

For any alternative proposal for this site with a reduced throughput, e.g. 200,000 tonnes per annum, it would be reasonable to assume that building height would not be an atypical factor that would distort the stack height determination carried out for Rivenhall.

In March 2018, Fichtner released a note[4] on behalf of Gent Fairhead, which seeks to show that the original permitted facility, with a 360,000 tonnes per annum throughput, but with waste of a higher calorific value, would also require a stack height of 58m. The argument is made that this facility would generate a similar thermal output and therefore the emission (of NO_x) would be also very similar. While this assertion may be valid from this comparison, in the context of this advice note, it only represents one particular combination of the overall set of relevant factors to be considered. If the calorific value is ignored, then the commentary presented here on the possible minimum stack height remains valid and is not contradicted by the Fichtner note. That is to say, there may exist a set of design and operating parameters for which the EA might consider a reduced stack height to represent BAT, although each case is judged on its merits and it is not possible to be definitive.

In summary, the Fichtner analysis tells us that, for an installation with a NO_x emission limit of 200 mg m^{-3}, a stack height of 35m falls outside the realms of what might be considered BAT (as shown in Figure 4) and is therefore unlikely to gain a permit. If, however, a lower emission limit for NO_x of 150 mg m^{-3} was adhered to, as in this case, it is considered that a stack height of 35m might prove to be acceptable to the Environment Agency, but would be at the extreme end of the likely range, as shown by analogy with other installations granted permits.[5]

[4] S1552-0700-0022SMO Rivenhall IWMF – Stack Height and Throughput 6 March 2018

[5] All the plants in the 200,000 tpa range plotted in Figure 6 operate at 200 mg/m^3. If they were operating at 150 mg/m^3, their stacks could have been lower, and therefore the whole set of points would be expected to shift downwards in the scatter plots, in line with the Rivenhall data point.

C. Conclusion

So, in answer to the questions posed:

1.Could a stack of 35m height be sufficient to allow the granting of an Environmental Permit for a CHP facility that could deal with 200,000tpa only?

Such a stack height is at the lower end of a range that is conceivable, but only if a lower emission limit for NO_x of 150 mg m^{-3} were to be adhered to as now proposed for the 595,000 tpa plant.

And, if not,

2. what would be the minimum required height of a stack for such a facility likely to be?

A minimum stack height is hard to define, as it depends on multiple factors, but my expert judgement tells me that it is extremely unlikely that the stack height could be any less than 35m and, in my expert opinion, it is far more likely that it would need to be greater than 40m but not as great as 58m currently proposed.

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