

16 May 2022

Your Reference

18399/APP/2022/411 (DC6 Data Centre)

Our Reference

60671881

London Borough of Hillingdon
c/o Dr Ana Grossinho
Air Quality Experts Global Ltd**Virtus DC6 – Air Quality Assessment Report – Addendum**

Dear Ana,

1. Introduction

During our recent telecon on the above subject, you requested that additional information be provided on behalf of the applicant to support your consideration of air quality matters of the proposed development. You kindly confirmed your expectations in your email dated 4th May 2022, which requested that the applicant submit an addendum to the already-submitted air quality assessment, covering the topics of: (1) consideration of cleaner alternatives to the diesel backup generators; and (2) updated damage cost calculations.

It is acknowledged that your email also contained additional information / requests, but that it is understood that addressing these will not form part of this addendum response, and is intended to be secured via condition.

2. Updated Damage Cost Assessment for Proposed Design

An environmental damage cost calculation was included in the air quality assessment to estimate the equivalent monetary 'damage cost' value of development-related emissions. Following receipt of LBH's feedback since submission of that report, the damage cost calculations have been updated.

These calculations have used information from the same manufacturer specification datasheet for a make / model of generator that could be used for the Proposed Development as was used for inputs to the dispersion modelling (refer to the air quality assessment report). The proposed generator sets would give rise to emissions of air pollutants guaranteed to be below the US Environmental Protection Agency (US EPA) 'Tier 2' standards.

This emission information was used in conjunction with the latest damage cost guidance and tools¹ to consider NO_x and PM_{2.5} emissions associated with the first 20 years of operation of the Proposed Development, in line with your recent email. The assessment considered a start year and price base year of 2022 and used the "Part A Category 3" NO_x and PM_{2.5} damage cost values from the Defra toolkit.

The key emissions-related input parameters used for the calculation are presented in Table 2.1, while the results of the assessment are presented in Table 2.2.

¹ Defra (2021), Air quality appraisal: damage cost guidance. Available at: <https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance>.

Table 2.1 Input Data for Calculation of Development-Related Emissions

Generator Operating Mode	Duration of Operation (minutes)	Frequency per Year	NO _x Emission Rate (g/hour)	PM _{2.5} Emission Rate (g/hour)
Off load testing	20	12	5,814	25
Mains failure test (initial period - maximum load)	20	2	15,096	265
Mains failure test (stable period - normal load)	40	2	9,527	246
Estimated emergency operation (initial period – maximum load)	20	1	15,096	265
Estimated emergency operation (subsequent stable operation)	100	1	9,527	246

Notes:

- Duration and frequency per year are based on best assumptions and experience.
- NO_x and PM_{2.5} emission rates are 'raw emissions' taken from the Caterpillar EM4791 generator set specification datasheet and represent 'per generator' emissions under various load conditions matched to the operating modes. All PM emissions have been assumed to be PM_{2.5}.
- "Off-load" = 10% load; "normal/stable load" = 75% load; "maximum load" = 100% load.
- A total of 2 hours of emergency operation per year due to grid failure. This is considered environmentally conservative as it is expected to over-estimate the frequency and duration of such occurrences in the study area.

Table 2.2 20-year Damage Cost Estimate of Development-Related Emissions

Parameter	Result	Notes
20-Year NO _x Emissions	21.419 tonnes	20-year emissions total for 16 generator sets
20-Year PM _{2.5} Emissions	0.353 tonnes	20-year emissions total for 16 generator sets
20-Year Damage Cost NO _x	£128,049	20-year damage cost (central present value) for 16 generator sets
20-Year Damage Cost PM _{2.5}	£33,495	20-year damage cost (central present value) for 16 generator sets
TOTAL 20-Year Damage Cost	£161,544	-

The total 20-year environmental damage cost has been calculated to be £161,533 at the central present value. LBH advises that this figure should be used to guide the Applicant's investment/expenditure on commensurate measures to mitigate the likely impacts on local air quality, as far as reasonably practicable. Potential alternative technologies / fuels to the proposed generators are discussed in the following section.

Kindly note that, based on experience, the applicant considers 30 years to be a more practical / representative lifespan for the stand-by generators. For comparison we have additionally undertaken the same damage cost calculations, albeit for a 30-year assessment period (Table 2.3).

Table 2.3 30-year Damage Cost Estimate of Development-Related Emissions

Parameter	Result	Notes
30-Year NO _x Emissions	32.128 tonnes	30-year emissions total for 16 generator sets
30-Year PM _{2.5} Emissions	0.529 tonnes	30-year emissions total for 16 generator sets
30-Year Damage Cost NO _x	£179,345	30-year damage cost (central present value) for 16 generator sets
30-Year Damage Cost PM _{2.5}	£46,913	30-year damage cost (central present value) for 16 generator sets
TOTAL 30-Year Damage Cost	£226,258	-

Applying a 30-year assessment period for the calculations returned a total 30-year environmental damage cost of £226,258 at the central present value.

3. Consideration of Alternatives to Diesel Stand-by Generators

The state of technology in the field of stand-by power generation is acknowledged to be constantly progressing. The Applicant advises that it is continuously reviewing the possible technologies that can be used to support its data centres in the event of the mains power not being available.

To support the evaluation of the current proposals for the provision of 16 diesel generator sets at the Site, a high-level desktop review of other potential technologies has been undertaken.

3.1 Lower-emission Diesel Generator Sets

In terms of UK regulations, the European Industrial Emissions Directive (IED)² was transposed into UK law by the Environmental Permitting (England and Wales) Regulations in 2010³, which were subsequently updated in 2016⁴. These regulations consider *inter alia* facilities which operate combustion plant with a cumulative total rated thermal input greater than 50 MW. Taking into account the aggregating rules of these regulations and the number and capacity of the generator sets envisaged for the Proposed Development, this threshold would likely be exceeded. The generator sets would also need an environmental permit issued by the Environment Agency (EA), prior to them being operated.

Diesel engines are specifically exempted from complying with the emission limits set out in Annex V of the IED and, in such instances, the EA may defer to an alternative appropriate source of emission limits or apply a derogation when compiling permit conditions.

The EA's most recent published draft of its 'Data Centre FAQ' document⁵ states that its expectation is that combustion plant for new data centre generators would be that the latest emission standards for stand-by plant are applied, unless otherwise justified under BAT (Best Available Techniques). The minimum appropriate standards are the 'TA-Luft 2g' or 'Tier 2' US EPA standards with guaranteed emissions.

The generator sets proposed by the Applicant, and considered within the submitted air quality assessment report, would give rise to emissions of air pollutants guaranteed to be below the US EPA Tier 2 standards.

There are no Tier 3 (more stringent than Tier 2) emission standards for the size of non-road diesel engines used in the proposed generator sets. The current most stringent standards are Tier 4. So-called Tier 5 standards are in the process of being developed by the California Air Resources Board and would not hold equivalent (national-level) status unless a corresponding regulation were adopted by the US EPA.

A comparison of the proposed generator set emission performance (Tier 2) and Tier 4 standards is presented below.

Table 3.1 Comparison of Emissions Performance

Parameter	Units	CO Emissions	NO _x Emissions	PM Emissions
US EPA Tier 2	g/kW-hr	3.5	6.4	0.20
US EPA Tier 4	g/kW-hr	3.5	0.86	0.04

The figures shown in Table 3.1 suggest that Tier 4 compliant generator sets could result in reductions in NO_x and PM emissions from the currently proposed option in the order of 87% and 80% respectively.

A damage cost calculation using the same main parameters as that for the primary design proposals described in Section 2 has been done, but assuming the NO_x and PM_{2.5} reductions referred to in the above paragraph are achieved for all 16 generators at all times. The key outputs of the calculations are presented in Table 3.2, and offer a clear improvement compared to the corresponding outputs from the Tier 2 generators' performance. Note that the 20-year damage cost is reduced but not completely eliminated. It is also noted that the cost premium for the purchase and ongoing operation and maintenance of just a single Tier 4 diesel generator (compared to an equivalent Tier 2 generator) is likely to exceed the calculated damage cost presented in Section 2.

Table 3.2 Damage Cost Estimate for Tier 4 Diesel Generators

Parameter	Result	Notes
20-Year NO _x Emissions	2.878 tonnes	20-year emissions total for 16 generator sets
20-Year PM _{2.5} Emissions	0.071 tonnes	20-year emissions total for 16 generator sets
TOTAL 20-Year Damage Cost	£23,906	Central present value for 16 generator sets

² European Parliament and Council (2010), Directive 2010/75/EU of 24 November 2010 on Industrial Emissions.

³ H.M. Government (2010), The Environmental Permitting (England and Wales) Regulations 2010.

⁴ H.M. Government (2016), The Environmental Permitting (England and Wales) Regulations 2016.

⁵ Environment Agency (2021), Data Centre FAQ Headline Approach (Draft version 10.0 – Release to Industry).

Diesel-fuelled generator sets with improved NO_x and PM performance are, therefore, available in the market, however cost-benefit considerations compared to 'standard' models within this intended application could affect the viability of the Proposed Development.

3.2 End-of-pipe Emission Abatement

Adopting 'end-of-pipe' emissions abatement systems such as selective catalytic reduction (SCR) to reduce NO_x emissions to atmosphere is an option that has been considered. Current SCR systems could reduce NO_x emissions by more than 90% (to achieve 'Tier 4' emissions performance, as referred to above), though for the type of application proposed (where generator sets are only run for relatively short periods of time), the actual efficiency will depend on how quickly the SCR system reaches its operating temperature following generator start-up.

It is typical for environmental permits to require any abatement system to be fully effective within 20 minutes of start-up of the process. This will almost certainly be achieved when the generator sets are started and immediately run under full/high load (probably in less than 20 minutes), however during off-load testing the SCR system would take longer to warm up and become effective.

A damage cost calculation using the same main parameters as that for the primary design proposals described in Section 2 has again been done, but assuming more modest NO_x reductions (and no PM_{2.5} reductions) are achieved for all 16 generators at all times. The NO_x calculations in this scenario have considered no reduction (from Tier 2 levels) for: (1) off-load testing; (2) the first 20 minutes of mains failure test; and (3) and the first 20 minutes of emergency operation. For other operating conditions, an 86% reduction in NO_x emissions has been applied.

The key outputs of the calculations are presented in Table 3.3, and represent an improvement compared to the corresponding outputs from the Tier 2 generators' performance. The 20-year damage cost is obviously also correspondingly reduced. As with the full Tier 4 specification generators described in Section 3.1, the cost premium for the purchase and ongoing operation and maintenance of just a single emissions abated diesel generator (compared to an equivalent Tier 2 generator) is likely to exceed the calculated damage cost presented in Section 2.

Table 3.3 Damage Cost Estimate for SCR-equipped Diesel Generators

Parameter	Result	Notes
20-Year NO _x Emissions	13,502 tonnes	20-year emissions total for 16 generator sets
20-Year PM _{2.5} Emissions	0.353 tonnes	20-year emissions total for 16 generator sets
TOTAL 20-Year Damage Cost	£114,213	Central present value for 16 generator sets

Due to the technology and equipment employed, plus the proposed configuration of the generator sets at the Site, such abatement systems would complicate and increase on-site systems / infrastructure (with commensurate additional capital cost, maintenance and operational requirements) which have not been factored into the current proposals.

3.3 Hydrotreated Vegetable Oil Fuel

The Applicant has investigated Hydrotreated Vegetable Oil (HVO) as a potential alternative fuel for the proposed generator sets. HVO is a low-carbon, fossil-free and more sustainable alternative to conventional fossil diesel.

HVO claims many environmental credentials but from the work that the Applicant has completed with generator manufacturers, the reduction in emissions is considered small on modern electrical generators but can have much greater impact on old generators. On modern electrical generators an approximate 10% reduction in emissions is understood to be achievable. The Applicant does not, however, currently hold verified emissions performance data for HVO use in generator sets of the size required to serve the Proposed Development, so no damage cost calculations for this option have been considered.

The main reason for not putting this fuel forward for the Proposed Development at present is that several of the generator manufacturers have not yet concluded their own testing and certifications. Whilst they do confirm that the generators will operate on HVO, because of the critical nature of the Applicant's business, which is classed as key infrastructure under utilities and communications, fully-tested and certified generator sets are required.

3.4 Gas-fuelled Generator Sets

Natural or liquid petroleum gas (LPG) fuelled generator sets are available in the market, and would give rise to lower NO_x and PM emissions compared to equivalent diesel generators. Based on EMEP/EEA emission factors⁶ for reciprocating engines, opting for gas-fuelled as opposed to diesel generator sets could be expected to result in like-for-like reductions in NO_x and PM emissions in the order of 86% and 93% respectively. We interpret these reductions to be achievable down from a 'starting point' of a diesel generator *without abatement* (indicatively a 'Tier 2' compliant unit).

Gas-fuelled generator sets have, therefore, been investigated as a potential option for the Proposed Development. However, there are three main considerations which restrict the feasibility of gas-fuelled generator sets for the proposed application. These considerations are:

- **Load acceptance** – Diesel engines are able to accept a load after approximately 15 seconds from starting, whereas gas engines would require approximately 5 minutes to reach the same condition. In the proposed application, where the generator sets are relied upon to provide immediate back-up power supply to the data centre in the event of a mains power failure, the significantly longer period to reach a point where load may be applied to the gas engines would compromise the integrity of the data centre's power supply to maintain essential operations.
- **Load stability** – Gas engines require a stable load to be applied to them. The Proposed Development includes several items of sizable mechanical equipment, potentially starting or stopping (i.e. a non-stable load profile). This variable load profile could currently not be feasibly accommodated by gas engines.
- **Fuel supply** – The nature of the proposed application of the generators means that they will require a secure supply of fuel for operation in the event of a mains power failure.
- **Where piped natural gas is used to support backup power systems**, the risk of the natural gas supply being interrupted at the same time as the electricity mains supply (e.g. due to natural disasters, domestic industrial action or terrorism) means that sufficient resiliency is not guaranteed to satisfy the mission critical IT operating requirements of the data centre.
- **In order to achieve security of supply for gas fuel**, there would be a requirement for a large quantity of gas to be stored under pressure on site in a large vessel/s. This would likely represent a potential major hazard installation, which would introduce both on-site and public health and safety risk considerations. Additionally, the level of potential risk posed by the on-site storage of such a large quantity of pressurised gas, could undermine the fundamental integrity of the data centre operation itself.

For completeness, a damage cost calculation using the same main parameters as that for the primary design proposals described in Section 2 has been done, but assuming the NO_x and PM_{2.5} performance for all 16 generators, at all times aligns with that for natural gas fuelled engines. This has been estimated simply by applying the relevant NO_x and PM reductions described above (based on the like-for-like differences published in the EMEP/EEA Guidebook) to the 'base case' (Tier 2 diesel generator) emissions. The key outputs of the calculations are presented in Table 3.4, and offer a clear improvement compared to the corresponding outputs from the Tier 2 generators' performance. Note that the 20-year damage cost is reduced but not completely eliminated. It is also noted that the cost premium for the purchase and ongoing operation and maintenance of just natural gas fuelled generators (compared to an equivalent Tier 2 generator) is likely to significantly exceed the calculated damage cost presented in Section 2.

Table 3.4 Damage Cost Estimate for Natural Gas Fuelled Generators

Parameter	Result	Notes
20-Year NO _x Emissions	2.999 tonnes	20-year emissions total for 16 generator sets
20-Year PM _{2.5} Emissions	0.025 tonnes	20-year emissions total for 16 generator sets
TOTAL 20-Year Damage Cost	£20,271	Central present value for 16 generator sets

Gas-fuelled generator sets were investigated by the Applicant during the project development stage, but were deemed technically incompatible with the intended application.

⁶ EMEP/EEA (2019), Air Pollutant Emission Inventory Guidebook, Chapter 1.A.4 Small Combustion.

3.5 Hydrogen Gas-fuelled Generator Sets

The adoption of hydrogen gas as a generator fuel has been considered. This would largely eliminate PM emissions, and would be expected to significantly reduce (though not completely eliminate) NO_x emissions. The potential for thermal-NO_x formation to occur during combustion would remain, similar to fossil fuel combustion. It is understood that this can be managed through adjustments to combustion controls, however this would likely be at the expense of power output and generator performance⁷.

Additionally, hydrogen gas is difficult to store over long periods, which makes its availability for on-demand use in the event of a mains power outage challenging.

Methods of generating hydrogen on-site are available, but these also have potentially significant trade-offs. For example, on-site generation using grid-supplied electricity has high conversion losses and the current carbon intensity of grid-supplied electricity is such that it is not necessarily considered a sustainable / low-carbon solution. Hydrogen reformer technology (where hydrogen gas is produced from chemical reformation of natural gas) would be constrained by issues relating to the reliability of gas supply referred to in the previous sub-section.

Insufficient data are available to enable an accurate damage cost calculation to be completed for this option.

Overall, hydrogen-fuelled generator sets were deemed to be technically incompatible with the intended application.

4. Conclusion

This addendum seeks to set out an updated air quality damage cost assessment for the primary proposed design in respect of stand-by diesel generator sets to be implemented by the Proposed Development. Potential alternative technologies and fuel types have been evaluated, with corresponding emission (and damage cost) reductions estimated, where possible.

The assessment concludes that the calculated damage cost for the primary proposed design is significantly less than that which would be associated with the adoption/implementation of most of the alternatives evaluated. Therefore the cost-benefit of pursuing a full (16 generator) adoption of an alternative at this stage does not appear to be viable.

However, LBH has indicated its intention to nonetheless seek commitment (secured through condition) to a staged review and improvement programme, whereby opportunities to sustainably reduce emissions are reviewed at milestones during the life of the Proposed Development. The details of this will be determined and agreed in due course, however the applicant wishes to raise its expectation that such future reviews would be informed by cost-benefit analyses, and that replacement of generator sets with significant useful life remaining would not be a default position of any improvement programme (rather that a holistic assessment of sustainability be considered at that time).

Yours sincerely,



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⁷ Lewis, A. C. (2021), Optimising air quality co-benefits in a hydrogen economy: a case for hydrogen-specific standards for NO_x emissions, *Environ. Sci.: Atmos.*, 2021, 1, 201.