POWERFUEL

Portland energy recovery facility

Environmental statement
Second addendum
Appendices

3.1

3.1

Air Quality Impact of Operation of Emergency Diesel Generators

FICHTNER

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Annex B to Schedule 5 Request – Air Quality Impact of Operation of Emergency Diesel Generators

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Document approval

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Contents

1 Introduction

The Portland Energy Recovery Facility (ERF) will include an Emergency Diesel Generator (EDG). This will be required to safely shutdown the ERF in the event of a loss of grid connection to maintain operation of the abatement control systems. This event would typically occur for no more than 4 hours. In this operating scenario, the EDG would need to operate at 100% load following the initial loss of grid connection. However, as the shutdown sequence progressed the abatement and control systems would be reduced in operation so that the EDG could operate at a reduced load prior to be switched-off until the grid connection could be reinstated to enable the ERF to commence the start-up sequence with power for start-up being provided by the grid connection, not the EDG.

A representative of the port has informed us that there have been three grid outages at the port over the last six years, so it is unlikely that the EDG would operate more than once every year. Given the low likelihood of an emergency, it is the regular testing that should be the main consideration in the context of the impact of the EDGs.

2 Technical characteristics

The thermal capacity of the EDG will be subject to detailed design and procurement of the engines by the technology provider. However, taking into consideration the parasitic load of the ERF (2.2 MWe), and a conservative electrical efficiency of 30%, the EDG will have a thermal capacity of approximately 7.3 MWth. Therefore, the EDG will not be subject to the Large Combustion Plant requirements of the IED but will be subject to the requirements of the Medium Combustion Plant Directive (MCPD) which applies to combustion plant with a thermal capacity of less than 50 MWth.

The MCPD states:

> *"Member States should be able to exempt medium combustion plants used in cases of emergency and operated during limited time periods from compliance with the emission limit values set out in this Directive."*

Furthermore, the TA Luft guidance for new and existing liquid fuelled engines (which the EA referred to in the Schedule 5 request) states:

> *"limits do not apply to emergency engines …"*

On this basis, it is understood that the emission limit values within the MCPD and the TA Luft guidance do not apply to the EDGs. However, the EDG would be designed to achieve the emission limit values in the MCPD after the initial warming up period.

3 Modelling methodology

The air quality impact of the operation of the EDG has been quantified using the ADMS dispersion model. This is the same model as used to carry out the dispersion modelling of the emissions from the main stack as detailed in the Dispersion Modelling Assessment (DMA) which was submitted as Appendix D of the EP application and as Appendix D2 of the Environmental Impact Assessment to support the planning application.

The principal inputs into the model with respect to emissions to air from the EDG are presented in Table 1 and Table 2. This data has been calculated from a datasheet for a 2.28 MWe diesel generator, similar to that which would be installed at site.

Table 1: Stack source data

Item	Unit	Value
Stack Data		
Height	m	8
Internal diameter	m	0.525
Location	m, m	369640, 72343
Flue Gas Conditions		
Temperature	°C	450
Exit moisture content	% v/v	7.7%
Exit oxygen content	% v/v dry	9.5%
Reference oxygen content	% v/v dry	15.0%
Volume at reference conditions (dry, ref O_2)	Nm^3/s	4.94
Volume at actual conditions	Am^3/s	7.36
Flue gas exit velocity	m/s	34.0

Table 2: Stack emissions data

Pollutant	Conc. (mg/Nm^3)		Release rate (g/s)	
	Unabated	Abated	Unabated	Abated
Oxides of nitrogen (as NO_2)	894	200	4.415	0.938
Notes: All emissions are expressed at reference conditions of dry gas, 15% oxygen, 273.15K. Unabated emission concentrations of oxides of nitrogen were provided by the engine supplier.				

As set out above, the EDG would operate under the following scenarios:

- For testing and maintenance purposes – expected to be tested every two weeks for less than 30 minutes; and
- In the event of loss of grid connection to maintain operation of the abatement and control systems to enable a safe shutdown the ERF – assumed to be typically no more than 4 hours for any one event.

In each case, the EDG would gradually 'warm up' over approximately 5-7 minutes. During this period the loading on the EDG would gradually increase until full load. Following this the EDG would operate at full load for the testing which would last up to 20 minutes. In total the EDG would be operational for up to 30 minutes.

Although the emission limit values in the MCPD do not apply to the EDG as it would operate for less than 500 hours in any calendar year, the EDG would be able to achieve the emission limits set out in the MCPD following the initial 'warm up' period. During the 'warm up' period the emissions of NOx would be significantly higher until the combustion system has settled, but the volume of air flow would also be increasing until full load is reached. It is not possible to account for this short term variability in loading in the dispersion modelling. However, the higher emissions during this 'warm up' period have been accounted for by conservatively calculating the emissions during this initial period by multiplying the emission concentration by the volume when operating at full load.

3.1 Testing

When modelling the impact of testing it has been assumed that:

- The EDG operates at full load for the entire 30 minutes of testing;
- The emissions of NOx during the first 10 minutes of testing are at the unabated level, while the remaining 20 minutes of testing are at the abated level;
- For the remaining 30 minutes of the 1-hour period the engine is off – i.e. no emissions; and
- Testing could start at any time between the hours of 08:00 and 17:00.

To allow for this the model has been set up with the unabated release rate and the results factored before comparison with AQALs. A time varying emission profile has been included in the model to ensure that the EDG is only modelled to operate between the hours of 08:00 and 18:00. This profile has been applied for all days of the year. The testing envelope is significantly longer than would be anticipated as this would normally occur at a set time. However, this ensures that the model assumes operation during the worst-case weather conditions which are likely to occur given the testing constraints of normal working hours.

3.2 Emergency Operation

When modelling the impact of the emergency operation it has been assumed that:

- The EDG operates at full load for the first hour, followed by 70% loading for the second hour, and 50% loading for the remaining 2 hours of emergency operation;
- The emissions of NOx during the first 10 minutes of operation are at the unabated level;
- For the remaining time, emissions are at the abated level; and
- Emergency operation could occur over any 4-hour rolling period in the year.

Due to the shorter stack on the EDG it is not appropriate to use the same grid resolution as for the modelling of the main stack of the ERF. Therefore, a nested grid has been incorporated into the grid used for the DMA. The modelling domain grid has the following parameters. The grid spacing of the finer resolution area covering the site is less than 1.5 times the stack height.

Table 3: Modelling Domain

Parameter	Large Grid	Fine Grid
Grid Spacing (m)	60	7.5
Grid Start X	366760	369175
Grid Finish X	370960	369925
Grid Start Y	72860	73775
Grid Finish Y	75860	74525

All other model inputs are as set out in the DMA.

4 Assessment levels

This analysis has considered the impact of the testing and emergency operation of the EDG. This has considered both the impact on human health and ecology.

The assessment level for the protection of human health considered in this analysis is:

- The 1-hour AQAL for nitrogen dioxide of 200 µg/m^3, which can be exceeded 18 times per year.

The assessment level for the protection of ecosystems considered in this analysis is:

- The maximum 24-hour Critical Level for oxides of nitrogen of 75 µg/m^3 which is applicable at ecological sites.

The impact of testing and emergency operation has not been considered in relation to the annual mean assessment levels as the contribution to annual mean impacts would not be significant due to the limited period of operation.

The EA's "guidance for air quality assessments for specified generators"[1] is designed to assess the situation where a generator only operates occasionally but in every year. This guidance requires an applicant to carry out statistical analysis if short term predictions show that there are a number of hours for which the impact exceeds the environmental standard at a sensitive receptor over the modelled operating envelope. The guidance states that *"Where the probability exceeds*

- *1% or less – exceedances are highly unlikely*
- *less than 5% – exceedances are unlikely as long as the generator plant operational lifetime is no more than 20 years*
- *more than or equal to 5% – there's potential for exceedances and the regulator will consider if acceptable on a case by case basis."*

[1] Environment Agency, Specified Generators: dispersion modelling assessment, at https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment.

5 Results - testing

5.1 Human health

Table 4 presents the maximum predicted impact at any grid point when testing. Results have been presented for each of the 5-years of meteorological data considered.

The 1-hour AQAL does not apply where public would not be expected to have regular access. Therefore, whilst this analysis has considered the point of maximum impact the AQAL does not necessarily apply at this point.

The AQAL is set as nitrogen dioxide whilst the model was used to predict concentrations of oxides of nitrogen. To allow for comparison to the AQAL, it has been assumed that 35% of the NOx will convert to nitrogen dioxide[2]. The EA's Air Quality Modelling and Assessment Unit (AQMAU) has stated that this is likely to be an overestimate and close to the stack, where the main impacts occur, the conversion is more likely to be 15%[3].

Table 4: Impact of Testing - Human Health

Weather data	Maximum 1-hour PC as % of AQAL
2014	226%
2015	227%
2016	237%
2017	233%
2018	246%

As shown, the maximum 1-hour nitrogen dioxide process contribution is predicted to exceed the AQAL. However, this conservatively assumes that testing occurs during the worst-case weather conditions for dispersion in the hours of 08:00 and 18:00 (i.e 3650 hours in each year). Testing would occur on a 2-week basis and as such would only occur about 26 times in a year.

Therefore, it is necessary to assess how likely it is that the testing period would coincide with the worst case weather years. To do this, a cumulative hypergeometric distribution calculation has been carried out in line with the EA's guidance for specified generators[4], which is designed to assess the situation where a generator only operates occasionally.

The 1-hour AQAL for nitrogen dioxide is 200 ug/m^3 not to be exceeded more than 18 times a year. Therefore, the calculation should be based on the probability of randomly selecting 19 or more exceedance hours (failures) in the sample size. This is the same as selecting at most 'N' minus 19 non-exceedance hours (successes) in the sample. The probability is defined using the following equation (from the EA's guidance for specified generators):

$$P = \sum_{i=0}^{N-19} \frac{\binom{K}{i}\binom{M-K}{N-i}}{\binom{M}{N}}$$

[2] Considered appropriate as the primary NOx to NO2 ratio is less than 10%

[3] Environment Agency, Diesel generator short term NO2 impact assessment, AQMAU-C1457-RP01, 2016.

[4] Environment Agency, Specified Generators: air dispersion modelling example short term statistical analysis.

In order to carry out the analysis it has been assumed that:

- The sample size denoted by 'N' is the number of hours of testing – 26
- The population size denoted by 'M' is the operating envelope – 8760
- The number of exceedance hours (e) has been calculated in ADMS by outputting the number of exceedances of a threshold.
- The number of successes in the population is denoted by 'K' where K = M – e.

As a conservative assumption, it is also assumed that an emergency event would occur each year which would last for 4 hours and cause 4 exceedance hours. Therefore, the probability has been calculated as randomly selecting 15 or more (i.e. 19 - 4) exceedance hours in the sample size.

The number of exceedance hours has been calculated by ADMS by outputting the number of exceedances of the following concentrations (allowing for testing for 30 minutes and the remaining 30 minutes offline, and a NOx to NO_2 conversion of 35%):

- 200 µg/m^3 – i.e. the PC exceeds the AQAL; and
- 200 µg/m^3 minus a background concentration of 23 µg/m^3 – i.e. the PEC exceeds the AQAL allowing for the background concentration.

Table 5: Probability Analysis - Testing

Weather data	PC exceeds AQAL		PEC exceeds AQAL allowing for background of 23 µg/m^3	
	Max number of exceedances at any point	Probability of exceedance of the AQAL	Max number of exceedances at any point	Probability of exceedance of the AQAL
2014	146	<0.1%	340	<0.1%
2015	132	<0.1%	293	<0.1%
2016	137	<0.1%	316	<0.1%
2017	194	<0.1%	404	<0.1%
2018	167	<0.1%	318	<0.1%

Note:
Probability of an exceedance of more than 15 times 200 mg/m^3 which allows for 4 exceedances as a result of emergency operations.

This has shown that the probability of the PEC exceeding the AQAL (allowing for the tolerable exceedances and emergency operation) is less than 0.1%, indicating that short term exceedances are highly unlikely, using the EA's criteria.

This assumes that testing occurs for 26 periods in a year. The calculation has also been used to calculate the number of hours of testing could occur before the probability of the PEC exceeding the AQAL (allowing for the tolerable exceedances and emergency operation) exceeds 5%. This has shown that if testing occurred for up to 190 hours the probability of the PEC exceeding the AQAL (allowing for the tolerable exceedances and emergency operation) would be less than 5%. In line with the EA guidance this indicates that short term exceedances would be unlikely even if testing was to occur for up to 200 periods in a year.

5.2 Ecological impacts

Table 6 presents the maximum predicted impact at any grid point within the Isle of Portland SSSI and SAC. Impacts have been presented for each site individually because the extents of the designations are slightly different where the greatest impacts from the EDG occur, with the SSSI being closer to the Portland ERF than the SAC.

Results have been presented for each of the 5-years of meteorological data considered. The results are based on the assumptions that:

- The EDG operates at full load for the entire 30 minutes of testing;
- The emissions of NOx during the first 10 minutes of testing are at the unabated level, while the remaining 20 minutes of testing are at the abated level;
- For the remaining 30 minutes of the 1-hour period the engine is off – i.e. no emissions; and
- Testing could start at any time between the hours of 08:00 and 17:00.

The PEC has also been calculated. This is based on the 2018 Defra mapped background dataset for the 1 km grid square containing the impacts. The Defra mapped background concentration for the grid square containing the port area is very high. The concentration predicted is higher than many other ports in the UK. Owing to the significantly lower number of vessels operating out of Portland this seems unusual. Reviewing the mapped background dataset shows that in 2017 there was a step change in the predicted concentration. This is attributed to a change in the way shipping emissions are accounted for in the mapped background dataset.

Therefore, a sensitivity has been carried out by calculating the number of exceedances of the critical level assuming both the higher background concentration and a more realistic background concentration of 23 µg/m^3 concentration, noting that this is still significantly higher than the concentration for the surrounding 1km grid squares.

Table 6: Impact of Testing at Portland Ecological Site

Weather data	Maximum PC as % of CL		Maximum PEC as % of CL	
	SSSI	SAC	SSSI	SAC
Assumed background concentration = 34 µg/m^3				
2014	47.5%	43.5%	92.9%	88.9%
2015	41.7%	33.8%	87.0%	79.2%
2016	47.5%	39.3%	92.8%	84.6%
2017	45.2%	40.5%	90.6%	85.8%
2018	51.2%	33.7%	96.5%	79.0%
Assumed background concentration = 23 µg/m^3				
2014	47.5%	43.5%	78.2%	74.2%
2015	41.7%	33.8%	72.4%	64.5%
2016	47.5%	39.3%	78.1%	69.9%
2017	45.2%	40.5%	75.9%	71.2%
2018	51.2%	33.7%	81.9%	64.4%
Note: PEC includes background contribution of NOx of 34 µg/m^3				

As shown the maximum predicted PC does not exceed the daily mean NOx Critical Level as a result of testing. Even when the background concentration is included, the PEC does not exceed the Critical level in the SSSI or the SAC.

6 Results – emergency operations

6.1 Human health

Table 7 presents the maximum predicted impact at any grid point during an emergency event. Results have been presented for each of the 5-years of meteorological data considered.

This assumes that:

- The event would last for 4 hours and could occur at any time of the day or night;
- The EDG operates at full load for the first hour, followed by 70% loading for the second hour, and 50% loading for the remaining 2 hours of emergency operation;
- Emissions of NOx:
  - are at the unabated level during the first 10 minutes;
  - are at the abated level for the remaining time;

Table 7: Impact of Emergency Operations - Human Health

Weather data	Maximum 1-hour PC as % of AQAL
2014	330%
2015	333%
2016	360%
2017	361%
2018	361%

As shown, the maximum 1-hour nitrogen dioxide process contribution is predicted to exceed the AQAL. This conservatively assumes that the emergency event occurs during the worst-case weather conditions for dispersion.

However, as noted earlier, the AQAL for nitrogen dioxide can be exceeded 18 times in a year and so emergency operation could only lead to an exceedance if there were to be more than 4 events in a year. This is extremely unlikely as emergency operation is only required if there is a loss of grid connection and there have only been three such occurrences over the past six years.

The hypergeometric distribution calculation carried out in section 5.1 assumed that an emergency event of four hours would occur every year, that the AQAL would be exceeded for each of these four years, and then calculated the probability of more than 18 exceedances of the AQAL due to testing. The probability of an exceedance of the AQAL (allowing for the tolerable exceedances and emergency operation) was calculated to be less than 0.1%, indicating that an exceedance of the AQAL is highly unlikely even combined with an emergency event.

6.2 Ecological impacts

Table 8 presents the maximum predicted impact at any grid point within the Isle of Portland SSSI and SAC. Results have been presented for each of the 5-years of meteorological data considered.

This assumes that:

- The event would last for 4 hours and could occur at any time of the day or night;

- The EDG operates at full load for the first hour, followed by 70% loading for the second hour, and 50% loading for the remaining 2 hours of emergency operation; and
- Emissions of NOx:
  - are at the unabated level during the first 10 minutes; and
  - are at the abated level for the remaining time.

In order to compare with the daily mean Critical Load, the maximum rolling 4 hour mean has been divided by 6. This accounts for operation during the worst case conditions for dispersion, assuming that the EDG would not be operated for the remainder of the 24 hour period.

As explained earlier, the results have been presented for two background concentrations.

Table 8: Impact of Emergency Operations at Portland Ecological Site

Weather data	Maximum PC as % of CL		Maximum PEC as % of CL	
	SSSI	SAC	SSSI	SAC
Assumed background concentration = 34 µg/m^3				
2014	151.9%	94.3%	197.2%	139.6%
2015	127.5%	87.8%	172.8%	133.1%
2016	122.6%	85.1%	167.9%	130.5%
2017	136.3%	83.4%	181.6%	128.8%
2018	127.8%	104.1%	173.1%	149.4%
Assumed background concentration = 23 µg/m^3				
2014	151.9%	94.3%	182.6%	125.0%
2015	127.5%	87.8%	158.2%	118.5%
2016	122.6%	85.1%	153.3%	115.8%
2017	136.3%	83.4%	167.0%	114.1%
2018	127.8%	104.1%	158.4%	134.7%

The PEC has been calculated by adding the annual mean background concentration to the PC. This is considered appropriate in line with the LAQM approach to account for background concentrations when calculating daily mean impacts.

As shown the maximum 24-hour impact is predicted to exceed the Critical Level of 75 µg/m^3. However, this conservatively assumes that the EDG ia required for emergency usage during the worst-case weather conditions. The probability of this occurring has been calculated as follows:

1. The dispersion model has been used to determine how many times the contribution from the operation of the EDG during an emergency event is more the headroom – i.e. more than the critical level of 75 µg/m^3 minus the background concentration.
2. There are 8757 hours during the year in which an event could have started and lasted for four hours during the year.
3. The chance of an event occurring which could have led to an exceedance is calculated as (1) divided by (2), assuming that one event occurs per year.

Table 9: Probability Analysis - Emergency Operations - Ecological Sites

Weather data	SSSI		SAC	
	Max number of PEC exceedances of the Critical Level at any point	Probability PEC exceeding the Critical Level	Max number of PEC exceedances of the Critical Level at any point	Probability PEC exceeding the Critical Level
Assumed background concentration = 34 µg/m³				
2014	119	1.36%	24	0.27%
2015	82	0.94%	17	0.19%
2016	137	1.56%	19	0.22%
2017	110	1.26%	15	0.17%
2018	171	1.95%	19	0.22%
Average	124	1.41%	19	0.21%
Assumed background concentration = 23 µg/m³				
2014	47	0.54%	5	0.06%
2015	35	0.40%	9	0.10%
2016	38	0.43%	4	0.05%
2017	43	0.49%	2	0.02%
2018	51	0.58%	10	0.11%
Average	43	0.49%	6	0.07%

As shown, the probability of the PEC exceeding the daily mean Critical Level in an emergency scenario in an average year is 1.41% in the SSSI, with the high background concentration, and 0.21% in the SAC.

The EA's "guidance for air quality assessments for specified generators"[5] is designed to assess the situation where a generator only operates occasionally, but in every year, hence a 5% probability of an exceedance of the daily mean Critical Level in any one year leads to a likely exceedance over a 20 year period (5% x 20 years = 100%).

The average probability of the PEC exceeding the daily mean Critical Level in the SSSI is 1.4% meaning that the DSG would need to operate for 70 years for the probability of the PEC exceeding the Critical Level in the SSSI to exceed 100% (100% / 1.41% = 70 years), or 466 years for the SAC even with the high background concentration. This is conservative, as there have only been three grid outages over the past six years. Therefore, an exceedance of the daily mean Critical Level is unlikely.

[5] Environment Agency, Specified Generators: dispersion modelling assessment, at https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment.

7 In combination impact with the ERF

The preceding analysis has been based on the operation of the EDG in isolation. The modelling has shown that impacts from the EDG occur close to the site. The contribution from the ERF in this area is minimal as the taller stack height of the ERF means that to the emissions travel further, and avoid significant building downwash effects.

Testing would occur at the same time as the operation of the ERF. However, it is highly unlikely that a significant contribution from the ERF would coincide with the operation of the EDG, or that the conditions which results in the greatest ground level contributions would occur in the same hour due to the significantly different stack heights.

During an emergency, the EDG would be used to safely shut down the ERF. Therefore, whilst there would be emissions from both the EDG and ERF initially, this would not be for any significant length of time. In addition, it is unlikely that the area impacted by the emergency operation of the EDG would also be impacted by emissions from the ERF during shut down.

As such it is not considered that including the contribution from the ERF would significantly change the conclusion of this assessment, that the operation of the EDG would not be significant.

8 Summary

Dispersion modelling has been carried out to determine the impact of the operation of the EDG during testing and an emergency event (specifically, the loss of grid connection). This has considered the impact on human health and ecology with reference to the short term assessment levels. The impact of testing and emergency operation has not been considered in relation to the annual mean assessment levels as the contribution to annual mean impacts would not be significant due to the limited time of operation.

1. Impact of testing on human health
    a. The EDG would run for about 30 minutes every 2 weeks, or 26 times a year.
    b. If a test coincided with the worst case weather conditions, the 1-hour air quality assessment level would be exceeded at the point of maximum impact.
    c. However, the air quality standard allows this to be exceeded 18 times a year. The chance of an exceedance of the air quality standard, even assuming that an emergency generator event also happened during the year, is less than 0.1%. Under the EA's assessment criteria, this can be described as "highly unlikely".
2. Impact of testing on ecology
    a. Even under worst case weather conditions, and assuming a high background concentration, the daily average air quality assessment level is not predicted to be exceeded during a test of the EDG.
3. Impact of emergency operation on human health
    a. The EDG would only run if there is a loss of grid connection to the site. This is expected to happen less than once a year.
    b. The EDG would run for up to four hours to facilitate a safe shutdown of the plant.
    c. If emergency operation coincided with the worst case weather conditions, the 1-hour air quality assessment level would be exceeded at the point of maximum impact.
    d. However, the air quality standard allows this to be exceeded 18 times a year and the emergency operation would only last for four hours. This has been included in the testing assessment.
4. Impact of emergency operation on ecology
    a. The short term critical level for the protection of ecology is a daily average. The EDG would only run for four hours, so we have calculated the impact over a four hour period and then divided by six to show the contribution to the daily average.
    b. The dispersion model has been used to determine the number of times in a year that emergency operation of the EDG could have led to an exceedance of the daily mean critical level, allowing for background concentrations.
    c. Allowing for a conservative background concentration, the chance of an exceedance is 1.4% in the Isle of Portland SSSI. If there were an emergency operation every year, then the chance of an exceedance can be described as "unlikely" over a period of 70 years.
    d. Allowing for a more realistic background concentration, the chance of an exceedance is 0.5% in the Isle of Portland SSSI. Under the EA's assessment criteria, this can be described as "highly unlikely".
    e. Allowing for a conservative background concentration, the chance of an exceedance is 0.21% in the Isle of Portland SAC, dropping to under 0.1% with a more realistic background concentration. This can be described as "highly unlikely".

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