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Consulting Engineers Limited

Lostock Sustainable Energy Plant Ltd

Abnormal Emissions Assessment

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Document approval

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1 Introduction

Lostock Sustainable Energy Plant Limited (LSEP Ltd) was granted an Environmental Permit (EP) for a waste incineration facility (referred to as the 'Facility') at Lostock Gralam, Northwich (Ref: EPR/WP3934AK). The EP was originally granted on 16 December 2013 and has since been subject to a single variation to include for a number of additional EWC codes.

Lostock Sustainable Energy Plant Ltd are proposing to vary the existing Environmental Permit to allow for an increased annual throughput of 728,000 tonnes. A detailed description of the proposed changes to the Facility are presented within the Supporting Information document submitted with this application.

Article 46(6) of the Industrial Emissions Directive (IED) states that:

"… the waste incineration plant … shall under no circumstances continue to incinerate waste for a period of more than 4 hours uninterrupted where emission limit values are exceeded.

The cumulative duration or operation in such conditions over 1 year shall not exceed 60 hours."

Article 47 continues with:

"In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored."

The conditions detailed in Article 46(6) are considered to be "abnormal operating conditions" for the purpose of this assessment apply to the LSEP.

Table S3.1(a) of the EP allows the Facility to operate in 'abnormal' operation. This assessment has been developed to consider the environmental impact of the Facility in abnormal taking into consideration the proposed changes to the design of the Facility.

2 Identification of Abnormal Operating Conditions

The following are considered to be examples of abnormal operating conditions which may lead to 'abnormal emission levels' of pollutants:

1. Reduced efficiency of lime injection system such as through blockages or failure of fans leading to elevated acid gas emissions (with the exception of hydrogen chloride);
2. Complete failure of the lime injection system leading to unabated emissions of hydrogen chloride. (Note: this would require the plant to have complete failure of the bag filter system. As a plant of modern design, it would have shut down before reaching these operating conditions);
3. Reduced efficiency of particulate filtration system due to bag failure and inadequate isolation, leading to elevated particulate emissions and metals in the particulate phase;
4. Reduced efficiency of the Selective Non-Catalytic Reduction (SNCR) system as a result of blockages or failure of ammonia injection system, leading to elevated oxides of nitrogen emissions; and
5. Complete failure of the activated carbon injection system and loss of temperature control leading to high levels of dioxin reformation and their unabated release.

As a modern design, it is anticipated that the LSEP will be operated to a high degree of compliance. Therefore, the identification of plausible abnormal emission levels has been based primarily on the data obtained from modern plants. Where actual data is not available, worst case conservative assumptions have been made.

2.1 Plant start-up and shutdown

Start-up of the LSEP from cold will be conducted with an auxiliary fuel (low sulphur fuel oil). Waste will not be introduced into the furnace unless the temperature is above the minimum requirement (850°C) and other operating parameters (for example, air flow and oxygen levels) are within the range stipulated in the permit. During the warming up period the flue gas treatment plant will be operational as will be the control systems and monitoring equipment.

The same is true during plant shutdown. The waste remaining in the furnace will be allowed to burn out, the temperature not being permitted to drop below 850°C by the simultaneous introduction of the auxiliary fuel. After complete burnout of the waste, the auxiliary fuel burners are turned off and the system will be allowed to cool. During this period, the combustion control systems, flue gas cleaning equipment, and the monitoring equipment will be fully operational.

It should also be noted that start-up and shutdown are infrequent events; the Facility is designed to operate continuously, and ideally only close down for its annual maintenance programme.

In relation to the magnitude of dioxin emissions during plant start-up and shutdown, research has been undertaken by AEA Technology on behalf of the EA. Whilst elevated emissions of dioxins (within one order of magnitude) were found during shutdown and start-up phases where the waste was not fully established on the grate, the report concluded that:

"The mass of dioxin emitted during start-up and shutdown for a 4-5 day planned outage was similar to the emission which would have occurred during normal operation in the same period. The emission during the shutdown and restart is equivalent to less than 1% of the estimated annual emission (if operating normally all year)."

Therefore, there is no reason why start-up and shutdown operations will affect the long-term impact of the LSEP.

3 Plausible Abnormal Emission Levels

The following plausible abnormal emission levels for the LSEP have been identified based on the performance of similar plants in the UK. The plausible abnormal emissions concentrations are presented in Table 1, where available, these have been based on measured data from a comparable facility.

Table 1: Plausible Abnormal Emissions from an EfW Facility

Pollutant	Permitted Emission Limit, (mg/Nm^3)(1)		Plausible Abnormal Emission, (mg/Nm^3)	% Above Max Permitted Emission
	Daily Average	½ hourly max		
Oxides of nitrogen	180	400	500(2)	25
Particulate matter (PM_{10})	5	30	150(3)	400
Sulphur dioxide	40	200	450(4)	125
Hydrogen chloride	8	60	900(4)	1,400
Hydrogen fluoride	1	4	20(1)	400
Dioxins and dioxin-like PCBs	0.08 ng/Nm³		8 ng/Nm³	9900(5)
PCBs	0.005 mg/Nm³(6)		0.5 mg/Nm³	9900(7)

NOTES:

1. All emissions expressed as Nm³ based (dry, 0°C, 11% reference oxygen content). Limits are as proposed as part of the EP variation which are based on the BAT AELS for an existing plant as set out in the Waste Incineration BREF, as agreed at the pre-application meeting with the EA.
2. Taken as the upper end of the range of monitored raw flue gas after the boiler from the Waste Incineration BREF (Table 3.6)
3. Taken from the IED maximum permitted level.
4. Based on information presented in the Devonport Decision Document (Reference: EPR/WP3833FT).
5. Assumes a 99% removal efficiency in lieu of any other information as set out in the Devonport Decision Document (Reference: EPR/WP3833FT).
6. Table 3.8 of the 2006 Waste Incineration BREF states that the annual average total PCBs is less than 0.005 mg/Nm³ (dry, 11% oxygen, 273K). In lieu of other available operational data, this has been assumed to be the emission concentration for the LSEP.

A number of assumptions have been made with regard to the emissions of individual metals.

7. Emission concentration of mercury has been assumed to be 100% of the Best Available Techniques Associated Emission Level (BAT-AEL) concentration for an existing plant of 0.03 mg/m³.
8. Emission concentration of cadmium has been taken as half the BAT-AEL concentration for cadmium and thallium and compounds for an existing plant of 0.03 mg/m³.
9. Emission concentration of heavy metals that have a short or long term AQAL have been considered (antimony, arsenic, chromium, copper, lead, manganese, nickel, vanadium) and have been taken from the EA guidance document "Guidance on assessing group 3 metal stack

emissions from incinerators" (version 4). This guidance summarises the existing emissions from 18 Municipal Waste Incinerators (MWIs) and Waste Wood Co-incinerators in the UK over a period between 2007 and 2015. This has been used in lieu of any more recent guidance from the EA.

10. The Predicted Abnormal Emissions are calculated based on 30 times the emission concentration, as it is assumed that metals are in the particulate phase with the exception of mercury where it has been assumed there is a 99% removal efficiency.

The plausible abnormal emissions concentrations for metals are presented in Table 2.

Table 2: Predicted Abnormal Metal Emissions from an EfW Facility

Pollutant	Emission Concentrations (µg/Nm³)	Predicted Abnormal Emission (µg/Nm³)	% Above Max Permitted Emission
Antimony	11.5	345	2,900
Arsenic	25	750	2,900
Cadmium	15	450	2,900
Chromium	92	2,760	2,900
Chromium (VI)	0.13	3.9	2,900
Copper	29	870	2,900
Lead	50.3	1,509	2,900
Manganese	60	1,800	2,900
Mercury	30	3,000	9,900
Nickel	220	6,600	2,900
Vanadium	6	180	2,900

The definition of 'abnormal operating conditions' also encompasses periods where the continuous emission monitoring equipment is not operating correctly and data relating to the actual emission concentrations are not available. This assessment has only used data where the concentration of continuously monitored pollutants has been quantified. Furthermore, no data on flow characteristics (flow rate, temperature etc.) during these abnormal operating conditions is available, so for the purposes of this assessment the design flow characteristics have been applied to the plausible emission levels to derive an emission rate and assess impact.

In defining abnormal operating conditions Annex VI, Part 3 (2) notes that under no circumstances shall the total dust concentration exceed 150 mg/Nm³ expressed as a half hourly average. As such total dust has been included in this analysis. However, Annex VI, Part 3 (2) goes on to state that the limits prescribed for TOC set must not be exceeded. As such there is no potential for the impact of emissions of TOC to be greater than that outlined in Appendix E2 – Process Emissions Modelling; therefore, TOC has not been considered within this abnormal emissions assessment.

4 Impact Resulting from Plausible Abnormal Emissions

4.1 Impact from normal operations

Appendix E2 – Process Emissions Modelling has considered the impact of the LSEP in isolation and has not identified any local developments that have the potential to cause significant point source cumulative impacts with the plant. Therefore, the process contribution used in this assessment is that of the LSEP operating in isolation. This data is presented in Appendix B.

4.2 Predicted abnormal short-term impacts

In order to assess the effect on short term ground level concentrations associated with the LSEP operating at the identified abnormal emission concentration, the calculated ground level concentration has been increased pro-rata as presented in Table 3.

Table 3: Short-term Impacts Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Predicted Impact – BAT-AELs		Predicted Impact – Abnormal Emission	
		Conc. µg/m³	% of AQAL	Conc. µg/m³	% of AQAL
Nitrogen dioxide	200	17.54	8.77%	21.93	10.96%
Particulate matter (PM_{10})	50	0.08	0.17%	2.54	5.09%
Sulphur dioxide (24-hour)	125	1.93	1.54%	21.72	17.38%
Sulphur dioxide (1-hour)	350	24.42	6.98%	54.95	15.70%
Sulphur dioxide (15-min)	266	29.15	10.96%	65.58	24.66%
Hydrogen chloride	750	12.44	1.66%	186.63	24.88%
Hydrogen fluoride	160	0.83	0.52%	4.15	2.59%
Pollutant	**AQAL (ng/m³)**	**Predicted Impact – BAT-AELs**		**Predicted Impact – Abnormal Emission**	
		Conc. ng/m³	**% of AQAL**	**Conc. ng/m³**	**% of AQAL**
Antimony	150,000	2.38	<0.01%	71.52	0.05%
Chromium	150,000	19.07	0.01%	572.14	0.38%
Copper	200,000	6.01	<0.01%	180.35	0.09%
Manganese	1,500,000	12.44	<0.01%	373.14	0.02%
Mercury	7,500	4.15	0.06%	414.60	5.53%
Vanadium	1,000	1.24	0.12%	37.31	3.73%
PCBs	6,000	1.04	0.02%	103.65	1.73%

This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions coincide with worst case meteorological conditions. Even with this highly conservative factor, the process contribution is not predicted to exceed any of the short term AQALs. The maximum predicted process contribution (as a % of the applied AQAL) 24.88% for hydrogen chloride, with all other pollutants lower.

4.3 Predicted abnormal long-term impacts

In order to assess the effect on long term ground level concentrations associated with the LSEP operating at the identified abnormal emission levels, the calculated long term ground level concentrations have been increased pro-rata as presented in Table 4.

This assessment assumes that the LSEP is operating at the daily average ELVs for 8,700 hours per year and at the plausible abnormal emission levels for 60 hours per year.

Table 4: Long-term Impacts Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Predicted Impact – BAT-AELs		Predicted Impact – Abnormal Emission	
		Conc. (µg/m³)	% of AQAL	Conc. (µg/m³)	% of AQAL
Nitrogen dioxide	40	0.53	1.31%	0.53	1.33%
Particulate matter (PM_{10})	40	0.02	0.05%	0.03	0.06%
Hydrogen fluoride	16	<0.01	0.03%	<0.01	0.03%
Pollutant	**AQAL (ng/m³)**	**Predicted Impact – BAT-AELs**		**Predicted Impact – Abnormal Emission**	
		Conc. (ng/m³)	**% of AQAL**	**Conc. (ng/m³)**	**% of AQAL**
Antimony	5,000	0.05	<0.01%	0.06	<0.01%
Arsenic	3	0.10	3.48%	0.13	4.17%
Cadmium	5	0.04	0.84%	0.05	1.00%
Chromium	5,000	0.38	0.01%	0.46	0.01%
Chromium (VI)	0.2	<0.01	0.27%	<0.01	0.33%
Copper	10,000	0.12	<0.01%	0.15	<0.01%
Lead	250	0.21	0.08%	0.25	0.10%
Manganese	150	0.25	0.17%	0.30	0.20%
Mercury	250	0.08	0.03%	0.14	0.06%
Nickel	20	0.92	4.59%	1.10	5.51%
Vanadium	5,000	0.03	<0.01%	0.03	<0.01%
PCBs	200	0.02	0.01%	0.04	0.02%

The process contribution is not predicted to exceed any of the long term AQALs. The maximum predicted process contribution (as a % of the applied AQAL) is less than 5.51% for nickel, with all other pollutants lower.

There is no AQAL for dioxins and dioxin-like PCBs against which the impact can be assessed. Therefore, to assess the impact of dioxins and dioxin-like PCBs, the increase in concentration at the point of maximum impact has been assessed. As can be seen from the results presented in Table 5, the impact of abnormal emissions is to increase in the maximum ground level concentration by 67.81%.

Table 5: Long Term Impacts from Predicted Dioxin Emissions

Pollutant	Predicted Impact – BAT-AELs	Predicted Impact –Abnormal Emission	
	fg/m³	fg/m³	% increase
Dioxins and dioxin like PCBs	0.038	0.064	67.81%

Based on the results of the Human Health Risk Assessment (HHRA), the highest dose of dioxins and dioxin-like PCBs is predicted to be 1.58% of the TDI. This is based on the ingestion and inhalation of dioxins and dioxin-like PCBs by a child agricultural receptor at the point of maximum impact. Assuming the impact of abnormal operations, it is calculated that the process contribution at this receptor will be (2.58% x 1.6781) = 4.33% of the UK TDI for dioxins and dioxin-like PCBs. Existing sources contribute 90.65% of the TDI, and therefore the total exposure will be 94.98% of the TDI.

In addition, the HHRA considers the impact of the ingestion of dioxins by an infant being breast fed by an adult agricultural receptor at the point of maximum impact. The impact is predicted to be 8.93% of the UK TDI for dioxins. There are no other significant pathways for infant receptors. Assuming the impact of abnormal operations, it is calculated that this receptor will be exposed to (8.93% x 1.6781) = 14.99% of the UK TDI for dioxins.

Based on the conservative assumptions used within the modelling, there will be no exceedances of the TDI for dioxins and dioxin-like PCBs.

5 Predicted Environmental Concentration – Abnormal Operations

The EA's Air Emissions Guidance includes the following method for identifying which emissions require further assessment by applying the following criteria:

- the long-term process contribution is <1% of the long term environmental standard; and
- the short-term process contribution is <10% of the short term environmental standard.

Where the impact of abnormal emissions is greater than the above criteria consideration of the background concentration has been made to ensure that the AQAL is not exceeded as a result of abnormal operations.

5.1 Baseline concentrations

The values for the annual average background concentrations that have been used to evaluate the impact of the LSEP are presented in Appendix A. These are the baseline concentrations, presented in Appendix E1 – Baseline Analysis.

5.2 Predicted short term impacts

Table 6 presents the predicted impacts of plausible abnormal operations in the short term at the point of maximum impact and the Predicted Environmental Concentration (PEC) (process contribution plus baseline) for those pollutants for which the impact cannot be screened as insignificant.

Table 6: Short Term PEC Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Baseline Conc.	PC – Abnormal Emissions	PEC – Abnormal Emissions	
		µg/m³	µg/m³	µg/m³	% of AQAL
Nitrogen dioxide	200	34.1	21.93	56.03	28.0%
Sulphur dioxide (24-hour)	125	29.4	21.72	51.12	40.9%
Sulphur dioxide (1-hour)	350	29.4	54.95	84.35	24.1%
Sulphur dioxide (15-min)	266	29.4	65.58	94.98	35.7%
Hydrogen chloride	750	1.42	186.63	188.05	25.1%

As shown, the PEC is not predicted to exceed the AQAL at the point of maximum impact for any pollutant during abnormal operations.

5.3 Predicted long term impacts

Table 7 presents the predicted impacts of plausible abnormal operations in the long term at the point of maximum impact, and the PEC. This assessment assumes that the LSEP is operating at the ELVs for 8,700 hours per year and at the plausible abnormal emission levels for 60 hours per year.

Table 7: Long Term PEC Resulting from Plausible Abnormal Emissions

Pollutant	AQAL (µg/m³)	Baseline Conc.	PC – Abnormal Emissions	PEC – Abnormal Emission	
		µg/m³	µg/m³	µg/m³	% of AQAL
Nitrogen dioxide	40	17.05	0.53	17.58	44.0%
Pollutant	**AQAL (ng/m³)**	**Baseline Conc.**	**PC – Abnormal Emissions (1)**	**PEC – Abnormal Emission**	
		ng/m³	**ng/m³**	**ng/m³**	**% of AQAL**
Arsenic	3	1.1	0.13	1.23	40.8%
Cadmium	5	0.57	0.05	0.62	12.4%
Nickel	20	14	1.10	15.10	75.5%

As shown, the PEC is not predicted to exceed the AQAL at the point of maximum impact for any pollutant during abnormal operations.

6 Summary

An assessment of the impact on air quality associated with abnormal operating conditions from the LSEP has identified plausible abnormal emissions based on a review of monitoring data from operational facilities of a similar type in the UK. Notwithstanding the low frequency of occurrence of such abnormal operating conditions identified by the review, the potential impact on air quality has been assessed.

The predicted impact on air quality associated with the identified plausible abnormal emissions has been calculated by pro-rating the impact associated with normal operations by the ratio between the normal and plausible abnormal emission values. This is considered to be a highly conservative assessment as it assumes that the plausible abnormal emissions coincide with the worst-case meteorological conditions for dispersion.

Even with these conservative factors, there are no predicted exceedances of any of the short term or long term AQALs associated with abnormal operation. The maximum predicted short term process contribution (as % of the applied AQAL) is 24.88%; and the maximum predicted long term process contribution (as % of the applied AQAL) is 5.51% In addition, the assessment has shown that there will not be any exceedances of the TDI for dioxins.

It is concluded that during periods of abnormal operation as permissible under the IED (Article 46) is not predicted to give rise to an unacceptable impact on air quality or the environment.

Appendices

A Baseline Concentrations

Table 8: Summary of Baseline Concentrations

Pollutant	Concentration	Units	Justification
Nitrogen dioxide	17.05	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2018 dataset.
Oxides of nitrogen	23.38	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2018 dataset.
Sulphur dioxide	14.70	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2001 dataset.
Particulate matter (as PM10)	12.98	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2018 dataset.
Particulate matter (as PM2.5)	8.79	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2018 dataset.
Carbon monoxide	345	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2001 dataset.
Benzene	0.56	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2001 dataset.
1,3-butadiene	0.25	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA 2001 dataset.
Ammonia	4.23	µg/m³	Maximum mapped background concentration from within 5 km of Site- DEFRA (CEH) 2014 dataset.
Hydrogen chloride	0.71	µg/m³	Maximum monitored concentration across the UK 2012 to 2015
Hydrogen fluoride	2.35	µg/m³	Maximum measured concentration from EPAQS report
Cadmium	0.57	ng/m³	Maximum annual concentration averaged across all urban industrial sites across the UK 2015 to 2019
Thallium	-	ng/m³	
Mercury	2.80	ng/m³	
Antimony	-	ng/m³	
Arsenic	1.10	ng/m³	
Chromium	39.00	ng/m³	
Cobalt	0.92	ng/m³	
Copper	33.00	ng/m³	
Lead	16.00	ng/m³	
Manganese	36.00	ng/m³	
Nickel	14.00	ng/m³	
Vanadium	1.70	ng/m³	
Dioxins and Furans	32.99	fgTEQ/m³	Maximum monitored concentration across all UK sites 2012 to 2016
Dioxin-like PCBs	128.93	pg/m³	Maximum monitored concentration across all UK sites 2014 to 2018

Pollutant	Concentration	Units	Justification
PaHs	0.98	ng/m^3	Maximum annual concentration averaged across all background sites across the UK 2015 to 2019

B Process Contribution – Normal Operations

Table 9: Dispersion Modelling Results – Point of Maximum Impact

Pollutant	Quantity	Units	AQAL	Max PC	
				Conc.	As a % of AQAL
Nitrogen dioxide	Annual mean	µg/m³	40	0.53	1.31%
	99.79th %ile of hourly means[1]	µg/m³	200	17.54	8.77%
Sulphur dioxide	99.18th %ile of daily means	µg/m³	125	1.93	1.54%
	99.73rd %ile of hourly means[1]	µg/m³	350	24.42	6.98%
	99.9th %ile of 15 min. means[1]	µg/m³	266	29.15	10.96%
Particulates (PM_{10})	Annual mean	µg/m³	40	0.02	0.05%
	98.4th %ile of daily means	µg/m³	50	0.08	0.17%
Hydrogen chloride	Hourly mean[1]	µg/m³	750	12.44	1.66%
Hydrogen fluoride	Annual mean	µg/m³	16	<0.01	0.03%
	Hourly mean*	µg/m³	160	0.83	0.52%
Mercury	Annual mean	ng/m³	250	0.08	0.03%
	Hourly mean	ng/m³	7500	4.15	0.06%
Cadmium	Annual mean	ng/m³	5.00	0.08	1.67%
Dioxins and furans and dioxin-like PCBs	Annual mean	fg/m³	-	0.33	-
PCBs	Annual mean	ng/m³	200	0.02	0.01%
	Hourly mean	ng/m³	6000	1.04	0.02%
Group 3 metals	Annual mean	ng/m³	-	1.25	-
	Hourly mean	ng/m³	-	62.19	-

Notes:

1. Assumes operation at the half-hourly ELV.

All other results based on operation at the daily or period mean ELV.

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