Light Valley Solar

Environmental Statement Volume 3

Appendix 16.5: BESS Fire Emissions Modelling Technical Note

Document Reference EN0110012/APP/LVS/06.03.16.05

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Infrastructure Planning

Planning Act 2008

**The Infrastructure Planning
(Applications: Prescribed Forms and Procedure) Regulations 2009**

Light Valley Solar

DCO Submission

Appendix 16.5: BESS Fire Emissions Modelling Technical Note

Regulation Reference	APFP Regulation 5(2)(a)
Planning Inspectorate Case Reference	EN00110012
Application Document Reference	EN00110012/APP/06.03.16.05
Author	Light Valley Solar Limited

Version	Date	Status of Version
1.0	February 2026	DCO Submission

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1 Introduction

1.1 Overview and purpose of the document

1.1.1 The Battery Energy Storage System (BESS) has the potential to cause air quality impacts in the rare event of a fire incident. Concentrations of carbon monoxide (CO), formaldehyde, hydrogen chloride (HCl), hydrogen cyanide (HCN), hydrogen fluoride (HF), ammonia (NH_3), nitrogen dioxide (NO_2) and particulates from a potential BESS fire have been modelled using an air quality dispersion model to determine the likely effects on human health.

1.1.2 A high-level visibility assessment has also been undertaken using the modelled particulates results to determine the effect of BESS fire emissions on visibility on the local road network to inform the outline Battery Safety Management Plan (oBSMP) [**EN0110012/APP/LVS/07.06**].

1.1.3 The following sections outline the methodology used in the assessment and the modelling results.

1.1.4 It should be noted that the final design of the BESS layout, size and type of BESS enclosure/unit have not yet been fixed and therefore appropriate assumptions have been made regarding concept design for the BESS Fire Emissions Modelling assessment.

2　Assessment methodology

2.1　Relevant Guidance and Standards

2.1.1　The assessment has been undertaken with due consideration of the Environment Agency's (EAs) 'Air emissions risk assessment for your Environmental Permit' guidance (Ref 1), which provides advice on assessing releases to air. Whilst this guidance is used for dispersion modelling for environmental permitting purposes, it includes useful general guidance on undertaking detailed modelling of emissions to air.

2.1.2　Given a potential BESS fire would be a relatively short-term incident, it is considered appropriate to compare predicted concentrations against Acute Exposure Guidance Levels (AEGLs), which have higher threshold concentrations than the national air quality objectives and are relevant to short-term releases. AEGLs are expressed as concentrations of a substance above which it is predicted that the general population could experience, including susceptible individuals:

1) AEGL 1 - Notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure;

2) AEGL 2 - Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape; and

3) AEGL 3 - Life-threatening health effects or death (Ref 2).

2.1.3　The occurrence of adverse health effects is not likely to occur in the general public at concentrations below the AEGLs. AEGLs have a range of exposure periods ranging from 10 minutes to 8 hours, and public exposure over every AEGL averaging period has been considered in this assessment. The AEGLs are presented in Table 2-1 and are expressed in units of parts per million (ppm) but have been converted into units of microgram per cubic meter ($\mu g/m^3$) to allow direct comparison against predicted concentrations (as background concentrations and model outputs are provided in $\mu g/m^3$).

Table 2-1   AEGLs for the Modelled Pollutants (Ref 2)

Pollutant	10 Minutes (ppm)			30 Minutes (ppm)			1 Hour (ppm)			4 Hour (ppm)			8 Hour (ppm)		
	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3
CO	*NR	420	1700	NR	150	600	NR	83	330	NR	33	150	NR	27	130
Formaldehyde	0.9	14	100	0.9	14	70	0.9	14	56	0.9	14	35	0.9	14	35
HCl	1.8	100	620	1.8	43	210	1.8	22	100	1.8	11	26	1.8	11	26
HCN	2.5	17	27	2.5	10	21	2	7.1	15	1.3	3.5	8.6	1	2.5	6.6
HF	1	95	170	1	34	62	1	24	44	1	12	22	1	12	22
NH_3	30	220	2700	30	220	1600	30	160	1100	30	110	550	30	110	390
NO_2	0.5	20	34	0.5	15	25	0.5	12	20	0.5	8.2	14	0.5	6.7	11

Pollutant	10 Minutes ($\mu g/m^3$)			30 Minutes ($\mu g/m^3$)			1 Hour ($\mu g/m^3$)			4 Hour ($\mu g/m^3$)			8 Hour ($\mu g/m^3$)		
	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3	AEGL 1	AEGL 2	AEGL 3
CO	NR	481,153	194,7526	NR	171,840	687,362	NR	95,085	378,049	NR	37,805	171,840	NR	30,931	148,928
Formaldehyde	1105	17,195	122,822	1105	17,195	85,975	1105	17,195	68,780	1105	17,195	42,988	1105	17,195	42,988
HCl	2684	149,121	924,548	2684	64,122	313,153	2684	32,807	149,121	2684	16,403	38,771	2684	16,403	38,771
HCN	2764	18,794	29,849	2764	11,055	23,216	2211	7849	16,583	1437	3869	9507	1106	2764	7296
HF	818	77,748	139,129	818	27,826	50,741	818	19,642	36,010	818	9821	18,005	818	9821	18,005
NH_3	20,896	153,235	1,880,613	20,896	153,235	1,114,438	20,896	111,444	766,176	20,896	76,618	383,088	20,896	76,618	271,644
NO_2	941	37,636	63,981	941	28,227	47,045	941	22,582	37,636	941	15,431	26,345	941	12,608	20,700

*NR = Not recommended due to insufficient data

2.1.4   There is no AEGL for particulates. As such, the Health and Safety Executive (HSE) Workplace Exposure Limit (WEL) (Ref 3) has been used, which is 4 mg/m^3 for respirable dust. Whilst this is over an 8-hour reference period, it is considered appropriate for use in the assessment in lieu of any other limits.

2.1.5   In the absence of an AEGL 1 threshold for CO, CO concentrations have been compared against the World Health Organisation (WHO) CO guideline values of 100 mg/m^3 for 15-minute average, 35 mg/m^3 for 1-hour average and 10 mg/m^3 for 8-hour average (Ref 4), which is a lower threshold concentration than AEGL 2 and 3. The WHO air quality guidelines are a set of evidence-based recommendations of limit values for specific air pollutants developed to help countries achieve air quality that protects public health.

2.1.6   The impact of the smoke plume on visibility has been calculated based on the mass concentration of particulate matter, using the following equation developed in the Principles of Smoke Management (Ref 5):

S = K / (αm x mp)

Where:

S = visibility through smoke (m).

K = proportionality constant; a value of 3 has been used in the assessment which is applicable to the observation of a non-light emitting object in smoke.

αm = specific extinction coefficient (m^2/g); a value of 7.6 m^2/g has been used in the assessment based on flaming combustion of wood and plastics (as opposed to smouldering which has lower αm value).

mp= mass concentration of particulate matter (g/m^3); a value has been calculated using the modelled PM$_{10}$ concentration associated with the BESS fire.

2.1.7   It should be noted that the visibility through smoke equation outlined above is based on certain assumptions and therefore has inherent limitations, for example the extinction coefficient will depend on the particle size distribution and optical properties of the particulates. The output of the visibility calculations should therefore be treated with caution and used as a guide only.

2.2   Study Area

2.2.1   There is no guidance that exists on the assessment of emissions from BESS fires. For the purposes of this assessment, a Study Area of 1 km from the BESS Compound has been used, based on professional experience of assessing emissions from similar schemes, and based on air quality assessments undertaken for fires at similar BESS sites such as Green Hill Solar Farm (Ref 6). The BESS fire emissions assessment Study Area is presented below in Plate 1.

Plate 1 **BESS Fire Emissions Assessment Study Area and Receptor Locations**
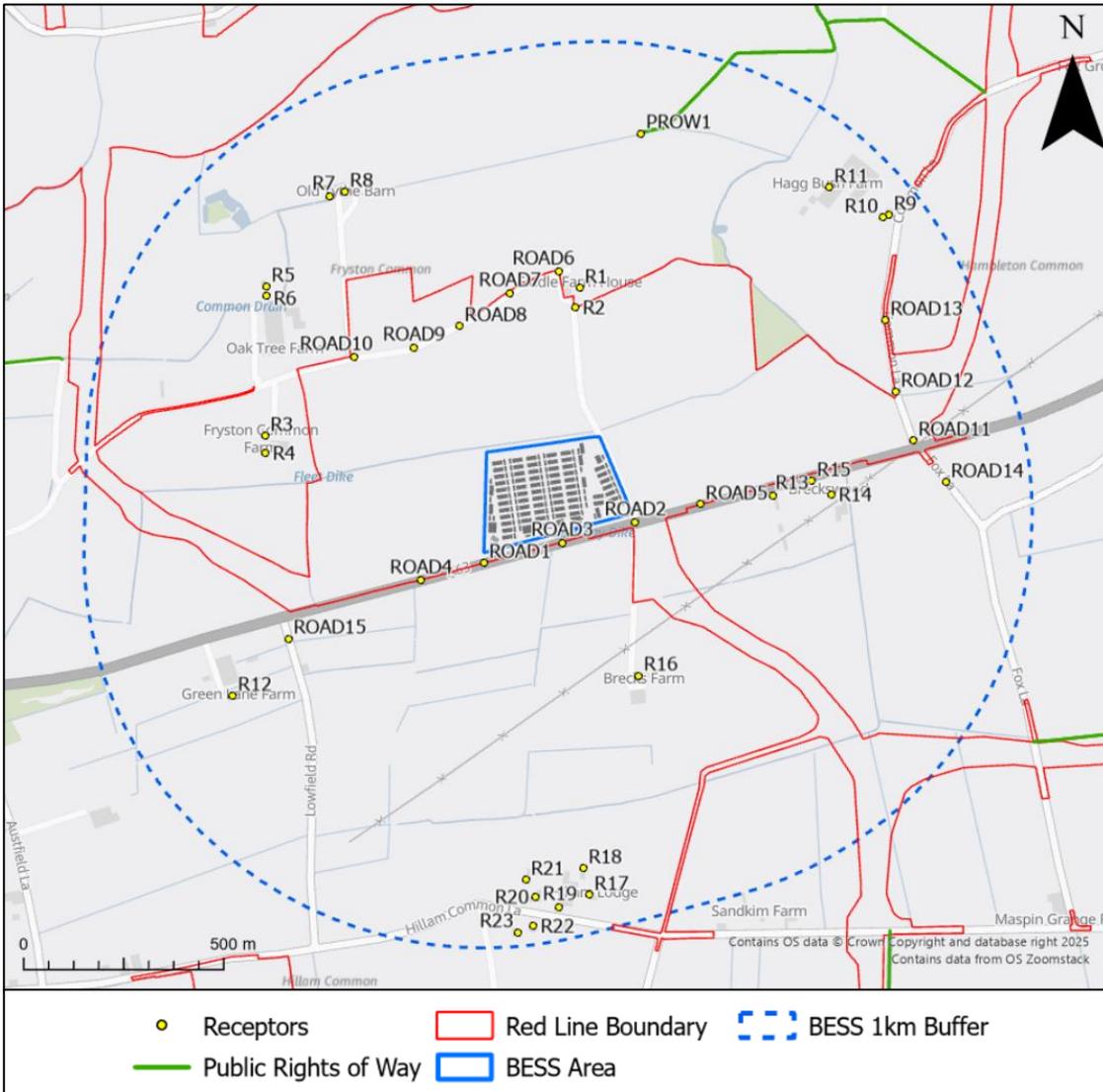
2.3 Modelling parameters

Input data

2.3.1 Dispersion modelling was undertaken using ADMS-6 (v6.0.2.1), which is developed by Cambridge Environmental Research Consultants Ltd and is accepted for the air quality assessment of industrial source type releases within the UK by the Environment Agency, Defra and local authorities. ADMS-6 is a short-range dispersion modelling software package that simulates a wide range of buoyant and passive releases to atmosphere. It is a new generation model utilising boundary layer height and Monin-Obukhov length (height at which turbulence is generated more by buoyancy than by wind shear) to describe the atmospheric boundary layer and a skewed Gaussian concentrations distribution to calculate dispersion under convective conditions.

2.3.2 The model utilises hourly meteorological data to define conditions for plume rise, transport and diffusion of pollutants. It estimates the concentration for each source and receptor combination for each hour of input meteorology and calculates user-selected long-term and short-term averages.

2.3.3 The BESS Compound would be situated within Solar Development Site 2 as presented in Figure 2.1: Illustrative Site Layout Plan (ES Volume 2) [**EN0110012/APP/LVS/06.02.02.01**]. The precise number of BESS enclosures will depend upon the level of power capacity of energy storage that the Proposed Development will require.

2.3.4 The final layout of the BESS Compound will be determined during detailed design. For the purpose of this assessment, five worst case BESS fire locations (i.e. locations within the BESS Compound closest to sensitive receptors) have been modelled as depicted in Plate 2. The arrangement of the BESS has not been finalised, therefore the maximum extent of the BESS Compound has been used as a worst case.

Plate 2   Modelled BESS Fire Locations
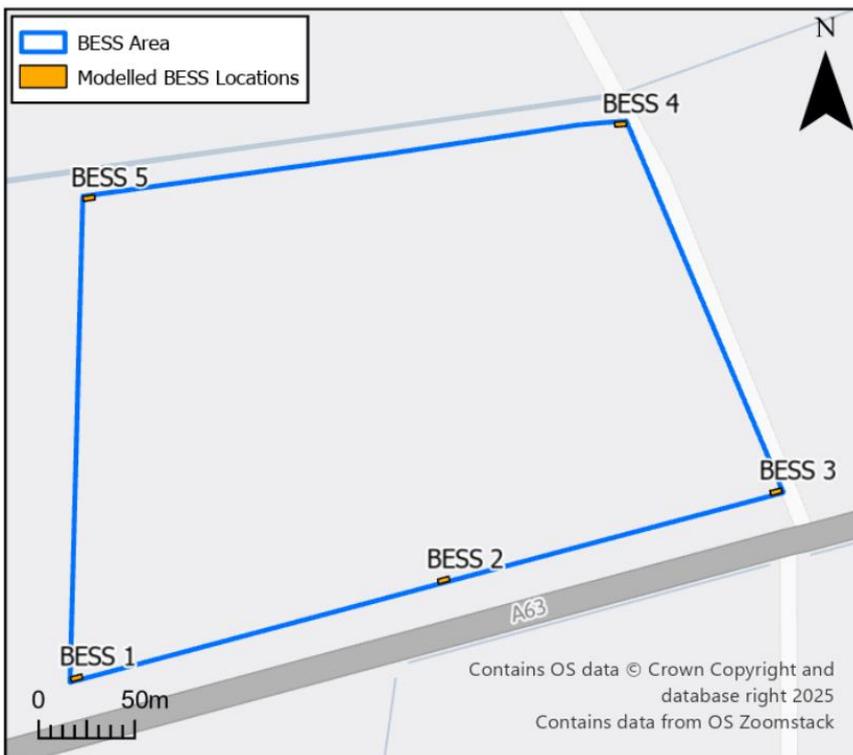
2.3.5 Each of the five BESS fire locations have been modelled as an area source so that plume rise was factored into the model (the model does not allow for plume rise for volume sources). The area source dimensions have been based on the dimensions of one BESS Enclosure (6.1 m long and 2.6 m wide). It should be noted that the dimensions detailed in Chapter 2: The Proposed Development (ES Volume 1) [**EN0110012/APP/LVS/06.01.02**] state the maximum footprint of the BESS containers would be 16 m long and 3 m wide, however in reality the BESS enclosure/unit sizes are likely to be significantly smaller. In order to assess the most accurate emissions release, the concept design have been derived based

on the GridSolv Quantum Cube Bespoke Unit Testing Summary Report, prepared by Fire & Risk Alliance LLC for Wartsila North America, Inc. (Ref 7), at the recommendation of the Applicant's Battery Safety and Testing Consultant.

2.3.6   Emissions data for BESS fires are limited. At the recommendation of the Applicant's Battery Safety and Testing Consultant, emissions data have also been derived from the GridSolv Quantum Cube Bespoke Unit Testing Summary Report (Ref 7). The test fire was conducted using lithium iron phosphate (LFP) lithium-ion battery technology; each module comprised 52 cells and each rack comprised eight modules. Emissions from a test fire were measured using a probe approximately 3.35 m above ground level. The maximum recorded concentrations are presented in Table 2-2. It should be noted that the report presents concentrations for other gases (such as carbon dioxide and methane), however, only gases considered the most harmful to human health have been considered in this assessment.

Table 2-2   Maximum Gas Concentrations Measured above the Initiating Unit (Ref 7)

Pollutant	Maximum Concentration (ppm)
CO	330
Formaldehyde	56
HCl	100
HCN	15
HF	44
NH_3	1,100
Nitric Oxide (NO)	20

2.3.7   Emissions data were not available in the report for particulates. As such, at the recommendation of the Applicant's Battery Safety and Testing Consultant, particulate emissions data were taken from the Axminster Energy Hub Plume Assessment Study prepared by DNV for Clearstone Energy (Ref 8). The assessment assumed that a battery unit fire is equivalent to a diesel fire for production of Particulate Matter and used a concentration of 0.25 g/m^3. The height at which the concentration was measured was not reported, therefore the same height as that reported in the Quantum Cube Bespoke Unit Testing Summary Report (Ref 7) has been assumed (3.35 m).

2.3.8   The Quantum Cube Bespoke Unit Testing Summary Report (Ref 7) did not report a maximum temperature at the sampling point. As such, the maximum recorded temperature from the roof of another test fire was utilised, at the recommendation of the Applicant's Battery Safety and Testing Consultant. The Sungrow BESS PowerTitan 2.0 Large Scale Burn Test Report prepared by DNV for Sungrow Power Supply Co., Ltd. (Ref 9) reported a maximum roof temperature of 914°C. In lieu of any other suitable data, this was used for the temperature. Roof temperatures can reach 1300°C during a fire; it is therefore considered that using a temperature of 914°C is a conservative estimate as a higher temperature would be expected to increase the buoyancy and aid dispersion.

2.3.9   When modelling a fire in ADMS, the height of the release should be the height of the flames. Maximum flame heights of around 4 m were reported in the Sungrow BESS PowerTitan 2.0 Large Scale Burn Test Report (Ref 9). However, this exceeds the height of the sampling point, therefore the height of the release was assumed to be 3.35 m (height of the sampling point). This is considered a conservative estimate as a higher release height would generally result in increased dispersion.

2.3.10   The plume rise is primarily buoyancy-driven rather than being mechanically expelled like a stack, as such a nominal value of 1 m/s has been used for the velocity to activate the plume rise module (which would not activate if the velocity was 0 m/s).

Meteorological data and surface characteristics

2.3.11   Meteorological data recorded at Bramham meteorological station was used for the air quality modelling as this was the closest, most appropriate station with good data capture for the desired time period. Bramham meteorological station is located approximately 14 km north-west of the BESS Compound and is predominantly surrounded by open agricultural land. In accordance with the EA guidance (Ref 1), models have been run using five years of meteorological data, from 2020 to 2024 inclusive. The meteorological data was obtained from Enviro Data Services which provided hourly meteorological data for each year.

2.3.12   Wind roses for each of the years are presented in Plate 3 to Plate 7. These show that the prevailing wind is from the west/south-west.

Plate 3   2020 Wind Rose for Bramham Meteorological Station
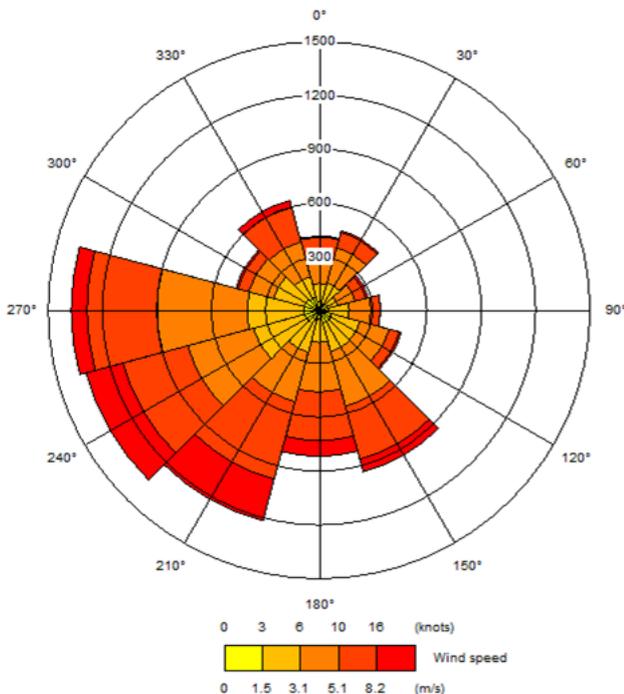
Plate 4   **2021 Wind Rose for Bramham Meteorological Station**
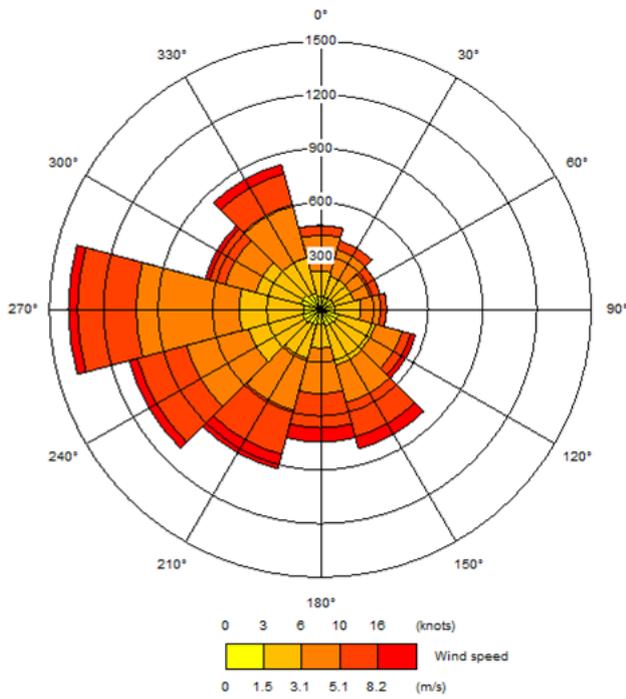
Plate 5   **2022 Wind Rose for Bramham Meteorological Station**
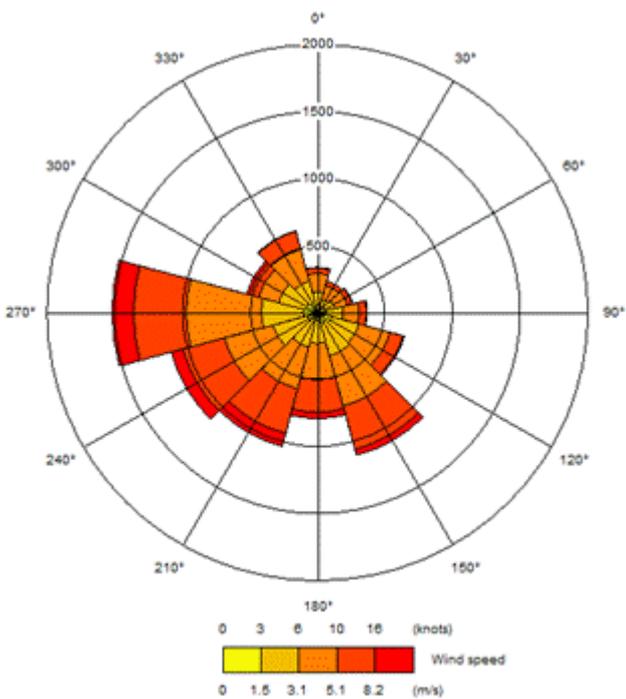
Plate 6   2023 Wind Rose for Bramham Meteorological Station
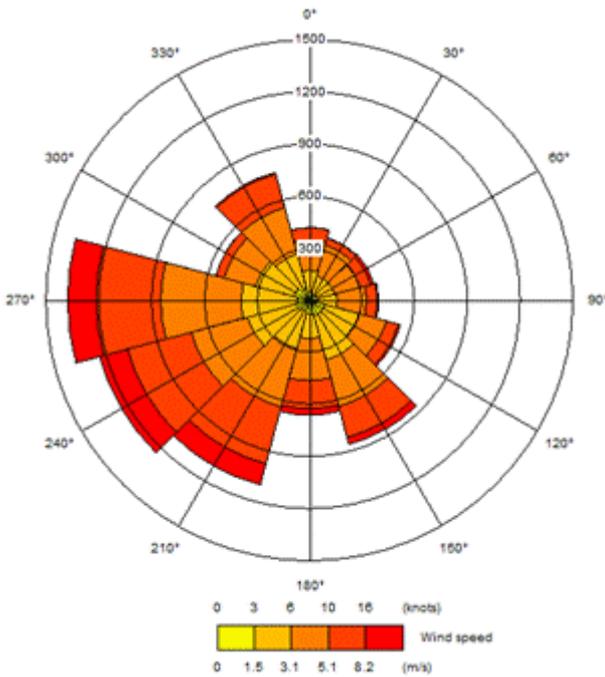
Plate 7   2024 Wind Rose for Bramham Meteorological Station
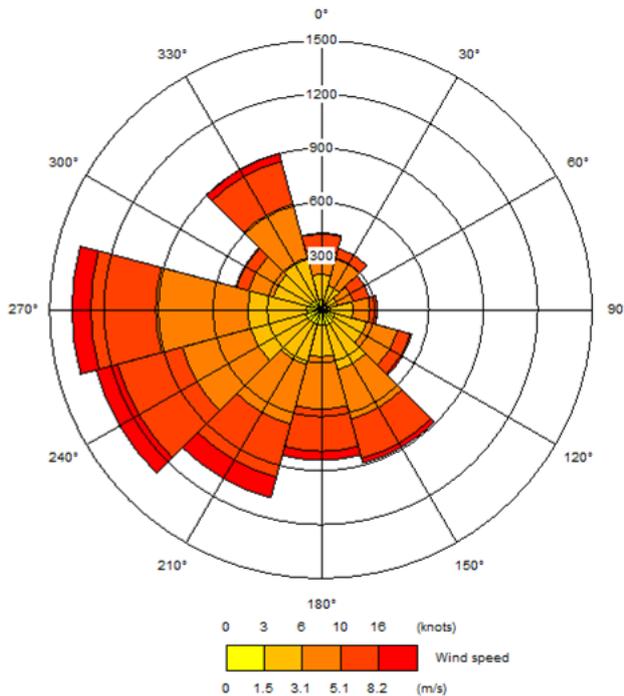
2.3.13   A surface roughness of 0.3 m and minimum Monin-Obukhov length of 10 m was used to represent the predominantly agricultural/rural surroundings of the Proposed Development. These parameters, which are determined by land use, influence wind patterns and atmospheric turbulence affect pollution dispersion. These values were selected as they were judged to be most representative of the predominant land use dispersion characteristics across the Study Area.

2.3.14 Terrain data has been incorporated into the model using 50 m x 50 m resolution terrain data from the Ordnance Survey (OS) OS Terrain 50 dataset. The terrain file covers the Proposed Development and its surroundings.

Emission rates

2.3.15 The data presented in Table 2-2 are measured concentrations at a point 3.35 m above ground level. Emission rates of 1 $g/m^2/s$ were initially used in the model, together with the parameters discussed above (summarised in Table 2-3).

Table 2-3   Parameters used to Derive Emission Rates for use in the Assessment

Parameter		Model Inputs
Area source geometry		6.1 m long and 2.6 m wide
Release height		3.35 m
Velocity		1 m/s
Temperature		914°C
Emission Rate	CO	1 $g/m^2/s$
	Formaldehyde	
	HCl	
	HCN	
	HF	
	NH_3	
	NO	
	PM_{10}	

2.3.16 The resulting concentrations were then compared with the measured concentrations to derive pollutant specific ratios. These ratios were applied to the preliminary emission rates (1 $g/m^2/s$) to derive the emission rates that were used in the assessment. A test model was then set up using the derived emission rates to ensure that the predicted concentrations at the sampling point matched the measured concentrations. The derived emission rates used in the model are presented in Table 2-4.

Table 2-4   Derived Emission Rates used in the Assessment

Pollutant	Emission Rate ($g/m^2/s$)
CO	6.34
Formaldehyde	0.17
HCl	0.31
HCN	0.11
HF	0.85
NH_3	0.03
NO	0.13
PM_{10}	0.45

Receptors

2.3.17   Human receptors have been identified in the vicinity of the Proposed Development using Google Earth imagery and Ordnance Survey mapping. Worst case receptors have been selected at locations closest to the BESS Compound where the public could be exposed to emissions from a potential BESS fire. These include existing residential properties (including gardens) and Public Rights of Way (PROW). There are no additional future receptors associated with committed developments within the 1 km Study Area. The receptor locations are presented in Table 2-5 and in Plate 1.

Table 2-5   Receptor Locations

Receptor	X (m)	Y (m)	Z (m)	Distance to BESS Compound (m)
R1	452781	430632	1.5	379
R2	452770	430582	1.5	331
R3	451995	430257	1.5	555
R4	451995	430214	1.5	553
R5	451998	430635	1.5	691
R6	451997	430611	1.5	678
R7	452155	430862	1.5	757
R8	452194	430875	1.5	748
R9	453554	430817	1.5	915
R10	453540	430810	1.5	900
R11	453405	430886	1.5	853
R12	451914	429600	1.5	724
R13	453263	430105	1.5	353
R14	453410	430110	1.5	500
R15	453362	430143	1.5	457
R16	452929	429650	1.5	401
R17	452806	429096	1.5	905
R18	452790	429163	1.5	836
R19	452728	429065	1.5	916
R20	452671	429092	1.5	879
R21	452646	429134	1.5	834
R22	452666	429018	1.5	951
R23	452628	429001	1.5	964
PROW1	452935	431022	1.5	774

2.3.18   Worst case locations on roads in the vicinity of the BESS Compound were selected for the visibility assessment, as detailed in Table 2-6 below.

Table 2-6   Visibility Assessment Locations

Receptor	Road Name	X (m)	Y (m)	Z (m)	Distance to BESS Compound (m)
ROAD1	A63	452541	429936	1.5	26
ROAD2	A63	452920	430038	1.5	24
ROAD3	A63	452737	429986	1.5	27
ROAD4	A63	452385	429891	1.5	172
ROAD5	A63	453083	430084	1.5	171
ROAD6	Fryston Common Lane	452729	430673	1.5	427
ROAD7	Fryston Common Lane	452607	430619	1.5	391
ROAD8	Fryston Common Lane	452481	430535	1.5	326
ROAD9	Fryston Common Lane	452367	430481	1.5	321
ROAD10	Fryston Common Lane	452218	430457	1.5	409
ROAD11	Common Lane	453615	430246	1.5	726
ROAD12	Common Lane	453571	430369	1.5	726
ROAD13	Common Lane	453545	430550	1.5	772
ROAD14	Fox Lane	453697	430140	1.5	788
ROAD15	Lowfield Road	452053	429744	1.5	535

Model outputs

2.3.19   The model has been used to predict the maximum 10-minute, 30-minute, 1-hour, 4-hour and 8-hour mean pollutant concentrations that would occur at each receptor, based on five years of meteorological data. These maximum concentrations have been compared against the AEGLs shown in Table 2-1 of this report. This approach is considered to be worst-case, as it assumes that a potential fire incident occurs at the same time that the meteorological conditions are poorest for pollution dispersion.

Background concentrations

NO$_2$ and PM$_{10}$

2.3.20   Defra predicted annual mean background maps provided in 1 km x 1 km grid squares (Ref 10) have been used to determine background pollutant concentrations for NO$_2$ and PM$_{10}$ for each receptor location. Base year concentrations (2025) have been used as a worst case as concentrations are predicted to reduce in future years.

CO

2.3.21   Defra Pollution Climate Mapping predicted annual mean background maps provided in 1 km x 1 km grid squares (Ref 10) have been used to determine background pollutant concentrations for CO for each receptor location. The latest year available from the maps is 2010, and maximum 8-hour mean background concentrations were used rather than annual mean concentrations, which is a worst-case assumption.

NH$_3$

2.3.22   The Air Pollution Information System (APIS) annual mean background maps provided in 1 km x 1 km grid squares (Ref 11) have been used to determine background pollutant concentrations for NH$_3$ for each receptor location. The concentrations represent a three-year average for the period 2020 to 2022.

Formaldehyde

2.3.23   As described by the UK Health Security Agency (Ref 12), concentrations of formaldehyde in ambient air are generally below 10 µg/m^3; but may reach 20 µg/m^3 in urban or industrial areas. Given the area surrounding the Proposed Development is predominantly rural, an annual mean background concentration of 10µg/m^3 has been used at all receptors in the assessment.

HF

2.3.24   Very little data exists on concentrations of HF in UK ambient air, but concentrations are expected to be extremely low. An annual mean HF concentration of between 0.06 and 0.23 µg/m^3 was monitored at a UK HF production site between 1991 and 1994 (Ref 13). In the absence of any other data, a background HF concentration of 0.23µg/m^3 has been used for all receptors in the assessment, which is expected to be worst-case given the nature of the measurements.

HCl

2.3.25   The latest annual mean background HCl concentration measured from Ladybower has been used, which corresponds with the year 2015 (Ref 10). Ladybower is part of the UK Eutrophying & Acidifying Atmospheric Pollutants

(UKEAP) Acid Gas and Aerosol Network and is the nearest site with data to the Proposed Development. An annual mean HCl concentration of 0.23 µg/m^3 was measured at this site in 2015 which has been used at all receptors.

HCN

2.3.26   No information is available on background concentrations of HCN, but the concentrations are expected to be negligible and have been assumed to be zero in the assessment.

Short-term background concentrations

2.3.27   In accordance with the EA guidance (Ref 1), it has been assumed that the short-term background concentration of a substance is twice its long-term concentration. As such, all the background concentrations described above were doubled to approximate the short-term background concentrations corresponding with the AEGL exposure periods shown in Table 2-1. The background concentrations used in the assessment are presented in Table 2-7. These background concentrations were added to the model outputs to calculate the total concentration for comparison against the AEGLs.

Table 2-7   Estimated Short-term Background Concentrations

Receptor	Short-term Background Concentration (µg/m^3)							
	CO	Formaldehyde	HCl	HCN	HF	NH$_3$	NO$_2$	PM$_{10}$
R1	2915.8	20.0	0.5	0.0	0.5	3.6	12.9	25.8
R2	2915.8	20.0	0.5	0.0	0.5	3.6	12.9	25.8
R3	2919.0	20.0	0.5	0.0	0.5	3.6	13.3	27.3
R4	2919.0	20.0	0.5	0.0	0.5	3.6	13.3	27.3
R5	2919.0	20.0	0.5	0.0	0.5	3.6	13.3	27.3
R6	2919.0	20.0	0.5	0.0	0.5	3.6	13.3	27.3
R7	2915.8	20.0	0.5	0.0	0.5	3.6	12.9	25.8
R8	2915.8	20.0	0.5	0.0	0.5	3.6	12.9	25.8
R9	2918.2	20.0	0.5	0.0	0.5	3.6	12.8	25.4
R10	2918.2	20.0	0.5	0.0	0.5	3.6	12.8	25.4
R11	2918.2	20.0	0.5	0.0	0.5	3.6	12.8	25.4
R12	2928.6	20.0	0.5	0.0	0.5	3.6	13.7	25.5
R13	2918.2	20.0	0.5	0.0	0.5	3.6	12.8	25.4
R14	2918.2	20.0	0.5	0.0	0.5	3.6	12.8	25.4
R15	2918.2	20.0	0.5	0.0	0.5	3.6	12.8	25.4
R16	2919.4	20.0	0.5	0.0	0.5	3.6	13.1	26.2
R17	2919.4	20.0	0.5	0.0	0.5	3.6	13.1	26.2

| Receptor | Short-term Background Concentration (µg/m³) | | | | | | | |
	CO	Formaldehyde	HCl	HCN	HF	NH_3	NO_2	PM_{10}
R18	2919.4	20.0	0.5	1.0	0.5	3.6	13.1	26.2
R19	2919.4	20.0	0.5	2.0	0.5	3.6	13.1	26.2
R20	2919.4	20.0	0.5	3.0	0.5	3.6	13.1	26.2
R21	2919.4	20.0	0.5	4.0	0.5	3.6	13.1	26.2
R22	2919.4	20.0	0.5	5.0	0.5	3.6	13.1	26.2
R23	2919.4	20.0	0.5	6.0	0.5	3.6	13.1	26.2
PROW1	2914.6	20.0	0.5	7.0	0.5	3.6	13.8	24.1
ROAD1*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26.2
ROAD2*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.8
ROAD3*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26.2
ROAD4*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26.2
ROAD5*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.4
ROAD6*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.8
ROAD7*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.8
ROAD8*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.8
ROAD9*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.8
ROAD10*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.8
ROAD11*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.4
ROAD12*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.4
ROAD13*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.4
ROAD14*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25.4
ROAD15*	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26.2

Background concentrations have been rounded to one decimal place.

*Receptors only considered in visibility assessment, therefore only PM_{10} background required.

Unit conversion

2.3.28   AEGL concentrations are expressed in units of ppm, whereas ADMS-6 outputs are provided in units of µg/m³ and background concentrations are also typically provided in µg/m³. To convert the AEGLs into µg/m³ for comparison against the modelled concentrations, the following equation was used:

AEGL (µg/m³) = molecular weight x AEGL (ppb) ÷ 24.45

2.3.29   The molecular weights for each pollutant used in the assessment are as follows:

1)   CO - 28.01;

2)   Formaldehyde - 30.03;

3) HCL - 36.46;

4) HCN - 27.03;

5) HF - 20.01;

6) NH_3 - 17.03; and

7) NO - 30.01.

3 Results

3.1 Human health

3.1.1 The concentrations presented in Table 3-1 to Table 3-5 are the maximum total concentrations predicted at receptors for 10-minute, 30-minute, 1-hour, 4-hour and 8-hour AEGL averaging periods, respectively. These results represent the highest concentrations predicted across five years of meteorological data. The final column of the table indicates which BESS fire location resulted in the maximum pollutant concentrations at each receptor. The results indicate that the highest concentrations for all pollutants were predicted at receptor R16 for the 10-minute and 30-minute exposure periods and receptor R2 for the 1-hour, 4-hour and 8-hour exposure periods. The maximum concentrations predicted at R16 resulted from a fire at the BESS 2 location and the maximum concentrations predicted at R2 resulted from a fire at the BESS 4 location. R2 is the garden of a residential receptor, closest to the BESS Compound, located approximately 331 m to the north of BESS 4. R16 is a residential receptor located approximately 401 m south of BESS 2.

3.1.2 The predicted maximum PM_{10} concentrations were all well below the 8-hour HSE WEL and the predicted maximum CO concentrations were well below the relevant WHO guideline values for all exposure periods. All other pollutant maximum concentrations were well below AEGL level 1 (notable discomfort, irritation, or certain asymptomatic non-sensory effects) for all exposure periods.

3.1.3 It should be noted that emissions data was available for NO rather than NO_2. However, there are no AEGLs available for NO and the AEGL guidelines state that "AEGL values for nitrogen dioxide should be used for emergency planning" rather than NO (Ref 2). As such, for the purposes of this assessment, it has been assumed that 100% of the modelled NO concentrations are NO_2, which is a worst-case assumption given that not all NO would be oxidised to NO_2, particularly over shorter averaging periods.

Table 3-1   Maximum Modelled 10-Minute Mean Concentrations including Backgrounds

Receptor	Maximum 10-Minute Mean Concentration including Background (µg/m^3)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH$_3$	NO$_2$	PM$_{10}$	
R1	4374.3	59.7	71.4	25.1	196.4	10.5	43.2	129.8	BESS 4
R2	4655.5	67.4	85.1	29.9	234.2	11.8	49.1	149.8	BESS 4
R3	3877.5	46.1	47.1	16.5	129.2	8.1	33.2	95.6	BESS 5
R4	3877.5	46.1	47.1	16.5	129.2	8.1	33.2	95.6	BESS 5
R5	3736.4	42.3	40.3	14.0	110.3	7.4	30.3	85.6	BESS 5
R6	3742.8	42.4	40.6	14.2	111.1	7.5	30.4	86.0	BESS 5
R7	3717.9	41.9	39.5	13.8	108.2	7.4	29.6	83.0	BESS 4
R8	3739.6	42.4	40.6	14.2	111.1	7.5	30.0	84.5	BESS 3
R9	3735.0	42.3	40.2	14.0	110.2	7.4	29.8	83.6	BESS 5
R10	3736.5	42.3	40.3	14.1	110.4	7.5	29.8	83.7	BESS 5
R11	3755.4	42.8	41.2	14.4	112.9	7.5	30.2	85.1	BESS 5
R12	3739.7	42.1	40.0	13.9	109.4	7.4	30.6	83.3	BESS 3
R13	4572.1	65.1	81.0	28.4	222.6	11.4	47.2	143.3	BESS 3
R14	3985.5	49.1	52.4	18.3	143.8	8.6	35.0	101.5	BESS 3
R15	4216.6	55.4	63.7	22.3	174.9	9.7	39.8	118.0	BESS 3
R16	4865.3	73.0	95.2	33.4	261.8	12.8	53.6	164.9	BESS 2
R17	3706.7	41.4	38.8	13.5	106.2	7.3	29.5	82.3	BESS 4
R18	3682.2	40.8	37.6	13.1	103.0	7.2	29.0	80.6	BESS 5
R19	3716.1	41.7	39.3	13.7	107.5	7.4	29.7	83.0	BESS 2
R20	3708.2	41.5	38.9	13.6	106.4	7.3	29.5	82.4	BESS 1
R21	3711.6	41.6	39.0	13.6	106.9	7.3	29.6	82.7	BESS 1
R22	3689.4	41.0	38.0	13.2	103.9	7.2	29.1	81.1	BESS 4

Receptor	Maximum 10-Minute Mean Concentration including Background (µg/m³)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH₃	NO₂	PM₁₀	
R23	3704.0	41.4	38.7	13.5	105.9	7.3	29.4	82.1	BESS 5
PROW1	3723.5	42.0	39.9	13.9	109.1	7.4	30.6	81.8	BESS 3
Maximum	**4865.3**	**73.0**	**95.2**	**33.4**	**261.8**	**12.8**	**53.6**	**164.9**	**BESS 2**
AEGL 1 (µg/m³)	*100,000	1105	2684	2764	818	20,986	941	**4000	-
Maximum as % AEGL 1	*4.9%	6.6%	3.5%	1.2%	32.0%	0.1%	5.7%	**4.1%	-

*No AEGL 1 for CO so WHO 15-minute guideline used. **No AEGL for PM₁₀ so 8-hour HSE WEL used.

Table 3-2   Maximum Modelled 30-Minute Mean Concentrations including Backgrounds

Receptor	Maximum 30-Minute Mean Concentration including Background (µg/m³)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH₃	NO₂	PM₁₀	
R1	4298.7	57.7	67.8	23.8	186.2	10.1	41.6	124.4	BESS 4
R2	4584.6	65.5	81.7	28.7	224.6	11.5	47.6	144.8	BESS 4
R3	3800.4	44.0	43.4	15.1	118.9	7.7	31.6	90.1	BESS 5
R4	3802.1	44.1	43.5	15.2	119.1	7.8	31.7	90.3	BESS 5
R5	3638.8	39.6	35.5	12.4	97.2	7.0	28.3	78.6	BESS 5
R6	3651.7	40.0	36.1	12.6	98.9	7.0	28.5	79.5	BESS 5
R7	3592.5	38.4	33.4	11.6	91.4	6.8	27.0	74.0	BESS 5
R8	3607.5	38.8	34.1	11.9	93.4	6.9	27.3	75.1	BESS 5
R9	3549.7	37.2	31.2	10.8	85.3	6.6	25.9	70.4	BESS 4
R10	3549.4	37.2	31.2	10.8	85.3	6.6	25.9	70.4	BESS 4
R11	3557.1	37.4	31.6	11.0	86.3	6.6	26.1	70.9	BESS 4
R12	3594.4	38.1	32.9	11.4	89.9	6.7	27.5	73.0	BESS 1

Receptor	Maximum 30-Minute Mean Concentration including Background (µg/m³)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH₃	NO₂	PM₁₀	
R13	4479.7	62.5	76.5	26.8	210.2	11.0	45.3	136.7	BESS 3
R14	3912.2	47.1	48.9	17.1	134.0	8.3	33.5	96.3	BESS 3
R15	4108.7	52.4	58.4	20.5	160.4	9.2	37.5	110.3	BESS 3
R16	4666.8	67.6	85.5	30.0	235.2	11.8	49.4	150.8	BESS 2
R17	3525.4	36.5	30.0	10.4	81.9	6.5	25.7	69.4	BESS 4
R18	3543.3	37.0	30.8	10.7	84.3	6.5	26.1	70.7	BESS 1
R19	3532.4	36.7	30.3	10.5	82.8	6.5	25.8	69.9	BESS 2
R20	3530.6	36.7	30.2	10.5	82.6	6.5	25.8	69.8	BESS 1
R21	3550.1	37.2	31.2	10.8	85.2	6.6	26.2	71.2	BESS 3
R22	3529.9	36.6	30.2	10.5	82.5	6.5	25.8	69.7	BESS 1
R23	3522.9	36.4	29.9	10.4	81.6	6.4	25.6	69.2	BESS 2
PROW1	3580.4	38.1	32.9	11.4	89.9	6.7	27.6	71.6	BESS 4
Maximum	4666.8	67.6	85.5	30.0	235.2	11.8	49.4	150.8	BESS 2
AEGL 1 (µg/m³)	*35,000	1105	2684	2764	818	20,896	941	**4000	-
Maximum as % AEGL 1	*13.3%	6.1%	3.2%	1.1%	28.8%	0.1%	5.2%	**3.8%	-

*No AEGL 1 for CO so WHO 1-hour guideline used. **No AEGL for PM₁₀ so 8-hour HSE WEL used.

Table 3-3   Maximum Modelled 1-Hour Mean Concentrations including Backgrounds

Receptor	Maximum 1-Hour Mean Concentration including Background (µg/m³)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH₃	NO₂	PM₁₀	
R1	4215.8	55.4	63.7	22.3	175.1	9.7	39.9	118.5	BESS 4
R2	4492.6	63.0	77.2	27.1	212.3	11.0	45.7	138.2	BESS 4
R3	3713.2	41.6	39.1	13.6	107.2	7.3	29.8	83.9	BESS 5
R4	3724.3	41.9	39.7	13.8	108.7	7.4	30.0	84.7	BESS 5
R5	3556.5	37.4	31.5	11.0	86.1	6.6	26.6	72.7	BESS 5
R6	3570.1	37.7	32.2	11.2	88.0	6.7	26.8	73.7	BESS 5
R7	3507.8	36.1	29.3	10.2	80.0	6.4	25.2	68.0	BESS 5
R8	3523.6	36.6	30.1	10.4	82.1	6.5	25.5	69.1	BESS 5
R9	3441.6	34.3	26.0	9.0	70.8	6.1	23.7	62.7	BESS 4
R10	3445.2	34.4	26.1	9.1	71.3	6.1	23.8	63.0	BESS 4
R11	3457.2	34.7	26.7	9.3	72.9	6.1	24.0	63.8	BESS 4
R12	3506.4	35.7	28.6	9.9	78.1	6.3	25.7	66.7	BESS 1
R13	4366.1	59.5	70.9	24.9	195.0	10.4	42.9	128.6	BESS 3
R14	3834.8	45.0	45.1	15.7	123.6	7.9	31.9	90.7	BESS 3
R15	3986.5	49.1	52.5	18.4	144.0	8.6	35.0	101.6	BESS 3
R16	4457.6	61.9	75.3	26.4	207.1	10.8	45.1	135.9	BESS 2
R17	3431.5	34.0	25.4	8.8	69.3	6.0	23.7	62.7	BESS 1
R18	3458.4	34.7	26.7	9.3	72.9	6.1	24.3	64.6	BESS 1
R19	3422.0	33.7	24.9	8.6	68.0	6.0	23.5	62.0	BESS 2
R20	3436.8	34.1	25.7	8.9	70.0	6.0	23.9	63.1	BESS 1
R21	3451.1	34.5	26.4	9.1	71.9	6.1	24.2	64.1	BESS 1
R22	3412.6	33.4	24.5	8.5	66.7	5.9	23.4	61.4	BESS 1
R23	3411.3	33.4	24.4	8.5	66.6	5.9	23.3	61.3	BESS 1

Receptor	Maximum 1-Hour Mean Concentration including Background ($\mu g/m^3$)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH_3	NO_2	PM_{10}	
PROW1	3492.0	35.7	28.6	9.9	78.1	6.3	25.8	65.3	BESS 4
Maximum	4492.6	63.0	77.2	27.1	212.3	11.0	45.7	138.2	BESS 4
AEGL 1 ($\mu g/m^3$)	*35,000	1105	2684	2211	818	20,896	941	**4000	-
Maximum as % AEGL 1	*12.8%	5.7%	2.9%	1.2%	26.0%	0.1%	4.9%	**3.5%	-

*No AEGL 1 for CO so WHO 1-hour guideline used. **No AEGL for PM_{10} so 8-hour HSE WEL used.

Table 3-4   Maximum Modelled 4-Hour Mean Concentrations including Backgrounds

Receptor	Maximum 4-Hour Mean Concentration including Background ($\mu g/m^3$)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH_3	NO_2	PM_{10}	
R1	4163.9	54.0	61.2	21.4	168.1	9.5	38.8	114.8	BESS 4
R2	4383.6	60.0	71.9	25.2	197.6	10.5	43.4	130.4	BESS 4
R3	3610.3	38.8	34.1	11.9	93.3	6.9	27.7	76.6	BESS 5
R4	3654.8	40.0	36.3	12.6	99.3	7.1	28.6	79.8	BESS 5
R5	3480.2	35.3	27.8	9.6	75.9	6.2	25.0	67.3	BESS 5
R6	3508.0	36.0	29.2	10.1	79.6	6.4	25.5	69.3	BESS 5
R7	3459.9	34.8	27.0	9.3	73.6	6.2	24.2	64.6	BESS 5
R8	3448.0	34.5	26.4	9.1	72.0	6.1	24.0	63.7	BESS 5
R9	3392.1	32.9	23.6	8.1	64.2	5.8	22.7	59.2	BESS 4
R10	3394.7	33.0	23.7	8.2	64.5	5.8	22.7	59.4	BESS 4
R11	3384.6	32.7	23.2	8.0	63.1	5.8	22.5	58.6	BESS 4
R12	3427.6	33.6	24.8	8.6	67.5	5.9	24.1	61.1	BESS 1
R13	4284.4	57.2	67.0	23.5	184.0	10.0	41.2	122.8	BESS 3

Receptor	Maximum 4-Hour Mean Concentration including Background ($\mu g/m^3$)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH_3	NO_2	PM_{10}	
R14	3762.2	43.0	41.6	14.5	113.8	7.6	30.3	85.6	BESS 3
R15	3894.1	46.6	48.0	16.8	131.6	8.2	33.1	95.0	BESS 3
R16	4021.0	50.0	54.1	18.9	148.4	8.8	36.0	104.7	BESS 2
R17	3324.2	31.0	20.2	7.0	54.9	5.5	21.5	55.1	BESS 1
R18	3360.3	32.0	21.9	7.6	59.7	5.7	22.3	57.6	BESS 1
R19	3350.5	31.7	21.5	7.4	58.4	5.6	22.1	56.9	BESS 2
R20	3331.1	31.2	20.5	7.1	55.8	5.5	21.7	55.5	BESS 2
R21	3348.0	31.7	21.3	7.4	58.1	5.6	22.0	56.8	BESS 1
R22	3302.6	30.4	19.1	6.6	52.0	5.4	21.1	53.5	BESS 2
R23	3292.1	30.2	18.6	6.4	50.6	5.4	20.8	52.8	BESS 1
PROW1	3453.1	34.7	26.7	9.3	72.8	6.1	25.0	62.5	BESS 4
Maximum	4383.6	60.0	71.9	25.2	197.6	10.5	43.4	130.4	BESS 4
AEGL 1 ($\mu g/m^3$)	*10,000	1105	2684	1437	818	20,896	941	**4000	-
Maximum as % AEGL 1	*43.8%	5.4%	2.7%	1.8%	24.2%	0.1%	4.6%	**3.3%	-

*No AEGL 1 for CO so WHO 8-hour guideline used. **No AEGL for PM_{10} so 8-hour HSE WEL used.

Table 3-5   **Maximum Modelled 8-Hour Mean Concentrations including Backgrounds**

Receptor	Maximum 8-Hour Mean Concentration including Background (µg/m³)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH₃	NO₂	PM₁₀	
R1	4082.4	51.8	57.2	20.0	157.2	9.1	37.2	109.0	BESS 4
R2	4292.9	57.5	67.5	23.7	185.5	10.1	41.5	124.0	BESS 4
R3	3525.5	36.5	30.0	10.4	82.0	6.5	25.9	70.5	BESS 5
R4	3585.6	38.2	32.9	11.5	90.0	6.7	27.2	74.8	BESS 5
R5	3440.1	34.2	25.8	9.0	70.5	6.1	24.1	64.4	BESS 5
R6	3461.1	34.8	26.9	9.3	73.3	6.2	24.6	65.9	BESS 5
R7	3401.9	33.2	24.1	8.3	65.8	5.9	23.0	60.5	BESS 5
R8	3405.8	33.4	24.3	8.4	66.3	5.9	23.1	60.7	BESS 5
R9	3264.5	29.4	17.3	5.9	47.0	5.2	20.0	50.1	BESS 4
R10	3266.0	29.5	17.4	6.0	47.2	5.2	20.0	50.2	BESS 4
R11	3322.6	31.0	20.2	6.9	54.8	5.5	21.2	54.2	BESS 4
R12	3420.1	33.4	24.4	8.4	66.5	5.9	23.9	60.5	BESS 1
R13	4223.9	55.6	64.0	22.4	175.9	9.7	39.9	118.5	BESS 3
R14	3721.2	41.9	39.6	13.8	108.4	7.4	29.5	82.6	BESS 3
R15	3885.1	46.3	47.5	16.6	130.4	8.2	32.9	94.3	BESS 3
R16	4003.4	49.5	53.2	18.6	146.1	8.7	35.6	103.5	BESS 2
R17	3295.1	30.2	18.8	6.5	51.0	5.4	20.9	53.0	BESS 1
R18	3323.5	31.0	20.2	6.9	54.8	5.5	21.5	55.0	BESS 1
R19	3293.0	30.2	18.7	6.4	50.7	5.4	20.9	52.8	BESS 2
R20	3310.8	30.7	19.5	6.7	53.1	5.4	21.2	54.1	BESS 2
R21	3324.1	31.0	20.2	7.0	54.9	5.5	21.5	55.1	BESS 2
R22	3281.6	29.9	18.1	6.2	49.1	5.3	20.6	52.0	BESS 2
R23	3267.7	29.5	17.4	6.0	47.3	5.2	20.3	51.0	BESS 2

Receptor	Maximum 8-Hour Mean Concentration including Background ($\mu g/m^3$)								Corresponding BESS Location
	CO	Formaldehyde	HCl	HCN	HF	NH_3	NO_2	PM_{10}	
PROW1	3378.1	32.6	23.0	8.0	62.7	5.8	23.4	57.1	BESS 4
Maximum	4292.9	57.5	67.5	23.7	185.5	10.1	41.5	124.0	BESS 4
AEGL 1 ($\mu g/m^3$)	*10,000	1105	2684	1106	818	20,896	941	**4000	-
Maximum as % AEGL 1	42.9%	5.2%	2.5%	2.1%	22.7%	0.0%	4.4%	3.1%	-

*No AEGL 1 for CO so WHO 8-hour guideline used. **No AEGL for PM_{10} so 8-hour HSE WEL used.

3.2 Visibility

3.2.1 Table 3-6 presents the modelled PM_{10} concentrations and corresponding predicted visibility at the modelled points corresponding with the closest sections of road network to the BESS Compound.

Table 3-6 Maximum Modelled 10-Minute Mean PM_{10} Concentrations including Backgrounds

Receptor	Road Name	Maximum 10-Minute PM_{10} Concentration (including Background) ($\mu g/m^3$)	BESS Location where Maximum Concentration was Modelled	Predicted Approximate Visibility (m)	Predicted Approximate Visibility (km)
ROAD1	A63	2155.7	BESS 1	183.1	0.2
ROAD2	A63	2701.5	BESS 3	146.1	0.1
ROAD3	A63	2276.9	BESS 2	173.4	0.2
ROAD4	A63	289.4	BESS 1	1364.0	1.4
ROAD5	A63	294.9	BESS 3	1338.6	1.3
ROAD6	Fryston Common Lane	122.9	BESS 4	3211.1	3.2
ROAD7	Fryston Common Lane	122.6	BESS 5	3219.5	3.2
ROAD8	Fryston Common Lane	160.5	BESS 5	2460.0	2.5
ROAD9	Fryston Common Lane	159.1	BESS 5	2480.9	2.5
ROAD10	Fryston Common Lane	124.1	BESS 5	3182.0	3.2
ROAD11	Common Lane	87.2	BESS 3	4529.0	4.5
ROAD12	Common Lane	82.5	BESS 5	4787.6	4.8
ROAD13	Common Lane	83.8	BESS 5	4710.9	4.7
ROAD14	Fox Lane	84.3	BESS 5	4684.5	4.7
ROAD15	Lowfield Road	95.2	BESS 1	4145.2	4.1

3.2.2 As indicated in Table 3-6, the lowest visibility predicted on local roads occurs at ROAD2, which represents the A63, 24 m south east of the BESS Compound. The worst-case visibility distance predicted at this location because of smoke from a BESS fire is 146.1 m, which is twice the vehicle stopping distance at the national speed limit for this road (the typical braking distance is 73 m for a car travelling at 60 mph (Ref 14)). It should be reiterated that these visibility calculations assume that a fire occurs at the closest BESS enclosure to the road and that this happens to coincide with the worst possible meteorological conditions for pollution dispersion at that road location (worst hour for dispersion across five years of meteorological data). Furthermore, the equation used to determine visibility is based on certain assumptions and therefore has inherent limitations.

4 Uncertainty

4.1.1   Uncertainty in dispersion modelling predictions can be associated with a number of different factors, including:

1) Model uncertainty due to model limitations;

2) Data uncertainty due to errors in input data, including emissions estimates, background estimates and meteorology; and

3) Variability due to randomness of measurements used.

4.1.2   Potential uncertainties in model results have been minimised as practicable and worst-case inputs used in the absence of definitive information. This encompassed the following:

1) Choice of model – ADMS-6 is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible;

2) Meteorological data – Modelling was undertaken using five years of meteorological datasets from the closest observation site to the Proposed Development. The highest concentrations predicted by the model over these five years were reported at the worst-case human and visibility receptors;

3) Receptor locations – The closest human and visibility receptors to the BESS Compound were selected as these are expected to experience the greatest impacts from the fire; and

4) Variability - All model inputs are as accurate as possible and worst-case conditions have been considered where necessary in order to ensure a robust assessment of potential pollutant concentrations.

4.1.3   It is considered that the use of the stated measures to reduce uncertainty and the use of worst-case assumptions when necessary has resulted in model accuracy of an acceptable level.

5 Assumptions and limitations

5.1.1   The following assumptions have been made within this assessment:

1) Modelling accounts for a steady burn as recorded during Large Scale Fire Testing (LSFT) as a result of a multiple cell thermal runaway occurring within a single battery module in one BESS enclosure. The BESS facility will be designed with multiple layers of protection to mitigate and minimise the probability of a fire or thermal runaway incident as outlined in the oBSMP [**EN0110012/APP/LVS/07.06**]. It is therefore assumed that the fire would be limited to one BESS enclosure;

2) It is assumed that Prismatic LFP batteries would be used. This is considered to be a reasonable worst case for the purposes of the assessment in terms of BESS toxic gas emission potential;

3) Batteries are sealed by design so do not vent when in normal use and have no free electrolyte;

4) The batteries will be controlled by charging management systems that will detect if a cell or battery is not operating correctly;

5) It is assumed that one BESS Enclosure is 2.438 m in height, 6.058 m long and 2.591 m wide. It should be noted that the dimensions detailed in Chapter 2: The Proposed Development (ES Volume 1) [**EN0110012/APP/LVS/06.01.02**] state the maximum footprint of the BESS containers would be 16 m long and 3 m wide, however in reality the BESS enclosure/unit sizes are likely to be significantly smaller. Using a smaller enclosure footprint increases the calculated emission rate per square meter (g/m²/s), as the same total emissions are released over a smaller area. Therefore, in order to assess the most accurate emissions release, the concept design have been derived based on the GridSolv Quantum Cube Bespoke Unit Testing Summary Report, prepared by Fire & Risk Alliance LLC for Wartsila North America, Inc. (Ref 7), at the recommendation of the Applicant's Battery Safety and Testing Consultant.;

6) The emission release height has been modelled at 3.35 m;

7) A nominal value of 1 m/s has been used for the velocity to activate the plume rise module;

8) Modelling is based on a test fire where each module comprised 52 cells and each rack comprised eight modules;

9) Emissions data for BESS fires are limited and have come from a range of sources. Worst case parameters have been used where possible;

10) There is limited real world data collated on fires associated with solar schemes. No suitable emissions data was found for particulates. As such, the assessment assumed that a battery enclosure/unit fire in the BESS is equivalent to a diesel fire for production of PM as recommended by the Applicant's Battery Safety and Testing Consultant and as done for previous assessments such as the Axminster Energy Hub Plume Assessment Study prepared by DNV for Clearstone Energy (Ref 8);

11) Due to the limited availability of data on fires associated with solar schemes, emissions data was available for NO rather than NO_2. For the purposes of this assessment, it has been assumed that modelled NO concentrations are NO_2, as a worst case (NO converts to NO_2 in the atmosphere, and NO_2 is considered more harmful in terms of its health effects);

12) There is no AEGL for particulates. As such, the Health and Safety Executive (HSE) Workplace Exposure Limit (WEL) (Ref 3) has been used

which is 4 mg/m^3 for respirable dust. Whilst this is over an 8-hour reference period, it is considered appropriate for use in the assessment in lieu of any other limits;

13) There is no AEGL 1 for CO. As such, CO concentrations have been compared against the World Health Organisation (WHO) CO guideline values of 100 mg/m^3 for 15-minute average, 35 mg/m^3 for 1-hour average and 10 mg/m^3 for 8-hour average (Ref 4);

14) Visibility is affected not only by particulate concentrations, but by a range of factors including smoke composition, particulate size distribution, humidity levels, light conditions etc, therefore the visibility assessment is considered to be high level, as such detailed conclusions should not be drawn from the results;

15) There were no background concentrations available for HCN. However, it is considered that background concentrations for this pollutant would be negligible;

16) In accordance with the EA guidance (Ref 1), it has been assumed that the short-term background concentration of a substance is twice its long-term concentration. As such, the background concentrations obtained for the assessment were doubled to approximate short-term background concentrations; and

17) The building effects option in ADMS 6 is not applicable to area sources. The dispersion of pollutants released from elevated sources can be influenced by the presence of buildings close to the emission point. The only building in the vicinity of the BESS Compound would be for the proposed substation located directly to the west. As the BESS fire emissions have been modelled as an area source and not a point source, building dispersion effects have not been incorporated into the modelling.

6 Mitigation

6.1.1 Prior to the commencement of construction of the BESS, Light Valley Solar Limited (the 'Applicant') will be required to prepare a BSMP. This will build upon the mitigation secured in the oBSMP [**EN0110012/APP/LVS/07.06**] submitted as part of this application. As part of preparation of the BSMP, the Applicant will incorporate the latest good practices for battery storage safety, failure detection and prevention, along with the emergency response planning, as guidance continues to develop in the UK and internationally. The following measures relating to air quality have been included:

1) Notification of potentially affected residents including advice on the health effects of smoke and ways to reduce exposure (e.g. close windows and stay indoors) in the event of a BESS fire;

2) Should there be a BESS fire in close proximity to the road, the site operator is to determine wind direction and seek to close the road if deemed necessary;

3) Notification of potentially affected members of the public to move to a cleaner air location in the event of a BESS fire; and

7 Conclusion

7.1.1 Based on the factors of distance to the nearest locations of human exposure and the anticipated short-term nature of a fire incident, the assessment concludes that there would be **no significant** air quality effects as a result of a BESS fire incident. It is also worth noting that an oBSMP [**EN0110012/APP/LVS/07.06**] has been produced as part of this application and identifies how the Applicant will use good industry practice to reduce risk to life, property, and the environment in the rare event of a BESS fire.

7.1.2 Notwithstanding, whilst there is low risk of adverse air quality effects at the closest receptors, the Emergency Response Plan produced at the detailed design stage will incorporate all necessary emergency response procedures and actions based upon thermal runaway test data supplied by the BESS system provider.

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