Appendix 11D

Acoustic Modelling Details

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APPENDIX 11D: ACOUSTIC MODELLING DETAILS

Site Layout

The Site Layout is based on Drawing Number "S7060-8310-0001AO1 Proposed Site Layout R8.0.pdf", refer to planning drawings.

Acoustic Modelling Input Data

Data Sources

Data sources used for construction sound modelling were reviewed and approved by the Applicant and have been based on a representative equipment lists used for similar scale power station developments in the UK & Ireland.

Data sources used for operational and construction sound modelling were provided by the Applicant in document "S7060-0100-0011AMB AECOM noise RFI request V2.xlsx" and have been based on representative equipment created by Fichtner and provided to the Applicant.

Sound Source Sound Power Levels

Construction Phase

A table of construction plant and associated on-time and broadband A-weighted sound power levels is provided below in Table 11D.1. For the Above Ground Installation (AGI) and in Table 11D.2 for Power Plant Area.

Construction noise sound sources were modelled:

- As area sources 3m high covering three areas, the main power plant, the adjacent 220kV substation area and the 400kV substation to the south as shown in Figure 11.3A and 11.3B (refer to EIAR Volume I Chapter 11: Noise and Vibration).
- The level applied to the construction area source was calculated from the combined sound power levels of all plant used for the named stage in the quantity specified, and for the percentage on-times provided.
- A total sound power level for each stage of the AGI and PPA construction was determined by the logarithmic summation of all plant sound power levels accounting for any associated on-time correction.
- The highest AGI construction stage and the highest PPA construction stage were combined to determine a conservative construction sound power level assumption.
- Sound propagation from the construction activity has been undertaken using BS 5228-2.

Table 11D.1 AGI Construction Plant, Quantities and Percent On-Times

Plant / Equipment	Sound Power Level (dBA) Ref. from BS 5228	% On Time (based on 12 hr day)	Stage of work					
			Site Access Preparation	Site Fencing	Pre and post construction land drainage	Topsoil Strip	Right of way preparation	Construction
20T backhoe	99	91	2	2	1	0	0	0
JCB (3CX)	97	91	2	2	2	0	1	2
Quad bike	82	91	0	1	0	0	0	0
Tractor & trailer	107	91	2	2	0	0	2	0
Stone wagons	107	91	0	0	6	0	4	0
Mastenbroek trencher	98	91	0	0	1	0	0	0
Stone carts	95	91	0	0	4	0	0	0
30T backhoe	108	91	0	0	0	3	0	0
CAT D5	106	91	0	0	0	1	0	0
CAT D6	109	91	0	0	0	1	0	2
CAT D8	114	91	0	0	0	3	0	0
25T backhoe	105	91	0	0	0	0	2	2
Stone compactor (Teran)	106	91	0	0	0	0	1	0
Tractor (Cat 583 or equivalent) with sideboom	108	91	0	0	0	0	0	2
Purpose-made welding rig, lorry mounted	108	91	0	0	0	0	0	3
Tracked crane 50t	103	91	0	0	0	0	0	1
Lorry ordinary up to 18t	111	91	0	0	0	0	0	2
Small tools	108	91	0	0	0	0	0	1
Dumper	105	91	0	0	0	0	0	2
Stone roller	107	91	0	0	0	0	0	2
Generator for welding	85	91	0	0	0	0	0	1
Angle grinder	108	91	0	0	0	0	0	1

Table 11D.2 Power Plant Area Demolition & Construction Plant, Quantities and Percent On-Times

Plant / Equipment	Sound Power Level (dBA) Ref. from BS 5228	% On Time (based on 12 hr day)	Stage of work					
			Site Clearance	Piling and Foundation Works	Building and General Site Activities	Fit Out	Landscaping	Demolition
Compressors	108	60	2	6	6	6	0	3
Hand held pneumatic breaker	111	60	3	0	0	0	0	3
Dump truck (tipping fill)	107	60	2	2	0	0	0	2
Dump truck (passby)	115	60	3	3	0	0	0	3
Wheeled loader	108	60	0	0	2	0	0	0
Lorry (delivery and collection)	108	60	4	6	6	6	0	2
Water pump (20 kW)	93	60	0	0	1	0	0	0
Pre-cast concrete piling hydraulic hammer rig	117	60	0	4	0	0	0	0
Hand-held welder (welding piles)	101	60	0	1	0	0	0	0
Generator for welding	101	60	0	1	0	0	0	0
Dumper (idling)	91	60	0	0	1	0	0	0
Wheeled backhoe loader	95	60	0	0	2	0	0	0
Tracked excavator	99	60	5	5	5	0	0	5
Concrete mixer truck	108	60	6	10	10	0	0	6
Truck mounted concrete pump and boom arm	108	60	0	3	3	0	0	0
Poker vibrator	106	60	0	0	1	0	0	0
Wheeled mobile telescopic crane	106	60	2	4	4	4	0	2
Tower crane	105	60	1	2	2	2	0	1
Lorry with lifting boom	105	60	1	0	0	1	0	1
Lifting platform	95	60	0	0	0	1	0	0
Fork lift truck	103	60	0	0	4	1	0	0

Plant / Equipment	Sound Power Level (dBA) Ref. from BS 5228	% On Time (based on 12 hr day)	Stage of work					
			Site Clearance	Piling and Foundation Works	Building and General Site Activities	Fit Out	Landscaping	Demolition
Mini tracked excavator	102	60	0	0	0	1	0	0
Electric core drill (drilling concrete)	113	60	0	0	1	1	0	0
Concrete floor cutter	119	60	0	0	1	1	0	0
Hand-held circular saw (cutting paving slabs)	112	60	0	0	0	1	0	0
Roller	101	60	0	0	0	0	1	0
Diesel generator for site cabins	94	60	4	2	2	2	1	2
Diesel generator for site lighting	93	60	1	2	2	2	1	1
Road sweeper	96	60	1	1	1	1	1	1
Angle grinder	108	60	1	1	1	1	0	1
Hand-held cordless nail gun	101	60	0	0	0	1	0	0
Road planer (road construction)	110	60	0	0	1	0	0	0
Vibratory compactor (asphalt)	110	60	0	0	1	0	0	0
Asphalt paver + tipper lorry	105	60	0	0	1	0	0	0
Electric water pump	96	60	2	2	2	2	0	2
Screen stockpiler	115	75	0	0	0	0	0	1
Concrete breaker on wheeled backhoe	120	75	0	0	0	0	0	3
Tracked crusher	112	75	0	0	0	0	0	1

Operational Phase

Operational sound sources were modelled using the following:

- ISO 9613-2 “Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation” describes a detailed procedure to calculate sound levels from point sources. Area and line sound sources are divided into component point sound sources. CadnaA 2002 MR2 was used to implement the calculation methodology for operational phase predictions. Further details about the prediction methodology is given below under Prediction Methodology section.
- Point sources - with an associated sound power level and elevation above ground.
- Area sources - As a box made up of four noise emitting walls and a roof according to the stated dimensions mentioned in the following section. The reported sound power level was distributed evenly over the total surface area in the absence of any detailed information about any bias in the directional characteristics of the sound emissions. Note the dimensions are only representative for modelling purposes.
- The octave frequency spectrums for each sound source are provided below in Table 11D.3.
- The dimensions used to represent sources in the model provided in Table 11D.4. Sources represented by point sources are not quoted with physical dimensions for the purpose of the noise modelling only.
- A 5m high blast wall barrier on the south, north and east side of the OCGT Transformer (S20).
- An 11m high 3-sided blast wall barrier around each of the two 440kV transformers.

Please note that a diagram of the operational area and point sound sources are provided in Figure 11.4A and 11.4B (refer to EIAR Volume I Chapter 11: Noise and Vibration).

Table 11D.3 List of all Sound Sources and applied Spectrums

Name	ID	Octave Band Hz								
		31.5	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Turbine and steam turbine halls	S1	120	112	105	88	83	86	79	80	78
Air inlet filters	S2	120	112	105	88	83	86	79	80	78
HRSG buildings	S3	125	116	104	95	91	90	87	85	92
HRSG Stack	S4	94	85	84	87	84	75	70	58	61
Electrical building	S5	99	96	96	86	72	56	59	61	60
Feedwater pump building	S6	91	95	94	83	72	65	63	61	58
Generator transformers	S7	74	86	99	97	83	84	76	64	63
Workshop and stores	S8	102	97	95	79	55	41	39	51	56
Demineralised water treatment plant, fire pumps and lab	S9	91	95	94	83	72	65	63	61	58
Wastewater treatment plant	S10	96	90	92	82	74	68	68	60	53
Gas Compressor Fin Fan Coolers	S11	91	95	94	83	72	65	63	61	58
Gas compressor	S12	91	95	94	83	72	65	63	61	58

Name	ID	Octave Band Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
Electrical, control room and admin building	S13	99	94	83	78	61	43	46	57	61
Closed circuit cooling water Fin Fan Coolers	S14	91	95	94	83	72	65	63	61	58
ACC Air Inlet	S15	113	109	107	101	100	98	95	87	80
ACC Air Outlet	S16	113	109	107	103	101	99	96	88	81
OCGT Fin Fan Cooler	S17	91	95	94	83	72	65	63	61	58
Stack base	S18	94	85	84	87	84	75	70	58	61
Stack outlet	S19	94	85	84	87	84	75	70	58	61
Main Transformer	S20	74	86	99	97	83	84	76	64	63
Auxiliary transformer	S21	74	86	99	97	83	84	76	64	63
OCGT Cladded	S22	118	119	108	105	101	93	87	77	66
Air Intake	S23	114	116	106	98	96	97	96	91	87
GIS electrical substation building	NA	93	99	91	78	62	43	49	58	60
400kV Transformer	NA	74	86	99	97	83	84	76	64	63
Note that the listed spectra above were adjusted to match the required broadband sound power level element representing a given plant item. i.e. Five area source elements make up a single building.										

Table 11D.4 Modelled Operational Plant Broadband Sound Power Levels and Dimensions.

Plant		Sound Power Level (L_{WA} dB) per Item	Dimensions (L.W.H metres)
1 x CCGT			
S1	Turbine and steam turbine halls	94	82.5 x 49 x 29.9
S2	Air inlet filters	94	Point Source @19m Height
S3	HRSG buildings	97	35 x 30 x 38.5
S4	HRSG Stack Outlet	92	Point Source @ 50m Height
S5	Electrical building	83	42 x 17 x 4.5
S6	Feedwater pump building	80	23 x 12 x 8
S7	Generator transformers	92	Point Source @ 4m Height
S8	Workshop and stores	80	75 x 20 x 12.3
S9	Demineralised water treatment plant, fire pumps and lab	80	43 x 20 x 9.5
S10	Wastewater treatment plant	80	15 x 9.2 x 4
S11	Gas Compressor Fin Fan Cooler	94	Point Source @ 3.5m Height
S12	Gas compressor	80	Area Source
S13	Electrical, control room and admin building	78	54 x 24 x 8

Plant		Sound Power Level (L_{wA} dB) per Item	Dimensions (L.W.H metres)
S14	Closed circuit cooling water Fin Fan Coolers	80	Area Source 33 x 18
S15	ACC Inlet	103	84 x 47 x 32.2
S16	ACC Outlet	104	84 x 47 x 32.2
2 x OCGT			
S17	OCGT Fin Fan Coolers	94	Point Source @ 3.5m Height
S18	Stack base	100	12 x 6 x 40
S19	Stack outlet	95	Point Source @ 40m Height
S20	Main Transformer (With 5m high blast barrier on north, south and east sides)	106	12.5 x 6 x 4
S21	Auxiliary transformer	102	Quantity (x2) 7.5 x 4.5 x 4
S22	Skid gas enclosure (internal)	106	20 x 10 x 12.8
	Turbine enclosure (internal)	105	
	Generator (internal)	107	
	Diffuser (internal)	105	
S23	Air intake inlet (external)	Unmit. 112 | Mit. 99	4 faces (Area sources) - 2 Long faces: 20 x 3.2 2 Short faces:10 x 3.2
	Air intake body (external)	Unmit. 114 | Mit. 99	
Electricity Grid Connection – Substations			
GIS Electrical Substation		78	60 x 19 x 17
400Kv Transformer		88	Quantity (x2) Point Source @ 5m Height

Prediction Methodology

Modelling of sound levels from the development have been undertaken using CadnaA 2022 MR2 acoustic modelling software. This software implements the sound propagation calculation methodology set out in the ISO 9613-2:1996. The propagation model described in this standard provides for the prediction of sound pressure levels based on either short-term downwind (i.e., worst case) conditions or long-term overall averages. The highest sound levels at NSRs occur under down wind conditions (wind blowing 1 to 5m/s from the Site towards the nearby receptors), and these have been adopted within the model. When the wind is blowing in the opposite direction, sound levels may be significantly lower than those predicted. The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each source and subtracting a number of attenuation factors according to the following:

$$\text{Predicted Sound Level} = L_{WA} + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

These factors are discussed in detail in the following paragraphs.

The Sound Power Level (LWA) defines the total acoustic power radiated by a noise source expressed in decibels (dB re 1 pW).

The directivity factor (D) allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. No directivity factor is considered within this assessment.

The geometrical divergence (A_{geo}) accounts for spherical spreading of the sound from the source within free-field conditions. Different sources at the Installation have been modelled to take account of their geometry, as area, line or point sources. The divergence factor is calculated from the distance from the source to the receiver, and the relationship between the attenuation provided and distance is dependent on the type of sound source assumed.

The atmospheric absorption factor (A_{atm}) considers the attenuation offered by the atmosphere as a result of the conversion of sound to heat. The degree of attenuation is dependent on the relative humidity and temperature of the air through which the sound is travelling and is frequency dependent. Increasing attenuation occurs towards the higher frequencies of sound.

Modelling parameters have assumed an ambient temperature of 10°C and 70% relative humidity which are found to result in worst case noise propagation. The corresponding atmospheric attenuation factors are summarised in Table 11.D5.

Table 11.D5 Atmospheric Attenuation (dB/km) at 10°C and 70% Relative Humidity

Octave Band Centre Frequency / Hz	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient dB / km	0.122	0.411	1.04	1.93	3.68	9.66	32.8	117

The ground effect (A_{gr}) is the result of sound reflected by the ground interfering with the sound propagating directly from source to receiver, and the interaction of the sound with porous and absorptive ground cover. The prediction of ground effects depends on the source height, receiver height, propagation height between the source and receiver and the ground conditions.

The ground conditions are described according to a variable defined as 'G', which varies between 0 for 'hard' ground (includes paving, water, ice, concrete and any locations with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation).

The effect of any barrier or topographical obstruction (A_{bar}) between the sound source and the receiver position is that sound will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the sound.

Acoustic Calculation Settings

Acoustic modelling has been undertaken using the following model settings:

- BS 5228-2 for construction phase and ISO 9613-2 for operational phase and
- Maximum search radius of 10,000m.
- Maximum number of reflections: 3.
- Freefield noise level predictions carried out at 1.5m and 4m above ground to represent ground and first floor levels respectively at sensitive receptors for day and night-time assessment.
- Side diffraction enabled.
- Ground absorption has been set as:
  - A ground absorption value of G=1.0 (representing soft ground) has been assigned to the surrounding agricultural areas.

- Areas of hard standing set to G=0 (representing hard ground) has been assigned across the Proposed Development Area as appropriate.

Uncertainty in Modelling

It should be noted than any predictions of sound levels have an associated degree of uncertainty. Whilst best endeavours have been made to minimise that uncertainty in this work, it is unavoidable that some remains. In particular, the following sources of uncertainty have been noted:

- Sound source levels have been based on client's instruction regarding sound pressure level at 1m or sound power levels from the plant and typical frequency spectrum data obtained from previous measurements by AECOM and literature references. It is possible that depending on the plant to be used, source spectrum may differ.
- Predictions of sound pressure levels according to ISO 9613 assume moderate downwind propagation, and hence could be considered as a worst-case calculation. However, the standard also indicates an estimated accuracy of ±3 dB LA in predicted levels.