# Appendix 8B: Air Quality, Cooling System Plume Visibility

# APPENDIX 8B – AIR QUALITY, COOLING SYSTEM PLUME VISIBILITY

## 8B.1 Introduction

8B.1.1 This Technical Appendix supplements Chapter 8: Air Quality and describes the potential visible plume impacts from the alternative cooling system options for the operational Proposed Development, as summarised in the main chapter.

8B.1.2 A plume becomes visible when water vapour in the plume condenses to form small particles, usually in the form of water droplets. This report presents the plume visibility modelling results and the assessment of amenity risk from the use of the two potential cooling options proposed for the CCGT, namely the use of new build hybrid cooling towers or the use of new build wet cooling towers. Other potential cooling options have been discounted from further consideration as they are not considered to represent the use of Best Available Techniques (BAT) for the Proposed Development. Cooling technology selection is the subject of a separate BAT justification for the proposed CCGT as part of a variation application for the existing Environmental Permit of the coal-fired power station.

## 8B.2 Methodology

Amenity Risk Assessment Criteria

8B.2.1 Visible plumes can cause impacts on local sensitive receptors through loss of light causing nuisance or annoyance, and may cause ice formation on roads in the event of grounding of the plume in certain meteorological conditions.

8B.2.2 The significance criteria used in the assessment are shown in Table 8B.1 and are derived from Environment Agency Amenity Risk Assessment criteria (Environment Agency, 2011). The cooling tower array has been assumed to be a minimum of 100 m from the Site boundary, as indicated in site layout plans (Figures 4.1a and 4.1b, ES Volume II).

**Table 8B.1: Significance Criteria for Visible Plume Emissions**

| Impact | Quantitative Description |
|---|---|
| Insignificant | • Regular small impact from the operation of the process<br>• Visible plume length exceeds the site boundary <5% of daylight hours per year<br>• No local sensitive receptors |
| Low | • Regular small impact from the operation of the process<br>• Visible plume length exceeds the site boundary <5% of daylight hours per year<br>• Sensitive local receptors |
| Medium | • Regular large impact from the operation of the process<br>• Plume length exceeds the site boundary >5% of daylight hours per year<br>• Sensitive local receptors |

| Impact | Quantitative Description |
| --- | --- |
| High | • Continuous large impact from the operation of the process<br>• Plume length exceeds the site boundary >25% of daylight hours per year<br>• Sensitive local receptors |

8B.2.3 Dispersion modelling has been used to assess the impact of visible plume emissions on the environment by using the initial water content of the emission and the humidity of the atmosphere to determine whether the plume will be visible, and if so the distance the visible plume will travel. The model used is the CERC model ADMS5[1] (v5.1) as described in Appendix 8A (ES Volume III). The dispersion model utilises site-specific hourly sequential meteorological data to enable a realistic assessment of dispersion from point sources to be conducted for weather conditions that are directly applicable to the site.

8B.2.4 The dispersion model module does not account for the effects of buildings within the plume visibility module, however the potential effects of buildings has been taken into account in the interpretation of the model outputs.

## 8B.3 Sensitive Receptors

8B.3.1 The nearest sensitive receptors to the cooling tower array are residential receptors located to the east of the Site at Gallows Hill (500 m east of the Proposed Power Plant Site) and Hensall (700 m east/south-east of the Proposed Construction Laydown area), residential properties approximately 500 m to the south of the Proposed Power Plant Site and Eggborough residential area approximately 750 m south-west of the Proposed Power Plant Site.

## 8B.4 Dispersion Model Parameters

8B.4.1 The potential for plume visibility from the cooling systems has been modelled using indicative emissions data derived for the two alternative systems. The model input parameters are provided in Table 8B.2 below.

**Table 8B.2: Modelled visible plume atmospheric release parameters**

| Parameter | Hybrid cooling system | Wet cooling system |
| --- | --- | --- |
| Number of vents | 42 | 42 |
| Release height (m) | 25 | 25 |
| Vent diameter (m) | 12 | 12 |
| Flow rate per vent (kg/s) | 1050 | 700 |
| Water ratio (kg/kg, dry) | 0.0064 | 0.0112 |
| Temperature (°C) | Ambient | Ambient |
| Surface roughness (m) | 0.2 | 0.2 |

[1] Cambridge Environmental Research Consultants Ltd (2016), ADMS 5, Atmospheric Dispersion Modelling System, User Guide, November 2016.

| Parameter | Hybrid cooling system | Wet cooling system |
|---|---|---|
| Terrain | Flat | Flat |
| Meteorological data | 5 years hourly sequential data from Church Fenton meteorological station (2008, 2009, 2010, 2011 or 2012) | |

## 8B.5 Modelled Plume Visibility

Water-Condensed Plume Frequency and Length

8B.5.1 Results for the two scenarios using different years of meteorological data are shown in Table 8B.3 below.

8B.5.2 It can be seen from Table 8B.3 that the hybrid cooling system will have lower frequency of forming water-condensed plumes, because of the lower initial water content in the emission. The average length of visible plumes is also shorter for the hybrid system, also because of the lower initial water content. The difference between the two scenarios is apparent: for the five years of meteorological data used in the modelling, the hybrid cooling system gives rise to plumes with condensed water at a frequency of about 25 – 40%; if the wet cooling system is used, the frequency of forming water-condensed plumes will be raised to 80 – 85%.

**Table 8B.3: Modelled results of plumes with condensed water**

| Parameter | Met. Year | Hybrid cooling system | Wet cooling system |
|---|---|---|---|
| Modelled water-condensed plume (hours per year) | 2008 | 2,513 | 6,724 |
| | 2009 | 2,399 | 6,493 |
| | 2010 | 3,244 | 6,668 |
| | 2011 | 2,191 | 7,038 |
| | 2012 | 2,633 | 7,093 |
| Frequency of water-condensed plumes (% of the year) | 2008 | 30.4% | 81.3% |
| | 2009 | 29.4% | 79.7% |
| | 2010 | 40.2% | 82.6% |
| | 2011 | 25.7% | 82.5% |
| | 2012 | 31.4% | 84.7% |
| Average length of water-condensed plumes (when formed within 100 m of the stack) (m) | 2008 | 0.6 | 19.4 |
| | 2009 | 1.4 | 27.9 |
| | 2010 | 3.7 | 35.1 |
| | 2011 | 0.1 | 15.8 |
| | 2012 | 1.2 | 20.9 |

Visible Plume Length and Direction

8B.5.3 A plume with condensed water is visible during daytime without fog or lower cloud. The modelled visible plumes can be sorted by wind direction, with the direction split into eight sectors. Each sector is of 45 degrees, and centred at north (N), or north-east (NE), etc. The length of visible plumes is grouped into ranges of 100 m increment. The extension of visible plumes beyond the Site boundary is an important factor in determining significance, therefore the length used in this assessment is the length when a visible plume disappears. Some visible plumes form at distance from the emission source. For the purposes of this assessment, if the distance to formation of a visible plume is predicted to be more than 100 m, that plume is excluded from the analysis. Tables 8B.4 – 5 below show the number of hours in the year and percentage of each length range and directional sector, for hybrid cooling and wet cooling systems respectively. Meteorological year 2010 is reported in the Tables because this meteorological year resulted in the longest average length and highest frequency of predicted visible plumes of the five years of data analysed.

8B.5.4 The potential for visible plume groundings is anticipated to be negligible from operation of either the hybrid cooling system or wet cooling system as the first plume grounding occurred approximately 1 km from where the plume is last predicted to be visible.

**Table 8B.4: Number of hours (with annual percentage) in each length range and directional sector for 2010 – Hybrid cooling system**

| Wind from | | North | North-east | East | South-east | South | South-west | West | North-west | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Plume towards | | S | SW | W | NW | N | NE | E | SE | |
| Modelled daytime (h) | | 666 | 359 | 262 | 363 | 462 | 528 | 826 | 651 | 4,117 |
| Total visible (h) | | 229 | 76 | 66 | 99 | 64 | 30 | 102 | 225 | 891 |
| Mean length (m) | | 5 | 0.1 | 2 | 1 | 10 | 2 | 1 | 3 | 3 |
| Max length (m) | | 216 | 0.5 | 62 | 60 | 393 | 32 | 43 | 81 | 393 |
| Length range | <100 m (h) | 225<br>5.5% | 76<br>1.8% | 66<br>1.6% | 99<br>2.4% | 63<br>1.5% | 30<br>0.7% | 102<br>2.5% | 225<br>5.5% | 886<br>21.5% |
| | 100-200 m (h) | 3<br>0.1% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3<br>0.1% |
| | 200-300 m (h) | 1<br><0.1% | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1<br><0.1% |
| | 300-400 m (h) | 0 | 0 | 0 | 0 | 1<br><0.1% | 0 | 0 | 0 | 1<br><0.1% |
| | 400-500 m (h) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 500-600 m (h) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 600-700 m (h) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | >700 m (h) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sum >100 m (boundary) | 0.1% | <0.1% | <0.1% | <0.1% | <0.1% | <0.1% | <0.1% | <0.1% | 0.1% |

Notes (h) = hours

**Table 8B.5: Number of hours (with annual percentage) in each length range and directional sector for 2010 – Wet cooling system**

| Wind from | | North | North-east | East | South-east | South | South-west | West | North-west | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Plume towards | | S | SW | W | NW | N | NE | E | SE | |
| Modelled daytime (h) | | 666 | 359 | 262 | 363 | 462 | 528 | 826 | 651 | 4,117 |
| Total visible (h) | | 572 | 291 | 160 | 255 | 276 | 245 | 476 | 499 | 2,774 |
| Mean length (m) | | 36 | 18 | 30 | 36 | 23 | 7 | 11 | 29 | 24 |
| Max length (m) | | 640 | 373 | 373 | 353 | 529 | 153 | 112 | 393 | 640 |
| Length range | <100 m (h) | 514 12.5% | 281 6.8% | 148 3.6% | 228 5.5% | 257 6.2% | 243 5.9% | 475 11.5% | 472 11.5% | 2,618 63.6% |
| | 100-200 m (h) | 46 1.1% | 6 0.1% | 10 0.2% | 19 0.5% | 14 0.3% | 2 <0.1% | 1 <0.1% | 16 0.4% | 114 2.8% |
| | 200-300 m (h) | 7 0.2% | 3 0.1% | 1 <0.1% | 6 0.1% | 1 <0.1% | 0 | 0 | 9 0.2% | 27 0.7% |
| | 300-400 m (h) | 1 <0.1% | 1 <0.1% | 1 <0.1% | 2 <0.1% | 3 0.1% | 0 | 0 | 2 <0.1% | 10 0.2% |
| | 400-500 m (h) | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | 500-600 m (h) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | 600-700 m (h) | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| | >700 m (h) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sum >100 m (boundary) | 1.3% | 0.2% | 0.2% | 0.6% | 0.4% | <0.1% | <0.1% | 0.6% | 3.6% |

## 8B.6 Amenity Risk Assessment

8B.6.1 The total percentage of visible plumes generated by the hybrid cooling system that exceed the Site boundary (more than 100 m visible plume length) is 0.1%, less than 5% of daylight hours, therefore, even though there are potentially sensitive local receptors in the vicinity, the impact from visible plumes on the local amenity is described as low magnitude. The maximum length plumes are predicted towards the north (393 m, <0.1% of hours) and south (216 m, 0.1% of hours) and therefore as the closest receptors are more than 500 m in these directions, visible plumes from the hybrid system are not expected to generate shadow effects on residential properties.

8B.6.2 The total percentage of visible plumes generated by the wet cooling system that exceed the Site boundary (more than 100 m visible plume length) is 3.6%, less than 5% of daylight hours, therefore even though there are potentially sensitive local receptors in the vicinity, the impact from visible plumes on the local amenity is also described as low magnitude. The maximum length plumes are predicted towards the south (640 m, <0.1% of hours) and north (529 m, <0.1% of hours) and therefore there is the potential for visible plumes from the wet cooling system to generate shadow effects on residential properties for a limited number of hours per year.

8B.6.3 The amenity risk assessment indicates that both system evaluated are described as having a low significance impact on the local amenity, although the use of a hybrid cooling system has a lower potential amenity risk than the wet cooling system due to the shorter predicted visible plume length.

8B.6.4 The dispersion modelling did not predict visible plume grounding for any of the scenarios assessed and therefore the risk of icing of roads is considered to be negligible.