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Ecological interpretation of AQA

Appendix 6.2

Prepared for Axis PED

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Contents

1 Introduction

This report provides further ecological interpretation of the emissions modelling undertaken by Fichtner Consulting Engineers, and reported in Appendix 8.2 of the ES. It addresses those air quality effects which are predicted to exceed Environment Agency screening thresholds at statutory designated sites, either as a consequence of the proposed North Beck Energy Centre (the Proposed Development) alone, or in combination with other planned or permitted developments.

Dispersion modelling has indicated that the process contribution from the Proposed Development (alone or in-combination) for a number of pollutants may exceed the relevant screening threshold over part of the Humber Estuary SAC, SPA, Ramsar site and SSSI. It is not therefore possible to screen these out as not likely to have a significant effect on European and internationally designated sites, or not likely to cause significant harm to the SSSI, without more detailed consideration of ecological effects. However, screening thresholds should not be regarded as 'effect thresholds' where a likely significant effect would occur, but indicate where more detailed ecological assessment is required; IAQM (2016) provides further guidance.

Potential ecological effects are considered in more detail below, based on the sensitivity of ecological receptors, and consideration of likely significant effects. This includes consideration of background levels, habitat condition, and other factors which may ameliorate or exacerbate the predicted air quality impacts.

The assessment is based on the most conservative assumptions built into the emissions modelling, as set out in Appendix 8.2. This includes consideration of consented but not constructed projects in the baseline (i.e. incorporation of in-combination effects), and uses current rather than future emission limits (i.e. IED Emission Limit Values (ELVs), not BAT Air Emission Limits (AELs), which will be lower) to predict effects.

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2 Sensitivity of designated sites

2.1 Humber Estuary – qualifying and notified features

Qualifying features of Humber Estuary SAC and SPA, listed features of Humber Estuary Ramsar Site, and notified features of Humber Estuary are set out in Appendix 6.1 (PEA), section 3.1.

2.2 Sensitive ecological receptors for AQA

Appendix 6.1, section 4.1 identifies sensitive ecological receptors for consideration in the AQA, based on the spatial disposition of qualifying and notified features within the 10km search radius defined by Environment Agency for European and international sites. Sensitivity of features to air quality effects was determined with the assistance of advice on the Air Pollution Information Service (APIS) website. Table 2.1 below summarises those features identified which occur within the 10km search radius (2km for SSSI notified features).

Table 2.1: Summary of sensitive features (from APIS)

Feature	Status	CLo N deposition	CLo acid deposition	CL NH_3 long-term
Atlantic salt-meadows	Ramsar / SAC qualifying feature	20kg N/ha/yr	Not sensitive	3 µg/m^3 (2-4 µg range)
brent goose	SPA qualifying species	20kg N/ha/yr	Not sensitive	3 µg/m^3 (2-4 µg range)
wigeon	SPA qualifying species	20kg N/ha/yr	Not sensitive	Not sensitive

For both Atlantic salt-meadows (coastal saltmarsh) and the bird species listed above which are at least partially dependent on this habitat as grazers, APIS lists the critical level for NO_x as 30µg/m^3 long-term (annual mean) and 75µg/m^3 short-term (24-hour). These limits are set for all vegetation; the ammonia critical loads are set for habitats which do not have important bryophyte or lichen communities associated with them.

A precautionary approach has been taken to nitrogen critical loads for saltmarsh, by applying the lower critical load assigned to upper saltmarsh habitat, in the absence of detailed survey data for the sections of saltmarsh within the assessment area; these are located on the north bank of the Humber. The critical load for lower saltmarsh is 30kg N/ha/yr.

Coastal saltmarsh is not present within a 2km buffer from the Site, and does not therefore require consideration in terms of its status as a SSSI notified feature.

Other Ramsar Site or SAC qualifying features of higher sensitivity (e.g. sand dune habitats) do not occur within the 10km buffer from the Site. Other habitats which do occur within the buffer (intertidal and sub-tidal sediment, part of the Estuaries Ramsar Site / SAC qualifying feature) are not regarded by APIS as sensitive to air quality effects, with no critical load set.

2.3 Hydrogen fluoride

Critical Levels / target values

Hydrogen fluoride (HF) is not included in the pollutants covered by APIS; however, the Environment Agency list short-term (weekly and daily average) targets for protected conservation areas of 0.5µg/m^3 (weekly) and 5µg/m^3 (daily)[1]. Long-term World Health Organisation (WHO) guidelines for protection of livestock and vegetation are 1µg/m^3, higher than the EA weekly value (WHO, 2000). It is also a contributor to acid deposition.

Sensitivity of habitats and species to fluorides

Scottish Environmental Protection Agency (SEPA) guidance[2] on HF emission limits states that the high solubility of HF leads to rapid wash-out (i.e. low atmospheric residence time) and it also binds to particles leading to deposition on soils and plants.

Effects of fluoride pollution on vegetation have been recorded around major emission sources such as aluminium smelters. Effects are most severe on lichens, and include damage to chlorophyll and effects on water retention (LeBlanc *et al*, 1971), and can result in loss of sensitive lichen species (Perkins, 1992). Another study showed that fluoride concentrations which resulted in severe injury to lichens corresponded to those where fluorosis in cattle was likely, but caused only minor visible symptoms in commercial forestry and amenity trees (Gilbert, 1985).

As well as the capacity of sensitive plant taxa such as lichens to bio-accumulate fluorides through gaseous uptake of HF, deposition of particulate fluorides onto leaf

[1] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions (accessed 03/01/18)
[2] Scottish Pollutant Release Inventory, HF http://apps.sepa.org.uk/spripa/Pages/SubstanceInformation.aspx?pid=7 (accessed 03/01/18)

surfaces provides a pathway for transfer to grazing animals and consequent risk of fluorosis. This could include grazing bird species such as geese or wigeon; one study showed greater levels of fluoride in bones of Canada geese originating near one aluminium smelter in Norway, but near normal levels near another smelter (Vikøren and Stuve, 1995), indicating that degrees of exposure are likely to vary widely in hghly mobile species such as waterfowl. The same study did not find any evidence of bone damage in the most highly exposed population.

Although gaseous HF could have an indirect effect on aquatic systems through deposition to water, fluoride inputs from discharges to water would make a far greater contribution. A study of fluoride levels in rivers in eastern UK, including the Humber catchment, found a high degree of correlation with point source inputs from sewage works (Neal *et al*, 2003). These included concentrations which exceeded the value of 0.5mg F^-/l, which is regarded as a safe level for protection of the most sensitive aquatic organisms, including freshwater invertebrates such as caddis flies, and fish such as migratory salmon (Camargo, 2003). However, fluoride toxicity is higher in soft waters, and lower in estuaries, probably because of lower bioavailability of fluoride in hard and brackish / saline waters (Camargo, *op cit*).

Potential sensitivity of habitats and species in River Humber

The preceding review has indicated that there are no habitats of high sensitivity to fluoride pollution in the Humber Estuary. Saltmarsh habitat does not contain sensitive lichen communities, while grazing waterfowl are mobile and migratory, and would be unlikely to ingest high levels of fluoride originating from aerial deposition, even if the emission source was of a much higher magnitude (e.g. an aluminium smelter). Estuarine waters are less sensitive than freshwater habitats, particularly where the latter occupy base-poor catchments, while deposition rates from air are likely to be inconsequential compared to point-source discharges to water from sewage works. The interpretation of predicted HF levels should therefore be undertaken against the background of this relatively low sensitivity environment.

3 Potential for likely significant effect

3.1 Predicted effects above screening thresholds

The following process contributions cannot be screened out as insignificant:

- Contribution (alone and in-combination) to long-term (annual mean) and short-term (24-hour) oxides of nitrogen (NOx) levels at saltmarsh habitats within the SAC and Ramsar site;
- Contribution to long-term (annual mean) ammonia (NH_3) levels at saltmarsh habitats within the SAC and Ramsar site;
- Contribution (alone and in-combination) to nitrogen deposition rates at upper saltmarsh habitats within the SAC and Ramsar site;
- Potential indirect effects of above on saltmarsh habitat quality on brent geese and wigeon (SPA qualifying species); and
- Potential effects on vegetation and fauna of short-term (weekly mean) hydrogen fluoride levels.

As explained in the AQA, for industrial process Environment Agency screening thresholds are set at process contributions (PC) over 1% of the relevant EQS (critical load or level) for long-term values, and 10% of the relevant EQS (critical level) for short-term (24-hour) mean values. Effects above the screening threshold can be excluded from further consideration if the predicted environmental concentration (PEC) is under 70% of the EQS. This is the case with predicted sulphur dioxide (SO_2) levels, where the maximum PC at any point on the Humber Estuary is 2.1% of critical level, but the maximum background level is 17.35% of critical level, giving a PEC of <20%.

Acid deposition rates can also be excluded from further consideration, as there are no sensitive qualifying features habitats within the respective 2km or 10km buffers.

3.2 Likely significant effect of oxides of nitrogen levels

Potential effects of critical level exceedance

The 30µg/m^3 annual mean NO_x level of has been set as a critical level for protection of ecosystems. Exceedance may cause direct effects on vegetation (e.g. changes to shoot : root ratio), changes in sensitive habitats such as calcareous grassland, and effects on sensitive species such as mosses and lichens. The 30µg/m^3 value is not habitat specific, and is set to protect the most sensitive habitats such as those outlined above. As most ecological changes are mediated through the effects of increased nitrogen availability, nitrogen deposition normally provides a more accurate indicator of possible ecological effects. Nevertheless there are some potentially distinct effects of the dry deposition of NOx, with direct foliar uptake giving potentially a relatively higher leaf nitrogen content. This could affect palatability, possibly increasing the risk of defoliation by predators, or increase frost sensitivity.

The 75µg/m^3 daily mean NO_x critical level could be postulated as being more likely to be associated with direct effects on vegetation, but is still significantly lower than the concentrations used in short-term fumigation experiments where direct negative effects such as leaf discolouration have been observed (400µg/m^3 reported by APIS). Other experiments report no effect or growth stimulation, although the latter could still potentially have negative ecological consequences.

Effects of elevated NOx levels are exacerbated if SO_2 and ozone (O_3) levels are also elevated; APIS report that the critical levels for NOx should only be applied if SO_2 and ozone are also close to their respective critical levels.

Predicted impacts on saltmarsh habitat

Figure 8.35 shows the magnitude and extent of predicted in-combination effects of the Proposed Development on NOx levels in the Humber Estuary, therefore representing a worst-case scenario.

The plot shows a maximum effect magnitude of over 2% of critical level over a small area of saltmarsh on the north shore of the Humber, with an >1% effect over a wider area. This can be regarded as a low magnitude impact.

Predicted ecological effects on saltmarsh habitat

Background levels are modelled as being close to or exceeding the critical level (88 – 101%). There is therefore a possibility that the PC could result in the PEC moving close to or potentially slightly exceeding the critical level on part of the saltmarsh, potentially increasing the significance of a small magnitude effect. However, as background SO_2 levels are low (around 7% of CL; see ES Figure 8.35 of the), a small magnitude exceedance of critical levels for NOx is not likely to result in a significant ecological effect.

The likelihood of any effect on saltmarsh habitat is reduced further when atmospheric NOx levels are compared with the likely magnitude of nitrogen inputs from estuarine sources; this is considered in more detail below in relation to nitrogen deposition effects.

3.3 Likely significant effect of predicted ammonia levels

Potential effects of critical level exceedance

As a major contributor to excess nitrogen deposition, many of the effects of atmospheric ammonia levels are as a consequence of eutrophication and acidification impacts. However there are also some direct toxicity effects, and secondary effects such as increased susceptibility to pests and pathogens, and an increased sensitivity to drought and frost (APIS), and some evidence from bog habitats that dry deposition of gaseous ammonia may result in a greater effect compared to wet deposition of ammonium ions (Sheppard *et al*, 2011).

The critical level (CLE) for ammonia levels has been revised downwards from 8 $\mu g/m^3$ annual mean value to 3 $\mu g/m^3$ for higher plants, with a range of 2-4 $\mu g/m^3$ (UN-ECE, 2010, based on review by Cape *et al*, 2009). For ecosystems where lichens and bryophytes are important components, the CLE has been revised to 1 $\mu g/m^3$; for saltmarsh habitats which do not contain a lichen or bryophyte component, the 3 $\mu g/m^3$ critical level is appropriate.

Predicted impacts on Humber Estuary

The maximum predicted PC in the Humber Estuary is 4.6% of critical level, i.e. 0.14 $\mu g/m^3$ (AQA Table 4.12), but will be lower (1-2% of critical level) at the north bank saltmarsh habitats. Predicted background levels at the north bank saltmarsh (from APIS query by location) of 0.91 $\mu g/m^3$. This predicts a PEC of 2.05 $\mu g/m^3$ annual mean, 68% of the median critical level for sites without bryophytes and lichens. Modelled background ammonia levels need to be interpreted with caution, due to multiple low-level agricultural sources and high deposition velocity, which give a high spatial heterogeneity poorly reflected in 5km grid square model. However, given the absence of agricultural sources upwind (i.e. across the estuary to the south-west) it is likely to be realistic, and lower than comparable agricultural areas inland.

Predicted ecological effects on saltmarsh habitat

The PEC is predicted to be just below the 70% screening threshold, and the small magnitude process contribution does not significantly increase the risk of critical level exceedance. There is therefore no risk to designated sites as a consequence of ammonia emissions from the Proposed Development.

3.4 Likely significant effect of predicted nitrogen deposition rates on saltmarsh habitat

Potential effects on critical load exceedance

Critical loads for nitrogen deposition to saltmarsh habitats have been recently reviewed in a Natural Resources Wales report (Stevens *et al.*, 2013). This study notes that saltmarsh systems have high levels of total nitrogen, and experience large inputs and outputs through surface water, which are significantly larger than the defined critical load range of 20-30kg N/ha/yr. They note that despite these large nutrient fluxes, they are still regarded as nitrogen-limited, and can still exhibit changes due to the effects of excess N deposition, such as in vegetation growth and the rate of succession. They note that impacts could be different in lower marsh communities, where growth is likely to be stimulated, while upper marsh communities may suffer a loss of species diversity. In terms of implications for critical loads, they refer to a study which suggests that nutrient inputs would have to be significantly higher than defined critical loads for any responses to occur (Boorman & Hezelden, 2012).

Boorman & Hezelden (2012) reviewed the types and range of nutrient nitrogen inputs likely to be taken up by a saltmarsh as a consequence of tidal flows. With respect to seawater inputs, they referred to the following estimated inputs:

Table 3.1: Estimated nitrogen inputs to saltmarsh from tidal flows

Form of nitrogen	Mean estimated input	Input range
Particulate N	87 kg N/ha/yr	10 - 240 kg N/ha/yr
Dissolved organic N	74 kg N/ha/yr	10 - 310 kg N/ha/yr
Ammoniacal N	29 kg N/ha/yr	4 – 48 kg N/ha/yr
Nitrate N	16 kg N/ha/yr	6 - 27 kg N/ha/yr

They also noted that the pool of nitrogen in saltmarshes (most of which is in the soil) can be 5 – 30x greater than these inputs.

Although this study concludes that atmospheric nitrogen deposition could still have an impact on saltmarsh communities, particularly upper marsh vegetation, the above figures give some indication of the relatively greater magnitude of inputs from water.

Predicted impacts on Humber Estuary

ES Figure 8.35 shows that nitrogen deposition is predicted to exceed the 1% screening threshold for upper marsh habitats within a ca. 2km section of the north bank saltmarsh.

As it is a large site, predicted background levels vary across the estuary, with a range of 11.2 – 24.08kg N/ha/yr (i.e. from 56% to 120% of the critical load for upper saltmarsh habitats); predicted deposition rates at the north bank saltmarsh are 14.42kg N/ha/yr, 72% of critical load. A maximum 0.245kg N/ha/yr PC (Appendix 8.2, Table 4.14) would increase the PEC to 14.67kg N/ha/yr, 73% of critical load.

Predicted ecological effects on saltmarsh habitat

Although the PEC is above the 70% screening threshold, there is still adequate headroom below the critical load, meaning there is no risk that the process contribution from the Proposed Development and other modelled sources would result in any ecological effect.

3.5 Likely significant effect on SPA qualifying features

Potential effects of critical load exceedance

<u>Brent goose</u>

Brent geese are grazers, feeding on marine plants such as *Zostera* and algae such as *Enteromorpha* on intertidal mudflats and lower saltmarsh areas in the early part of the winter, before switching to grassland habitats and arable crops as this food resource becomes depleted (Stroud *et al*, 2001). As noted in Appendix 6.1, dietary preferences of brent geese utilising saltmarsh habitats are complex, and include elements of both lower and upper marsh communities (Rowcliffe & Mitchell, 1996), so there is unlikely to be a simple effect pathway.

A potential mechanism of impact on brent goose is set out by Bobbink *et al* (2002) in an earlier review of empirical nitrogen Critical Loads: "*there is a clear indication that increased nitrogen availability does increase the rate of succession. As the successional age of these salt marshes is an important determinant of their quality as staging areas for brent geese…(Bakker, 1985) increases in nitrogen deposition might decrease the surface of early successional vegetation on the marsh and thereby the foraging area that is suitable for these migratory birds*.".

Wigeon

Wigeon are also grazers, feeding on a range of habitats including saltmarsh, coastal grassland and wetland habitats, showing flexibility in habitat choice in response to food availability and disturbance.

In saltmarsh habitats, a study in Somerset found an early season preference for common saltmarsh-grass (*Puccinellia maritima*) over creeping bent (*Agrostis stolonifera*) and red fescue (*Festuca rubra*) (Owen, 1973), possibly due to greater palatability. As *Puccinellia* is associated with mid-marsh habitats and bents and fescues with upper marsh, this provides a mechanism whereby acceleration of successional change could affect quality of diet. This is likely to be a very weak causative effect, however, due to the ability of wigeon to exploit other habitats, including improved grassland (Williams and Forbes, 1980).

Predicted impacts on brent geese and wigeon on Humber Estuary

The distribution of brent geese within the Humber Estuary is also an important consideration in determining sensitivity. The main areas for wintering brent geese are downstream of the 10km buffer, between Tetney and Donna Nook (Woodward *et al*, 2015). There is therefore no likelihood of any impacts on brent goose habitat.

Wigeon populations are concentrated in the inner estuary, but they also occur on the north bank saltmarsh (Woodward *et al*, 2015). There is therefore a potential effect pathway.

Likely significant effect

As the predicted effect is low in magnitude and will not result in critical load exceedance for saltmarsh habitat, there is no risk of a likely significant indirect effect on grazing wigeon.

3.6 Likely significant effect of HF levels

Potential effects of target value exceedance

The preceding review in section 2.3 above indicated that habitats and fauna on the Humber Estuary could be regarded as having a low sensitivity to elevated HF levels, with none of the attributes of more sensitive habitats. A low or moderate magnitude exceedance of Environment Agency target values is therefore unlikely to result in a significant effect on qualifying species and habitats.

Predicted impacts on Humber Estuary

The predicted process contribution to HF levels in the Humber Estuary is illustrated in the contour plots in Appendix 8.2, Figures 8.25 (weekly mean) and 8.26 (daily mean) as a percentage of the relevant critical level. Table 4.9 shows the maximum PCs at any point within the Humber Estuary.

The PC to the daily mean value is 1.9% of critical level, and therefore below the 10% screening threshold for short-term levels. The PC to weekly mean levels is predicted to be 11.2%, which is a low magnitude exceedance of screening thresholds. Figure 8.25 shows that this is predicted to affect a very small area of the south bank of the estuary closest to the Proposed Development, in an area which comprises intertidal mud habitat (see Appendix 6.1, Figure 4.1 & 4.2).

There are no modelled background levels to provide an assessment of predicted environmental concentrations (PEC); the emissions modelling uses the most pessimistic estimate of 2.4µg/m^3 weekly mean, which is well in excess of target values. In reality there is likely to be a high degree of spatial heterogeneity dependent on proximity to sources, due to the relatively low atmospheric residence time of HF gas.

Likely significant effect

Even taking the most conservative assumption of background exceedance, a low magnitude effect over a small area of habitat which does not have a high sensitivity to fluoride pollution is very unlikely to have a measurable ecological effect on designated sites in the Humber Estuary. It can therefore be safely concluded that there will be no likely significant effect on qualifying species or habitats.

4 Conclusions

Further ecological assessment has been undertaken of all predicted impacts which are above screening thresholds for the most sensitive habitats within designated sites. After consideration of effect magnitude, background levels, and other mitigating and exacerbating factors, it can be safely concluded that there would be no likely significant effect on Humber Estuary Ramsar Site, SAC and SPA as a consequence of the Proposed Development's emissions to air.

This conclusion takes into account in-combination effects of consented developments in the vicinity which do not form part of the current baseline, and does not rely on future planned reductions in emission limits, or on improvements in background pollutant levels from other sources. As noted in Appendix 6.2 (section 5.3) implementation of the BREF will result in reduction of annual / daily mean NOx levels by 40%; reduction of long-term SO_2 levels by 40%; and reduction of nitrogen deposition rates by 14%. This provides further confidence in conclusions regarding NOx levels and nitrogen deposition in particular.

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