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Tees CCPP Project

The Tees Combined Cycle Power Plant Project
Land at the Wilton International Site,
Teesside

Stack Diameter Sensitivity Study

Applicant: Sembcorp Utilities UK
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1 STACK DIAMETER SENSITIVITY STUDY

1.1 INTRODUCTION

1.1 Within the Development Consent Order ('DCO') there is a desire to maintain flexibility in the final power plant design, as this has not yet been confirmed. One item which requires this flexibility is the final internal stack diameter. Flexibility is required as the diameter may change from the current 8.0 metres ('m'), depending upon the final specification of the plant and turbines that would be used. During the examination process, the question has been raised as to what difference would arise in environmental impacts if the stack diameter is varied. Small changes in environmental impacts can be potentially significant. This is because nearby sensitive ecological receptors are subject to baseline conditions that are in excess of the Critical Load, and therefore there is only a small degree of 'headroom' for additional impacts.

1.2 The current impact assessment for the Project uses an 8.0m internal diameter stack and identifies that impacts at all relevant ecological receptors are below the threshold of potentially significant impacts (Refer to the No Significant Effects Report REP1-001). Notwithstanding this, care needs to be taken around any design commitments that could potentially increase these impacts.

1.2 BACKGROUND

1.3 Dispersion modelling has been undertaken for the Environmental Impact Assessment ('EIA') for the Proposed Power Plant, consisting of two 850$MW_{thermal}$ gas turbines. This utilises a stack height of 75m, and an internal stack diameter of 8.0m. This note sets out the modelling of internal stack diameters at 7.0m, 7.5m and 8.5m to ascertain any variation in environmental impacts with varying stack diameter.

1.4 The dispersion of the plume is driven by three principal factors:

- the height of the stack, which provides the initial release height;
- the temperature of the plume which provides the initial thermal buoyancy; and
- the exit velocity of the plume which provides the initial momentum.

1.5 As the underlying plant design is unchanged, the stack height and the exit temperature remain constant. However, as the stack diameter changes, the exit velocity and therefore the initial momentum changes. A greater stack diameter leads to a lower exit velocity and lower momentum; a smaller stack diameter leads to a higher exit velocity and a higher momentum. Therefore as stack diameter is reduced, dispersion is improved and the expectation is that environmental impacts will be reduced.

1.6 In practice, the exit velocity is determined by the optimum operating envelope of the installed turbine. There is an ideal stack diameter for any given turbine related to the optimum exhaust pressure. In turn this is related to maximising the efficiency of the turbine. With this in mind, whilst a sensitivity test for stack diameter has been undertaken (as set out in this note), in practice the final stack diameter will be determined on the basis of the optimum operation the turbine, which is yet to be chosen by the Applicant and will not be chosen prior to finalising the Examination. This point is of relevance in the event that the final plant capacity is reduced to below $1700MW_{thermal}$. In this instance, the stack diameter would be reduced to maintain optimum exit velocity for the smaller turbine.

1.3 MODELLING APPROACH

1.7 The dispersion modelling is the same in all respects as the modelling that was submitted in the final Environmental Statement originally submitted as part of the DCO application. The only parameters that have been varied are the stack diameter and exit velocity; volume flow rate remains the same. Of note is that the exit velocity is varied on the basis of the stack cross-sectional area as a function of stack diameter.

1.8 The modelling has been run for one meteorological year, 2015 (see Table 1). This year was selected as it produced the highest annual mean concentration at off-site locations. This approach is used to give a clear understanding of the influence of changing stack diameter/exit velocity only.

Table 1 Summary Emission Parameters

Parameter	Units	7.0m	7.5m	8.0m	8.5m
Height	m	75	75	75	75
Diameter per stack	m	7	7.5	8	8.5
Area per stack	m^2	38.5	44.2	50.3	56.7
Exit velocity	m/s	23.5	20.5	18.0	15.9

1.4 RESULTS

1.9 Results are shown for internal stack diameters of 7.0m, 7.5m and 8.5m in comparison to the 8.0m base scenario (see Table 2).

Table 2 Results

Habitat Name	Type	Highest PC NOx annual mean (µg/m3) anywhere within the respective site				% change from 8.0m stack		
		8.0m	7.0m	7.5m	8.5m	7.0m	7.5m	8.5m
Teesmouth & Cleveland Coast	Ramsar	0.261	0.259	0.259	0.264	-0.86%	-0.60%	1.1%
North York Moors	SAC	0.176	0.176	0.176	0.176	-0.089%	-0.075%	0.14%
North York Moors	SPA	0.176	0.176	0.176	0.176	-0.089%	-0.075%	0.14%
Teesmouth and Cleveland Coast	SPA	0.261	0.259	0.259	0.264	-0.86%	-0.60%	1.08%
Cliff Ridge	SSSI	0.150	0.150	0.150	0.151	-0.076%	-0.084%	0.16%
Cowpen Marsh	SSSI	0.0387	0.0385	0.0386	0.0388	-0.37%	-0.23%	0.34%
Hartlepool Submerged Forest	SSSI	0.0621	0.0617	0.0619	0.0624	-0.52%	-0.33%	0.54%
Kildale Hall	SSSI	0.0968	0.0967	0.0966	0.0971	-0.14%	-0.15%	0.29%
Langbaurgh Ridge	SSSI	0.0500	0.0498	0.0499	0.0501	-0.31%	-0.20%	0.28%
Lovell Hill Pools	SSSI	0.175	0.174	0.174	0.176	-0.70%	-0.44%	0.67%
North York Moors	SSSI	0.176	0.176	0.176	0.176	-0.089%	-0.075%	0.14%
Pinkney and Gerrick Woods	SSSI	0.0895	0.0894	0.0894	0.0896	-0.034%	-0.067%	0.16%
Redcar Rocks	SSSI	0.261	0.259	0.259	0.264	-0.86%	-0.60%	1.08%
Roseberry Topping	SSSI	0.190	0.189	0.189	0.190	-0.082%	-0.095%	0.18%
Saltburn Gill	SSSI	0.0951	0.0949	0.0950	0.0954	-0.21%	-0.16%	0.29%
Seal Sands	SSSI	0.0979	0.0971	0.0974	0.0988	-0.82%	-0.53%	0.89%
Seaton Dunes and Common	SSSI	0.136	0.135	0.135	0.137	-0.76%	-0.49%	0.83%
South Gare & Coatham Sands	SSSI	0.283	0.279	0.280	0.286	-1.2%	-0.82%	1.32%
Tees and Hartlepool Foreshore and Wetlands	SSSI	0.0893	0.0889	0.0891	0.0897	-0.46%	-0.29%	0.47%
Eston Moor (LWS)	LWS	0.755	0.753	0.754	0.757	-0.26%	-0.18%	0.27%
Wilton Woods Complex (LWS)	LWS	0.615	0.612	0.613	0.619	-0.55%	-0.40%	0.65%

1.10 The results illustrate that as expected the environmental impacts increase with an 8.5m internal diameter stack, and decrease with 7.0m and 7.5m internal diameter stacks.

1.11 Where impacts increase in the 8.5m case, for the large majority of sites the change is sufficiently small as to make no material difference to the predicted impacts. However, impacts at South Gare & Coatham Sands Site of Special Scientific Interest ('SSSI') were assessed in the ES for an 8 m internal diameter stack to be right on the 1% significance threshold of potential likely significant effects. Therefore, in theory the predicted increase at this site for an 8.5 m stack diameter would possibly exceed that threshold (noting that exceedance does not necessarily mean that a significant effect would occur since the maximum concentration may not be coincident with sensitive features within the SSSI). However, in overall terms, varying the stack diameter between 7 and 8.5 m results in a variations in air quality impact of at most -1.2% to +1.32% and as little as -0.034% to +0.16 % from the impacts of an 8 m diameter stack. These very small differences, and also considering the worst case approach taken in the assessment, mean that air quality impacts at sensitive ecological receptors can be considered as being relatively insensitive to stack diameter.

1.12 Taking into account the results above it is suggested that the internal stack diameter stipulated in the DCO ranges between 7.0 m to 8.0 m.