Thurrock Flexible Generation Plant

Preliminary Environmental Information Report
Appendix 12.4: Model Inputs and Outputs

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Environmental Impact Assessment

Preliminary Environmental Information Report

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Appendix 12.4

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Summary

This appendix summarises the atmospheric dispersion model inputs, and outputs owing to the proposed Thurrock Flexible Generation Plant.

Qualifications

This chapter has been prepared by Rosemary Challen, a Member of the Institution of Environmental Sciences and Member of the Institute of Air Quality Management (IAQM).

It has been checked and reviewed by Fiona Prismall, a Chartered Environmentalist, Member of the Institution of Environmental Sciences and Member of the Institute of Air Quality Management (IAQM). Fiona is the IAQM committee secretary. Fiona was a member of the working groups that produced the IAQM 2014 'Guidance on the assessment of dust from demolition and construction' and the EPUK&IAQM 2017 'Land-use Planning & Development Control: Planning for Air Quality' guidance.

1. Model Inputs and Outputs

Dispersion Model Selection

1.1.1 A number of commercially available dispersion models are able to predict ground level concentrations arising from emissions to atmosphere from elevated point sources. Modelling for this study has been undertaken using ADMS 5, a version of the ADMS (Atmospheric Dispersion Modelling System) developed by Cambridge Environmental Research Consultants (CERC) that models a wide range of buoyant and passive releases to atmosphere either individually or in combination. The model calculates the mean concentration over flat terrain and also allows for the effect of plume rise, complex terrain, buildings and deposition. Dispersion models predict atmospheric concentrations within a set level of confidence and there can be variations in results between models under certain conditions; the ADMS 5 model has been formally validated and is widely used in the UK and internationally for regulatory purposes.

1.1.2 ADMS comprises a number of individual modules each representing one of the processes contributing to dispersion or an aspect of data input and output. Amongst the features of ADMS are:

- An up-to-date dispersion model in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and the heat flux at the surface. This approach allows the vertical structure of the boundary layer, and hence concentrations, to be calculated more accurately than does the use of Pasquill-Gifford stability categories, which were used in many previous models (e.g. ISCST3). The restriction implied by the Pasquill-Gifford approach that the dispersion parameters are independent of height is avoided. In ADMS the concentration distribution is Gaussian in stable and neutral conditions, but the vertical distribution is non-Gaussian in convective conditions, to take account of the skewed structure of the vertical component of turbulence;
- A number of complex modules including the effects of plume rise, complex terrain, coastlines, concentration fluctuations and buildings; and
- A facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes and radioactivity, and percentiles of hourly mean concentrations, from either statistical meteorological data or hourly average data.

Meteorological Data

1.1.3 The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind direction, wind speed and atmospheric stability as described below:

- Wind direction determines the sector of the compass into which the plume is dispersed;
- Wind speed affects the distance that the plume travels over time and can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise; and
- Atmospheric stability is a measure of the turbulence of the air, and particularly of its vertical motion. It therefore affects the spread of the plume as it travels away from the source. New generation dispersion models, including ADMS, use a parameter known as the Monin-Obukhov length that, together with the wind speed, describes the stability of the atmosphere.

1.1.4 For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made.

1.1.5 The year of meteorological data that is used for a modelling assessment can have a significant effect on source contribution concentrations. Dispersion model simulations have been performed using five years of data from Gravesend between 2012 and 2016.

1.1.6 Wind roses have been produced for each of the years of meteorological data used in this assessment and are presented in Figure 1.1.

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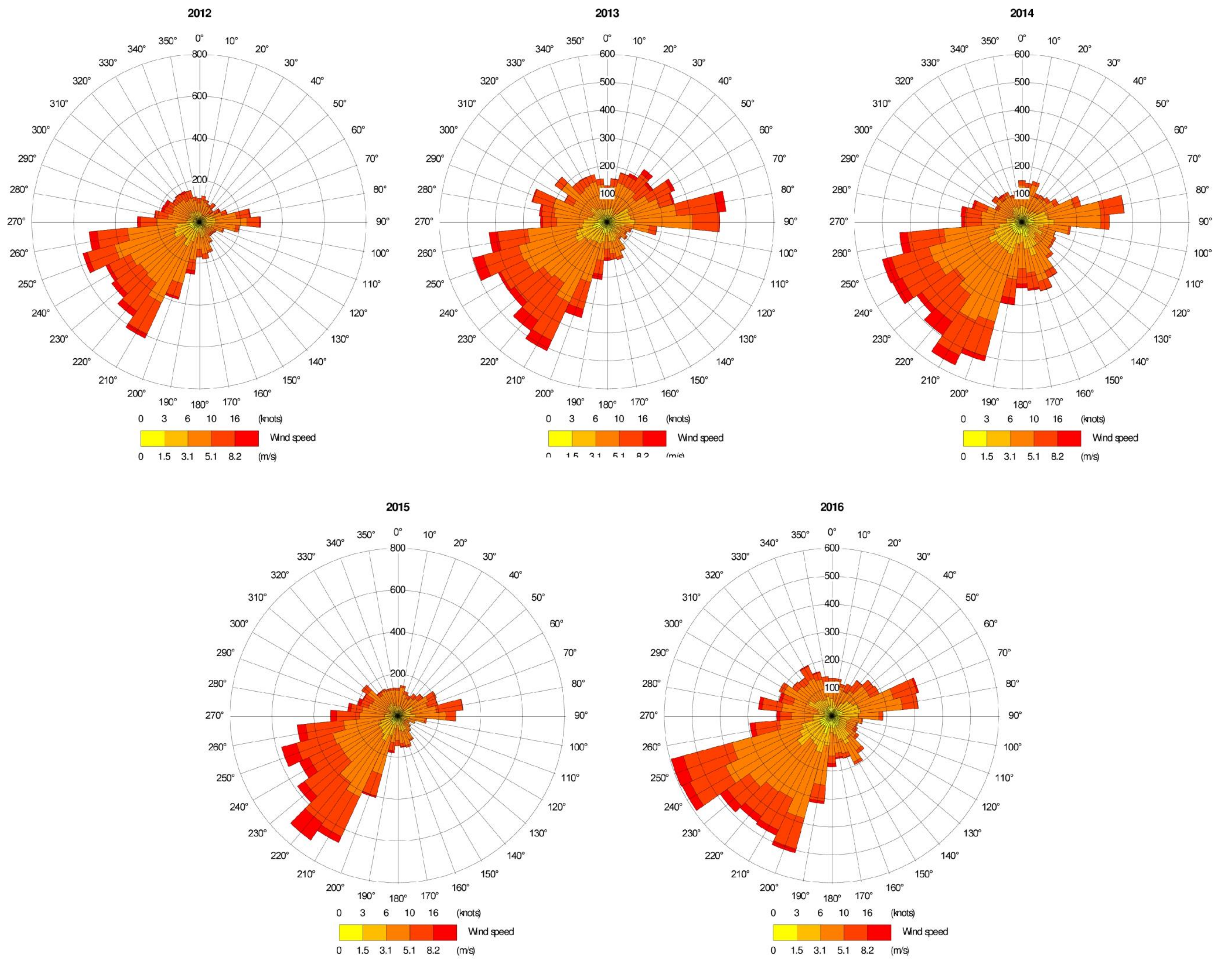

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Thurrock Flexible Generation Plant
Wind roses

RPS THURROCK POWER

Figure 1.1 Wind Roses – Gravesend, 2012- 2016

Time Varying Emissions

1.1.7 For the purposes of assessing the air quality impacts, modelling has been undertaken for a worst case scenario assuming that the gas engines operate for 4,000 hours per year which represents the largest total number of operational hours considered as part of this assessment.

Surface Roughness

1.1.8 The roughness of the terrain over which a plume passes can have a significant effect on dispersion by altering the velocity profile with height, and the degree of atmospheric turbulence. This is accounted for by a parameter called the surface roughness length.

1.1.9 A surface roughness length of 0.5 m has been used within the model to represent the average surface characteristics across the study area.

Terrain

1.1.10 A complex terrain file has been included within the model to ensure that the relative height between receptors and the source of emissions is taken into account.

Building Wake Effects

1.1.11 The movement of air over and around buildings generates areas of flow circulation, which can lead to increased ground level concentrations in the building wakes. Where building heights are greater than approximately 30 - 40% of the stack height, downwash effects can be significant. Volume 2, Chapter 2: Project Description provides a site layout plan. The likely buildings associated with the proposed development that have been included within the model are provided in Table 1.1.

Table 1.1: Maximum Buildings Dimensions Included Within the Model

Building Name	Approx. location of centre (x,y)	Length (m)	Width (m)	Height (m)
Substation 1a	566149, 176519	67	175	10
Substation 2a	566309, 176513	65	165	10
Substation 2b	566384, 176522	75	107	10
Battery Storage a	566156, 176646	120	75	10
Battery Storage b	566116, 176588	31	62	10
Substation 1b	566106, 176525	25	65	10
Gas Engines 1	566374, 176799	50	120	15
Gas Engines 2	566444, 176781	50	120	15
Gas Engines 3	566338, 176663	50	120	15
Gas Engines 4	566407, 176645	50	120	15
Substation 2c	566351, 176465	40	18	10

Stack Parameters and Emissions Rates Used in Model

1.1.12 Stack and emissions characteristics modelled are provided in Table 1.2. Four different engine scenarios have been modelled as outlined below:

- 60 x 10.4 MW engines, each engine has its own stack (60 stacks);
- 60 x 10.4 MW engines, aggregated stacks of five engines per stack (12 stacks);
- 33 x 18.4 MW engines, each engine has its own stack (33 stacks); and
- 33 x 18.4 MW engines, aggregated stacks of 6 groups of five engines per stack and one group of three engines per stack (7 stacks).

1.1.13 For the purposes of modelling, it has been assumed that pollutant emission concentrations are at the limit set in the IED. As this is the maximum concentration that could be permitted, this is a worst case assumption. The modelled stack locations are shown in Table 1.3. Stack Locations for other scenarios are shown in Appendix 12.5: Results of Other Scenarios.

Table 1.2: Stack and Emissions Characteristics

Parameter	Unit	10.4 MW Engine (Individual Stack)	5 x 10.4 MW Engines (Combined Stack)	18.4 MW Engine (Individual Stack)	5 x 18.4 MW Engines (Combined Stack)	3 x 18.4 MW Engines (Combined Stack)
Stack height	m	40				
Internal diameter	m	0.9	2.0	1.6	3.6	2.8

Parameter	Unit	10.4 MW Engine (Individual Stack)	5 x 10.4 MW Engines (Combined Stack)	18.4 MW Engine (Individual Stack)	5 x 18.4 MW Engines (Combined Stack)	3 x 18.4 MW Engines (Combined Stack)
Efflux velocity	$m.s^{-1}$	43.2	43.2	26.6	26.6	26.6
Efflux temperature	°C	326	326	360	360	360
Actual Volumetric flow	$m^3.s^{-1}$	27.5	137.5	53.4	267.0	160.2
O_2 (dry)	%	11.3	11.3	13.2	13.2	13.2
Water	%	9.8	9.8	8.6	8.6	8.6
NO_x Emission Concentration Limit	$mg.Nm^{-3}$	50				
Normalised Volumetric Flow (°C, dry)	$Nm^3.s^{-1}$	18.3	91.5	21.1	105.5	63.3
NO_x Mass Emission Rate	$g.s^{-1}$	1.37	6.85	2.04	10.21	6.13

Table 1.3: Stack Locations for 60 x 10.4 MW, each engine has its own stack scenario.

Engine Number	X (m)	Y (m)
1	566354	176607
2	566356	176614
3	566358	176621
4	566359	176627
5	566361	176634
6	566363	176642
7	566366	176648
8	566368	176655
9	566370	176662
10	566372	176670
11	566374	176676
12	566376	176683
13	566378	176690
14	566380	176696
15	566382	176703
16	566389	176701
17	566387	176694
18	566386	176688
19	566384	176680
20	566382	176673
21	566380	176667
22	566378	176660
23	566376	176652

Engine Number	X (m)	Y (m)
24	566374	176645
25	566372	176639
26	566370	176631
27	566369	176625
28	566367	176619
29	566365	176611
30	566363	176604
31	566390	176744
32	566392	176751
33	566393	176757
34	566395	176764
35	566397	176771
36	566399	176778
37	566401	176785
38	566403	176792
39	566405	176799
40	566407	176806
41	566409	176813

Engine Number	X (m)	Y (m)
43	566412	176827
42	566414	176834
44	566416	176840
45	566411	176820
46	566427	176837
47	566426	176830
48	566424	176823
49	566422	176816
50	566419	176810
51	566419	176803
52	566416	176796
53	566414	176789
54	566412	176782
55	566410	176775
56	566408	176768
57	566406	176761
58	566404	176754
59	566403	176748

Engine Number	X (m)	Y (m)
60	566401	176740

Stack Height Determination

1.1.14 Gas is a clean-burning fuel; nevertheless there is a need to discharge the flue gases through an elevated stack to allow dispersion and dilution of the residual combustion emissions. The stack needs to be of sufficient height to ensure that pollutant concentrations are acceptable by the time they reach ground level. The stack also needs to be high enough to ensure that releases are not within the aerodynamic influence of nearby buildings, or else wake effects can quickly bring the undiluted plume down to the ground.

1.1.15 A stack height determination has been undertaken to identify the stack height required to overcome the wake effects of nearby buildings and to establish the height at which there is minimal additional environmental benefit associated with the cost of further increasing the stack. The Environment Agency removed its detailed guidance, Horizontal Guidance Note EPR H1 (Environment Agency, 2010), for undertaking risk assessments on 1 February 2016; however, the approach used here by RPS is consistent with that EA guidance which required the identification of;

"an option that gives acceptable environmental performance but balances costs and benefits of implementing it."

1.1.16 The stack height determination involved running a series of atmospheric dispersion modelling simulations to predict the ground-level concentrations with the stack at different heights. The results of the stack height determination are provided in Appendix 12.3: Stack Height Determination.

NOx to NO_2 Assumptions for Annual-Mean Calculations

1.1.17 Total conversion (i.e. 100%) of NO to NO_2 is sometimes used for the estimation of the absolute upper limit of the annual mean NO_2. This technique is based on the assumption that all NO emitted is converted to NO_2 before it reaches ground level. However, in reality the conversion is an equilibrium reaction and even at ambient concentrations a proportion of NO_x remains in the form of NO. Total conversion is, therefore, an unrealistic assumption, particularly in the near field (Environment Agency, 2007). While this approach is useful for screening assessments, it is not appropriate for detailed assessments.

1.1.18 Historically, the Environment Agency has recommended that for a 'worse case scenario', a 70% conversion of NO to NO_2 should be considered for calculation of annual average concentrations. If a breach of the annual average NO_2 objective/limit value occurs, the Environment Agency requires a more detailed assessment to be carried out with operators asked to justify the use of percentages lower than 70%.

1.1.19 Following the withdrawal of the Environment Agency's H1 guidance document, there is no longer an explicit recommendation; however, for the purposes of this detailed assessment, a 70% conversion of NO to NO_2 has been assumed for annual average NO_2 concentrations in line with the Environment Agency's historic recommendations.

NOx to NO_2 Assumptions for Hourly-Mean Calculations

1.1.20 An assumed conversion of 35% follows the Environment Agency's recommendations (Environment Agency, undated) for the calculation of 'worse case' scenario short-term NO_2 concentrations.

Modelling of Long-term and Short-term Emissions

1.1.21 Long-term (annual-mean) NO_2 has been modelled for comparison with the relevant annual mean objectives.

1.1.22 For short-term NO_2, the objective is for the hourly-mean concentration not to exceed 200 $\mu g.m^{-3}$ more than 18 times per calendar year. As there are 8,760 hours in a non-leap year, the hourly-mean concentration would need to be below 200 $\mu g.m^{-3}$ in 8,742 hours, i.e. 99.79% of the time. Therefore, the 99.79th percentile of hourly NO_2 has been modelled.

2. References

Environment Agency (2010) Environmental Permitting Regulations (EPR) – H1 Environmental Risk Assessment, Annex K

Environment Agency (2007) Review of methods for NO to NO_2 conversion in plumes at short ranges

Environment Agency (undated) Conversion Ratios for NO_x and NO_2