Thurrock Flexible Generation Plant

Environmental Statement Volume 6
Appendix 12.4: Model Inputs and Outputs

Date: February 2020

Environmental Impact Assessment

Environmental Statement

Volume 6

Appendix 12.4

Report Number: OXF10762

Version: Final

Date: February 2020

Prepared by: Kathryn Barker

Contributors: Rosemary Challen

Checked by: Fiona Prismall

Thurrock Power Ltd

1st Floor

145 Kensington Church Street

London W8 7LP

Table of Contents

List of Tables

List of Figures

Summary

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

Qualifications

This appendix 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 Fellow of the 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', the Environmental Protection UK & IAQM 2017 'Land-use Planning & Development Control: Planning for Air Quality' guidance and the IAQM 2019 'A guide to the assessment of air quality impacts on designated nature conservation sites'.

1. Model Inputs and Outputs

1.1 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.

1.2 Meteorological Data

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

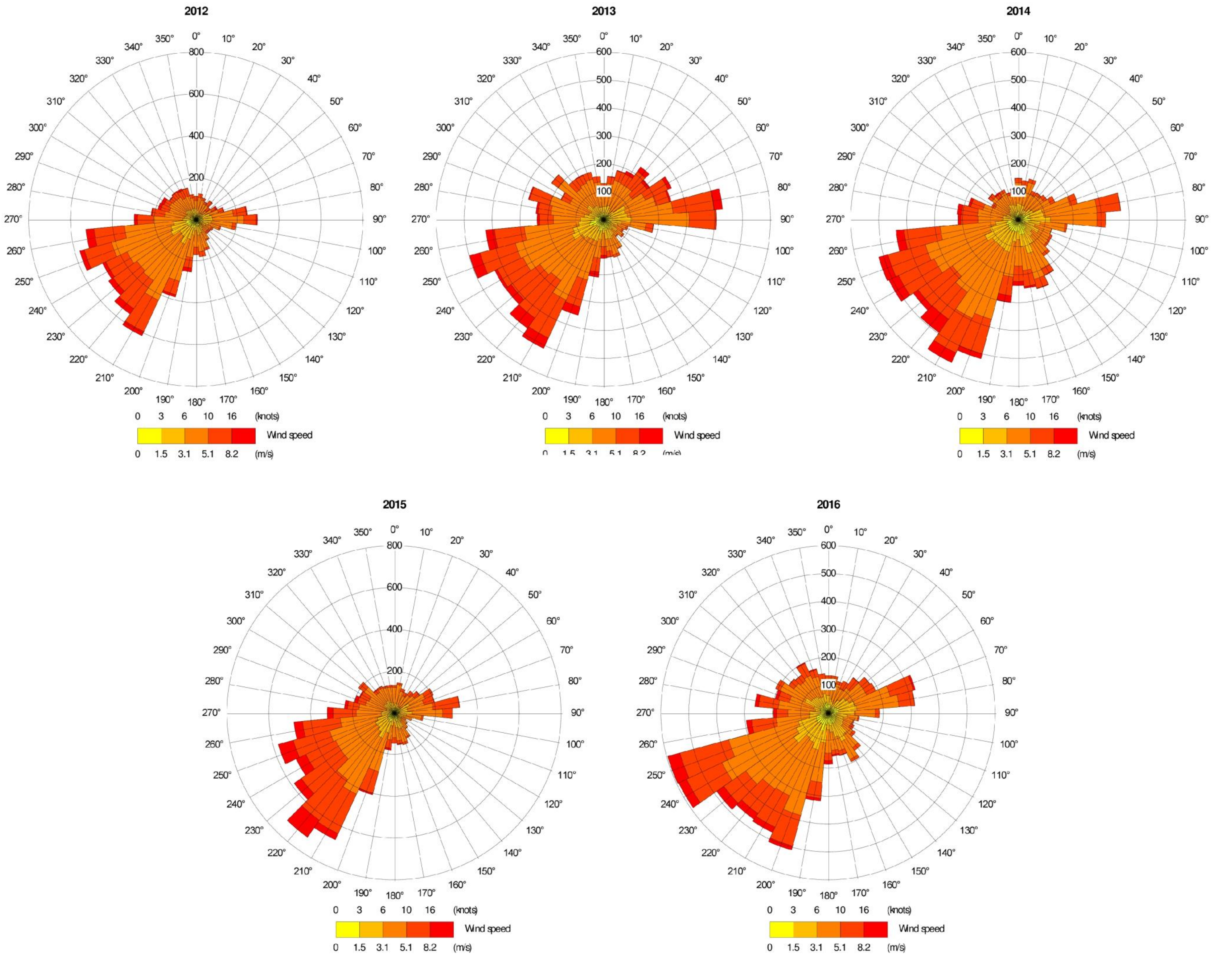
- Wind direction determines the sector of the compass into which the plume is dispersed;
- Wind speed affects the distance that the plume travels over time and can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise; and
- Atmospheric stability is a measure 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.

1.2.2 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.

1.2.3 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.

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

N



Legend

Created by: MS Scale: A3@ 1:16,998 Date: 01/10/2018
Checked by: CD Doc no: 10872-0077-01

Thurrock Flexible Generation Plant
Wind roses

Figure 1.1 Wind Roses – Gravesend, 2012- 2016

1.3 Time Varying Emissions

1.3.1 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.

1.4 Building Wake Effects

1.4.1 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 illustrative site layout plans. These indicative layouts have been used to develop a set of worst-case input assumptions for modelling purposes with regard to both layout of buildings and their size. Reconfiguration or resizing of the buildings within the parameters allowed in Chapter 2 and the Works Plans will not increase the effects on air quality but may reduce these. 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)
Gas Engines 1	566345, 176691	55	311	20
Substation 1a	566140, 176482	63	101	15
Substation 2a	566291, 176461	70	155	15
Substation 2b	566373, 176496	69	47	15
Battery Storage a	566149, 176637	139	75	10
Battery Storage b	566142, 176565	114	58	10
Substation 1b	566102, 176510	25	65	15
Gas Engines 2	566425, 176670	55	311	20
Substation 2c	566351, 176465	40	18	15

1.5 Surface Roughness

1.5.1 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.

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

1.6 Terrain

1.6.1 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.

1.7 Stack Parameters and Emissions Rates Used in Model

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

- 48 x 12.4 MW engines, each engine has its own stack (48 stacks);
- 48 x 12.4 MW engines, aggregated stacks of four 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).

1.7.2 For the purposes of modelling, it has been assumed that pollutant emission concentrations are at the limit set in the Industrial Emissions Directive (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	12.4 MW Engine (Individual Stack)	4 x 12.4 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	1.3	2.6	1.6	3.6	2.8

Parameter	Unit	12.4 MW Engine (Individual Stack)	4 x 12.4 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	$m.s^{-1}$	17.4	17.4	17.3	17.3	17.3
Efflux temperature	°C	140	140	140	140	140
Actual Volumetric flow	$m^3.s^{-1}$	23.0	115.0	34.8	174.0	104.5
O_2 (dry)	%	12.9	12.9	13.2	13.2	13.2
Water	%	9.2	9.2	8.6	8.6	8.6
NO_x Emission Concentration Limit	$mg.Nm^{-3}$	75				
Normalised Volumetric Flow (°C, dry)	$Nm^3.s^{-1}$	18.7	74.8	27.2	136.2	81.7
NO_x Mass Emission Rate	$g.s^{-1}$	1.40	5.60	2.04	10.21	6.13

Table 1.3: Stack Locations for 48 x 12.4 MW, each engine has its own stack scenario.

Engine Number	X (m)	Y (m)
1	566354	176587
2	566357	176595
3	566359	176602
4	566361	176609
5	566364	176615
6	566365	176622
7	566368	176629
8	566370	176636
9	566372	176643
10	566373	176650
11	566383	176681
12	566385	176688
13	566387	176695
14	566388	176701
15	566391	176708
16	566393	176715
17	566395	176722
18	566397	176729
19	566399	176736
20	566401	176743
21	566407	176772
22	566409	176779
23	566411	176786
24	566413	176794
25	566422	176791
26	566419	176783
27	566416	176776
28	566414	176769
29	566407	176741
30	566405	176733
31	566402	176726
32	566401	176719
33	566399	176712
34	566396	176705
35	566394	176698
36	566392	176693
37	566390	176686
38	566389	176679
39	566381	176648

Engine Number	X (m)	Y (m)
40	566379	176641
41	566377	176634
43	566375	176628
42	566373	176620
44	566371	176614
45	566369	176607
46	566367	176600
47	566366	176593
48	566363	176585

Stack Height Determination

1.7.3 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.

1.7.4 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."*

1.7.5 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.

1.8 NO_x to NO_2 Assumptions for Annual-Mean Calculations

1.8.1 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.

1.8.2 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%.

1.8.3 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.

1.9 NO_x to NO_2 Assumptions for Hourly-Mean Calculations

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

1.10 Modelling of Long-term and Short-term Emissions

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

1.10.2 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. [Online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/448754/H1_2013_consultation_response.pdf [Accessed 07 October 2019]

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

Environment Agency (EA) (undated) Conversion Ratios for NO_x and NO_2. [Online] Available at: https://webarchive.nationalarchives.gov.uk/20140328232919/http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for__NOx_and_NO2_.pdf [Accessed 07 October 2019]