Air Quality and Greenhouse Gas Emissions — Chapter 9

Air Quality and Greenhouse Gas Emissions – Summary of Key Outcomes

Impacts During Construction

The distance to the nearest residential dwelling is more than 2 km which is considered to provide a sufficient buffer zone between the main work area to prevent nuisance dust impacts. The minimisation and control of dust emissions during the construction period would be implemented using procedures contained in the Construction Environmental Management Plan (CEMP) for the Project.

Impacts During Operation - Air Quality Assessment

The potential air quality impact of the Dalton Power Project has been assessed using the Calpuff dispersion modelling package. The pollutants assessed included nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter (PM_{10}) and formaldehyde. The dispersion modelling has used a largely conservative approach, in accordance with the DECCW (2005) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*. In order to assess the cumulative impact of the plant emissions on the local air quality, background concentrations of the criteria pollutants were obtained from the relevant OEH and TMS monitoring stations.

Given the quantity, velocity and temperature of the exhaust gases emitted from the exhaust stacks, open cycle gas turbine plumes can travel at high velocities through the atmosphere. The assessment found that the plant has potential issues for aviation safety, where the high velocity of the exhaust gases can potentially affect the handling characteristics of aircraft, with the risk of airframe damage in extreme cases.

The results of the dispersion modelling showed that the predicted impacts on ground level concentrations of NO_2, PM_{10}, CO and SO_2, when added to peak background concentrations, were within the OEH regulatory criteria. In addition, the predicted incremental concentrations of formaldehyde were found to be within OEH criteria. This analysis has also assumed that all oxides of nitrogen (NO_x) exist as nitrogen dioxide.

Impacts During Operation - Greenhouse Gas Assessment

A greenhouse gas assessment has been performed for the Facility, and has included scope 1, scope 2 and scope 3 emissions associated with natural gas combustion in the open cycle gas turbine generators, and the consumption of electricity from the electricity grid. The principal greenhouse gas emission from the Facility is carbon dioxide (CO_2), which is a product of natural gas combustion. Minor quantities of other greenhouse gases may be emitted and have been represented in this assessment, as carbon dioxide equivalent (CO_2-e). The assessment has considered four potential plant configurations, each with an average of operational time of 15 % of the year.

Total annual emissions were estimated to be in the range of 0.66 to 1.47 Million tonnes of carbon dioxide equivalent (Mt CO_2-e). The associated emissions intensity of generation was calculated to be approximately 800 kilograms of carbon dioxide equivalent per megawatt hour of electricity generated (kg CO_2-e/MWh).

Based on a project life of 30 years, the total lifetime emissions were estimated to be between 20.1 and 44.0 Mt CO_2-e.

A comparison of emissions from the Facility to state and national greenhouse gas inventories was also made. Emissions from the project were estimated to be in the range of 0.41-0.90% and 0.11-0.25% of the state and national inventories, respectively. In addition, emissions from the project were estimated to be in the range of 0.85-1.85% and 0.23-0.49% of stationary energy emissions from the state and national inventories, respectively.

Impacts during Operation - Plume Rise Assessment

A plume rise assessment was performed which showed that the peaking power plant would produce exhaust plumes with vertical velocities that exceed 4.3m/s above the Obstacle Limitation Surface. Due to the plume rise from the stack emissions, an aviation hazard analysis based on the predicted impacts of the proposed facility has been performed. The aviation hazard analysis was compiled in accordance with the Civil Aviation Safety Authority's (CASA) Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (June, 2004). A search of CASA registered aerodromes and unregistered landing strips indicated that there are no known landing strips within a 15 km radius of the Project site.

Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, the Civil Aviation Safety Authority (CASA) may choose to designate this to be a potential hazard to aircraft operators in the area.

Further consultation with CASA would be undertaken to ensure the Project is appropriately recognised as a potential aviation hazard.

9.1 Introduction

In order to assess the likely impact of the operation of the proposed Dalton Power Project on local and regional air quality, the study included:

1. An assessment of local air quality.
2. Dispersion modelling of pollutants such as nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter (PM_{10}) and formaldehyde.
3. An assessment of plume rise.

The impact on ambient air quality with respect to regulatory emission limits and ground level concentration criteria of the primarily gaseous emissions has been assessed by URS. The local air quality assessment involved dispersion modelling and has been conducted in accordance with OEH's *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) (referred to herein as the *Approved Methods)*. The assessment of the impact on local air quality used a largely conservative approach, in accordance with the *Approved Methods*. This chapter provides summary of this assessment and the full assessment is presented in **Appendix C**.

An aviation safety assessment has also been conducted for the Project to determine compliance with the Civil Aviation Safety Authority's (CASA) Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (June, 2004). This assessment is summarised in this chapter and presented in full in **Appendix D**.

The impact from construction on air quality has been qualitatively assessed.

9.2 Existing Environment

9.2.1 Climate and Meteorology

A summary of climatological data collected at Yass by the Bureau of Meteorology (BoM) is provided in **Appendix C**. The weather station at Yass is considered to be representative of the region, including the proposed development site. The Yass Meteorological Station is located approximately 25 km to the south-west of the site. These data indicate that the region experiences hot summers and cold winters. The mean daily maximum temperature is approximately 29^0C during summer and 12^0C during winter. Sub-zero temperatures have been recorded between April and November and are regularly recorded during winter with temperatures lower than -8^0C having been measured. The area receives moderate rainfall having a mean annual rainfall of 648.5 mm over an average of 93.5 rain days per year.

The meteorological data used in the assessment was generated using CSIRO's The Air Pollution Model (TAPM) and further discussed in **Appendix C.** The TAPM derived meteorological data indicates that the region experiences moderate to high wind speeds, primarily from the north to north west, with an average wind speed of 4.38 m/s, and 1.4 % calms (wind speeds less than 0.5 m/s) recorded for the year 2006.

9.2.2 Background Air Quality

No site-specific background monitoring data was available for this assessment. Therefore, background concentrations of NO_2, CO, SO_2 and PM_{10} have been adopted from areas which have a greater pollution potential as a function of population, industrial emissions, meteorology and topography. Whilst this is unsuitable for predicting the actual scale of cumulative air quality impacts of the proposed Project, it is conservative, and appropriate for the purposes of this assessment in demonstrating compliance with regulatory criteria. The background data for this assessment were sourced from two government monitoring stations which undertake monitoring as part of the National Environment Protection Measure for Ambient Air Quality (AAQ NEPM); Monash (ACT) and Chullora (NSW).

The ACT Government Territory & Municipal Services Performance Monitoring Station (PMS), located at Monash in the Australian Capital Territory, is approximately 82 km south of the proposed site. The population in the area of the PMS is 324,000 and the station is located at a site that is considered "generally representative of the upper bound" of pollutant concentrations for the region. The monitoring data collected here is considered to provide a conservative representation of the background concentrations required for this assessment due to the size of the surrounding population and the siting of the PMS within valley topography where wood fired heaters are commonly used.

Background levels of CO and SO_2 are not measured at Monash. The background data for these pollutants were taken from the OEH monitoring station at Chullora, located in Sydney's south west. It should be noted that the Chullora monitoring station is located in within Sydney's south west and is surrounded by industry, residential areas and heavily trafficked roads, consequently the background SO_2 and CO concentrations used in this assessment are considered conservative as the proposed development site is situated away from such sources. Whilst the incorporation of these data is unsuitable for predicting the actual scale of cumulative air quality impacts of the proposed Facility, it is conservative, and appropriate for the purposes of this assessment in demonstrating compliance with regulatory criteria.

The concentrations listed in **Table 9-1** have been incorporated into this assessment for the purpose of estimating cumulative concentrations.

Table 9-1 Summary of Background Pollutant Concentrations

Substance	Averaging Period	Monitoring Source	Background Concentration (μg/m³)	OEH Criteria (μg/m³)
NO_2	1 hour	Monash, ACT	90[A]	246
	Annual	Monash, ACT	37[A]	62
CO	15 minutes	Chullora, NSW	6270[B]	100,000
	1 hour	Chullora, NSW	4752	30,000
	8 hours	Chullora, NSW	2876	10,000
SO_2	10 minutes	Chullora, NSW	61[B]	712
	1 hour	Chullora, NSW	43	570
	24 hours	Chullora, NSW	11	228
	Annual	Chullora, NSW	3	60
PM_{10}	24 hour	Monash, ACT	45.3	50
	Annual	Monash, ACT	16.9	30
Formaldehyde	1 hour	NA[C]	NA[C]	20

Notes:
A: Values reported in TMS (2007) as ppm have been converted assuming 273K and 1 atm.
B: Sub hourly concentration estimated from peak hourly concentration based on power law discussed in **Appendix C**.
C: Not Applicable: The *Approved Methods* stipulate that only the incremental impact be evaluated.

- Monash data sourced from: TMS(2007), The Australian Capital Territory 2006 Ambient Air Quality Report against the Ambient Air Quality National Environment Protection Measure
- Chullora data sourced from: DECCW (2007), National Environmental Protection (Ambient Air Quality) Measure Compliance *Report New South Wales.*

9.3 Impacts During Construction

The Stage 1 construction phase is anticipated to take around 24 months and will involve the construction of concrete footings for the generator units, the formation of unsealed site roads, installation of turbine units, construction of a switchyard and transmission connection, installation of the gas pipeline and gas receiving station, fencing, commissioning and other minor works.

The construction program for the second stage would comprise construction activities to achieve the residual generating capacity for a completed maximum of six turbines on site. Although it is assumed that the construction would be generally similar to the first stage, the intensity is likely to be lower as the majority of site preparation works and infrastructure would be established in the first stage.

During both the Stage 1 and Stage 2 construction phases, there is the potential for dust to be generated due to the excavation and handling of soils, site grading activities and vehicles movements. Given the undeveloped nature of the site, there is considered to be no significant potential for any dust emissions from construction activities to contain contaminants, or for the works to give rise to odorous emissions, consequently emissions during construction have not been quantified.

The distance to the nearest residential dwelling is more than 2 km which is considered to provide a sufficient buffer zone between the main work area to prevent nuisance dust impacts. The minimisation and control of dust emissions during the construction period will be implemented using procedures contained in the Construction Environmental Management Plan (CEMP) for the Project.

9.4 Impacts During Operation

9.4.1 Air Quality Modelling

Methodology

The potential air quality impact of the Dalton Power Project has been assessed using the Calpuff dispersion modelling package. The pollutants assessed included nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter (PM_{10}) and formaldehyde. The assessment of the impact on local air quality used a largely conservative approach, in accordance with the *Approved Methods*. Modelling was performed of a 40 x 40 km modelling domain. From previous modelling assessments of open cycle gas turbine facilities, peak impacts have occurred at a distance of up to 10 km from the emission source. The modelling domain has been selected to include the region where the peak impact might be predicted to occur.

This assessment has considered a total of eight scenarios. These are:

- Stage 1, E Class Plant, Startup;
- Stage 1, E Class Plant, Operation;
- Stage 1, F Class Plant, Startup;
- Stage 1, F Class Plant, Operation;
- Stage 2, E Class Plant, Startup;
- Stage 2, E Class Plant, Operation;
- Stage 2, F Class Plant, Startup; and
- Stage 2, F Class Plant, Operation.

For modelling purposes it has been assumed that all turbines would operate continuously for all hours of the year, under all meteorological conditions. Given the use of a Lagrangian puff model, where emissions from sequential hours are tracked and have the potential to co-contribute to ground level concentrations within a single hour, the assumption of continuous operation is considered conservative, particularly for startup scenarios where, in reality, the Facility would not startup in sequential hours.

The emission parameters for the Dalton Power Project are contained in **Table 9-2**, while the assumptions used for the detailed air modelling are detailed in **Appendix C**.

Table 9-2 Gas turbine emission parameters

Parameter	E Class		F Class	
	Startup	Operation	Startup	Operation
Stack Height (m)	35	35	46	46
Stack Diameter (m)	6.0	6.0	6.7	6.7
Exit Temperature (ºC)	365	532	435	610
Exit Velocity (m/s)	20	40	13	45
Duration (min)	15	-	20*	-
Emission Rates (g/s)	**Startup**	**Operation**	**Startup**	**Operation**
NO_x	48.1	19.3	26.3	30.6
CO	730.7	4.6	179.6	9.1
SO_2	1.3	1.3	2.0	2.0
PM_{10}	3.0	3.0	3.8	3.8
Formaldehyde	1.79	0.15	2.88	0.24

Note: The stack parameters for the F Class startup are the average over a 16 minute startup, however emission rates have been weighted with an additional 4 minutes of operating emissions, such that the net emissions flux is representative of that which would occur over the 20 minutes after ignition.

Results

Table 9-3 provides the results of the dispersion modelling. All predictions were below regulatory criteria. Although one result is shown to be approaching criteria, Stage 2 F Class operation scenario NO_2 prediction, this result has been calculated in a conservative manner.

Contour isopleths for nitrogen dioxide across the modelling domain have been provided in **Appendix C**. Isopleths for other compounds have not been presented due to the low levels predicted.

Table 9-3 Summary of maximum dispersion modelling results with comparison against regulatory criteria (ll results in µg/m^3)

Substance	Averaging Period	Stage 1				Stage 2				Background	Maximum Cumulative*	OEH Criteria
		E Class		F Class		E Class		F Class				
		Startup	Operation	Startup	Operation	Startup	Operation	Startup	Operation			
NO_2	1 hour	71.8	87.3	46.5	64.6	96.9	92.0	100.8	150.7	90	240.7	246
	Annual	0.3	0.1	0.2	0.1	0.4	0.2	0.3	0.2	37	37.4	62
CO	15 minute	1439	27	282	25	1717	29	798	59	6270	7987	100,000
	1 hour	1091	21	214	19	1301	22	605	45	4750	6051	30,000
	8 hour	320	5	29	3	420	7	64	8	2880	3300	10,000
SO_2	10 Minute	6.3	8.4	4.4	6.0	6.8	8.9	9.9	14.1	61	75.1	712
	1 hour	4.4	5.9	3.1	4.2	4.8	6.2	6.9	9.8	43	52.8	570
	24 hour	0.4	0.5	0.4	0.2	0.6	0.7	0.7	0.6	11	11.7	228
	Annual	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	3	3.0	60
PM_{10}	24 hour	1.0	1.2	0.8	0.5	1.3	1.6	1.4	1.1	45.3	46.9	50
	Annual	0.03	0.02	0.03	0.01	0.04	0.03	0.05	0.02	16.9	16.9	30
Formaldehyde	1 hour	0.9	0.2	1.5	0.1	1.3	0.20	3.2	0.1	NA	3.2	20

*Cumulative results presented for all compounds except formaldehyde, which has been assessed on an incremental basis in accordance with the *Approved Methods.*

Comparison Against Emission Limits

The turbines proposed for the Facility would comply with the relevant emission limits specified in the *Protection of the Environment Operations (Clean Air) Regulation 2002*. The proposed use of DLN emission controls guarantees that the turbine emissions would be less than 25 ppmvd (parts per million volumetric dry) at the 15 % oxygen reference condition. **Table 9-4** presents the proposed in-stack emission limit for oxides of nitrogen.

Table 9-4 Proposed in-stack emission limit for oxides of nitrogen

Air Impurity	In-Stack Concentration (mg/m^3 dry, 273K,15%O_2)	Regulatory Limit (Group 6) (mg/m^3 dry, 273K,15%O_2)
Nitrogen dioxide (NO_2) or nitric oxide (NO) or both as NO_2 equivalent	51	70

Discussion of Results

The predicted impact of nitrogen dioxide, carbon monoxide, sulphur dioxide, particulate matter and formaldehyde emissions from the Facility were shown to be below OEH criteria. Consequently, on the basis of these predictions, no adverse impacts on local air quality are expected as a result of the intermittent discharge of these pollutants from the proposed Facility.

The intent of the assessment was to investigate the compliance of the proposal with air quality criteria. As required by the *Approved Methods,* the assessment has included, in some instances, an overestimation of actual impacts. This is appropriate for the purpose of investigating compliance with regulatory criteria.

Nitrogen Dioxide

As there is uncertainty as to how NO_x from the Facility would be manifested, the modelling conservatively considered all NO_x as NO_2. The peak prediction for NO_x, when added to the peak NO_2 background concentrations, was found to be below regulatory criteria. Of the eight scenarios, the Stage 2, F Class Operation scenario was shown to be approaching criteria. The peak impact area was predicted to occur at a point some 10 km south south-west of the Facility, as shown in the Figures section of **Appendix C.** This result has been calculated in accordance with the *Approved Methods* using conservative assumptions.

Carbon Monoxide, Sulphur Dioxide, Particulate Matter (PM_{10}) and Formaldehyde

The predicted impact of carbon monoxide, sulphur dioxide, particulate matter (PM_{10}) and formaldehyde from the Facility were shown to be below criteria. Consequently, no adverse impacts on local air quality are expected as a result of the intermittent discharge of these pollutants from the proposed peaking power plant.

9.4.2 Greenhouses Gas Assessment

A greenhouse gas assessment for the Project was also undertaken, the results of which are attached as **Appendix E**. The assessment discusses the current regulatory context of greenhouse gas emissions from the Project and includes a quantitative model of the tonnages of greenhouse gas produced by the Facility. This is compared to state and national greenhouse gas inventories for both the energy sector, and the sum of all sectors. The results of that assessment are discussed below.

Greenhouse Gas Assessment Methodology

The greenhouse gas inventory for the Facility has been based on the accounting and reporting principles detailed within the Greenhouse Gas Protocol (the Protocol) (WBCSD/WRI, 2004). The greenhouse gas emission inventory for the Project is based on the methodology detailed in the Protocol, and the relevant emission factors in the *National Greenhouse Accounts (NGA) Factors* (the NGA factors) (DCC, 2009a), and the relevant *Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance* (IPCC, 2000).

A spreadsheet model has been specifically developed for the Project and uses the data sources and emission factors detailed below in order to calculate project emissions for every year of operation according to the Protocol. This model uses the methodology detailed in the NGA Factors.

The main greenhouse gases emitted during operation of the Dalton Power Project activities will be carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). To report these emissions, they are converted to carbon dioxide equivalents (CO_2-e) as specified under the Kyoto Protocol.

The Protocol further defines direct and indirect emissions through the concept of emission “scopes”.

- **Scope 1: Direct greenhouse gas emissions**

Direct greenhouse gas emissions occur from sources that are owned or controlled by a company. For example:

– Emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.;

– Fugitive emissions of greenhouse gases; and

– Emissions from on-site power generators.

- **Scope 2: Electricity indirect greenhouse gas emissions**

This accounts for greenhouse gas emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated but they are allocated to the organisation that owns or controls the facility or equipment where the electricity is consumed. Scope 2 emissions also capture the importing of energy (such as chilled water or steam) into a site.

- **Scope 3: Other indirect greenhouse gas emissions**

This is an optional reporting class that accounts for all other indirect greenhouse gas emissions resulting from a company's activities, but occurring from sources not owned or controlled by the company. Examples include extraction and production of purchased materials; extraction and distribution of purchased fuels; and use of sold products and services.

Greenhouse Gas Inventory

The quantitative component of this assessment encompasses the operational stage of the Facility. The operational boundary has been defined as the boundary of the power station site. Power generated has been quantified as gross power sent out, whilst electricity required to power auxiliary plant equipment has been quantified as electricity imported from the grid. The estimated fuel consumption and power generated per year (electricity sent out) are presented in **Table 9-5**.

Table 9-5 Estimated Gas Consumption and Electricity Sent Out and Consumed

Project Stage	Amount Gas Combusted (PJ/yr)	Electricity Sent Out (GWh/yr Gross)	Electricity Consumed (GWh/yr)
Stage 1, E Class	9.8	838	12
Stage 1, F Class	10.7	927	14
Stage 2, E Class	14.7	1257	18
Stage 2, F Class	21.4	1854	27

Table 9-6 presents estimated greenhouse gas emissions from the Facility on an annual basis. These estimates have included Scope 1, Scope 2, and Scope 3 emissions. These account for emissions from combustion, (indirect) emissions associated with the extraction, production and transport of the natural gas to the site, as well as emissions associated with electricity imported from the grid for use in the production of electricity

Table 9-6 Estimated Greenhouse Gas Emissions on an Annual Basis

		Emissions (Mt CO_2-e)				Full Fuel Cycle Emissions Intensity
Scenario	Activity	Scope 1	Scope 2	Scope 3	Total	kg CO_2-e/MWh
Stage 1, E Class	9.8 PJ Consumed 838 GWh Generated	0.50	0.01	0.16	0.67	801
Stage 1, F Class	10.7 PJ Consumed 927 GWh Generated	0.55	0.01	0.17	0.73	791
Stage 2, E Class	14.7 PJ Consumed 1257 GWh Generated	0.76	0.02	0.23	1.01	801
Stage 2, F Class	21.4 PJ Consumed 1854 GWh Generated	1.10	0.02	0.34	1.47	791

Based on the fuel consumption and power sent out, for the four plant configurations, with operating duty of 15%, the plant was estimated to emit between 0.66 and 1.44 Mt CO_2-e at an emissions intensity of approximately 800 kg CO_2-e/MWh.

Table 9-7 shows greenhouse gas emissions for the proposed plant on a project lifetime of 30 years. assuming 15% operation per year. AGL's current peaking experience indicates that on a long term average, the plant would be in operation for approximately 3% of the year. Consequently, the use of the upper limit of proposed operation is considered highly conservative. Long term market trends define the operating duty, and ultimately the commercial life, of the Facility. Consequently, large uncertainties are associated with potential emissions over the project lifetime.

Table 9-7 Estimated Greenhouse Gas Emissions on a Project Lifetime Basis

	Project Lifetime Emissions (Mt CO_2-e)			
Scenario	Scope 1	Scope 2	Scope 3	Total
Stage 1, E Class	15.1	0.3	4.7	20.1
Stage 1, F Class	16.5	0.4	5.1	22.0
Stage 2, E Class	22.7	0.5	7.0	30.2
Stage 2, F Class	33.0	0.7	10.2	44.0

Generator Performance

The proposed use of natural gas fired open cycle gas turbine technology at Dalton results in electricity production at a lower greenhouse intensity than the existing NSW average. Whilst detailed plant selection for the proposed Facility is yet to be made, **Table 9-8** shows the emissions intensities for the proposed open cycle gas turbine technology, as well as a range of other generator technology types. The data in **Table 9-8** are primarily sourced from the Technical Guidelines: Generator Efficiency Standards (AGO, 2006) and the Energy Directions Green Paper (NSW Government, 2004).

The emissions intensities contained in AGO(2006) were generated for the purpose of identifying standards of performance for new plant types under the recently defunct "Greenhouse Challenge Plus" program. Within the document, the presented emissions intensities are defined as representing Best Available Technology (BAT) on the basis of reviews conducted during 2004-2005. The technologies included in AGO(2006) represent mature technologies for which efficiency improvements are gradual, and have been limited in recent years. It is considered that these technologies are representative of current BAT.

Table 9-8 Emissions intensity of various generator technology types

Technology Type	Emissions Intensity (kg CO_2-e/MWh)
Open Cycle Gas-Fired Turbine	~600 – 700[1]
Open Cycle Gas-Fired Turbine (BAT)	710[2]
Combined Cycle Gas Turbine	~400 – 500[1]
Combined Cycle Gas-Fired Turbine (BAT)	454[2]
Coal-Fired – Best Existing Australian Plant	830[1]
Coal-Fired – World's Best Practice	~800 – 810[1]
Coal-Fired with Water Cooling (BAT)	855[2]
Coal-Fired with Air Cooling (BAT)	893[2]
Current NSW Average (NGA Scope 2 + Modified Scope 3)*	960[3]
2009 NSW GGAS Pool Coefficient*	967[4]

Notes:
[1]NSW Government (2004) *Energy Directions Green Paper*.
[2]AGO (2006) *Technical Guidelines: Generator Efficiency Standards* - These intensities have been scaled with emission factors from DCC(2008) to incorporate the full fuel cycle (Scope 1+3) emissions and thus allow comparison with NSW Government (2004)[1] and DCC (2009a)[3]. Note that DCC(2008) factors have been used in this analysis, as DCC(2009a) does not include a Scope 3 emission factor for NSW black coal in electricity generation.
[3]DCC (2009a) *National Greenhouse Accounts (NGA) Factors*, June 2009. *Includes standard NSW Scope 2 emission factor of 890 CO_2-e/MWh, as well as transmission network operator specific scope 3 factor from footnotes of Table 39 of DCC (2009a) of 70 kg CO_2-e/MWh. This particular Scope 3 emission factor has been used in order to avoid the inclusion emissions due to transmission and distribution losses, and thus provide a factor suitable for comparison against full fuel cycle emissions intensities.
[4]NSW Government (2008) *Fact Sheet – The NSW Pool Coefficient* November 2008. **Pool Coefficient does not include full suite of Scope 3 emissions, and is also calculated from a subset of NSW based national electricity market generators.

As can be seen in **Table 9-8**, the proposed technology has a lower intensity than the grid average, which is largely defined by the balance of coal and hydroelectric generation. It should also be acknowledged that of the technology types presented in **Table 9-8**, open cycle gas turbine technology is the only technology that is designed to proceed from standby to generation at full load in a timeframe consistent with the peaking regime in which AGL proposes to operate.

Comparison to National and NSW Greenhouse Gas Inventories

Quantitative greenhouse gas emissions from the Facility and comparison with greenhouse gases generated from the electricity sector in NSW and Australia are provided in **Table 9-9**. For the four plant configurations considered in this assessment, at an operating duty of 15%, the total annual emissions were predicted to be in the range of 0.67 to 1.46 Mt CO_2-e. For the sectors considered, these emissions constitute a small percentage of the inventory totals.

Table 9-9 Comparison of Proposal to State and National Greenhouse Gas Inventories

2007 Greenhouse Gas Inventory Sector	Greenhouse Gas Emissions (Mt CO_2-e)	% Contribution represented by the Dalton Power Project			
		Stage 1		Stage 2	
		E Class	F Class	E Class	F Class
NSW Stationary Energy sector	79.4	0.85%	0.92%	1.27%	1.85%
Total NSW GHG emissions	162.7	0.41%	0.45%	0.62%	0.90%
Australian Stationary Energy sector	297.7	0.23%	0.25%	0.34%	0.49%
Total Australian GHG emissions	597.2	0.11%	0.12%	0.17%	0.25%

Australia's future greenhouse gas inventory data are not possible to forecast with certainty. The 2007 inventory data shows that national emissions across all sectors rose by 9.3 % from 1990 to 2007. The largest sector increase was the stationary energy sector, followed by transport, showing a rise due to population growth and electricity demand for resources. Since future trends are unknown, the greenhouse gas emissions from the Facility cannot be meaningfully compared to future emissions from other sources of greenhouse gases in Australia over the operational life of the plant.

Greenhouse Gas Abatement

AGL is the largest producer of renewable energy in Australia, with installed capacity of 1,170 MW, and an additional 928 MW currently under construction. AGL is, and has been for many years, committed to investing in low emission (including natural gas) technology or renewables projects.

AGL proposes to implement technology that is consistent with current BAT. Hence the Project design has incorporated a range of greenhouse gas mitigation measures. In addition, greenhouse gas mitigation measures have been identified for the detailed design, and operational phases of the Project. These measures are detailed in **Table 9-10**.

Table 9-10 Greenhouse Gas Mitigation Measures Available to the Project

Mitigation Measure	Greenhouse Gas Reduction
Incorporated at Project Design Phase	
Technology Selection: Adoption of OCGT – Plant is able to be started and stopped quickly thus minimising fuel consumption outside of periods when the generator is on line. Alternatives to OCGT include CCGT or coal-fired generation, which would have to run on standby for large proportions of the year in order to be available to the peaking market (and would have significantly higher emissions). OCGT also has lower operational emissions than alternative peaking technologies.	Not Quantified[1]

Fuel Selection: Use of Natural Gas – Natural Gas has lower emissions per GJ of heat energy than alternative fuels such as oil or coal.	~20-40%[2]
Plant Selection: Implementation of OCGT with high thermal efficiency - AGL propose plant for this Project that achieves a thermal efficiency that is consistent with Best Available Technology (BAT) as defined in the Generator Efficiency Standards (AGO,2006).	~10% (60 kg CO_2-e/MWh)
Plant Selection: Implementation of Evaporative Cooling - AGL propose evaporative cooling which will offer efficiency benefits reducing greenhouse gas emissions when operating during hot conditions.	~1.5% (10 kg CO_2-e/MWh)
Available to Project at Detailed Design, Commissioning and Operational Phases	
Efficiency Auditing – In a manner consistent with both AGL's internal directives, and regulatory requirements under the *Energy Efficiency Opportunities Act 2006* (as amended), conducting audits to ensure that plant is being operated efficiently, and to identify opportunities to improve efficiency and reduce emissions intensity e.g.: • restoring the plant to design condition – e.g. replacing filters and removing fouling; • changing operational settings – e.g. ensuring control systems are operating correctly; • investigating and implementing retrofit improvements, and other mitigation options – e.g. turbine blades capable of withstanding higher combustion temperatures, CCS and waste heat brine concentration. EEO obligations involve assessment and implementation of efficiency improvements with a payback period of four years or less on a 5 year assessment cycle.	Varied: Operational efficiency improvements would typically result in reductions in the vicinity of 1-2% (6-12 kg CO_2-e/MWh), whilst CCS may achieve reductions in the range of 90% (500 kg CO_2-e/MWh[2])
Carbon Capture and Sequestration - separation of carbon dioxide from the generator exhaust stream, with subsequent transportation and underground storage.	AGL do not anticipate CCS will prove commercially effective on the proposed OCGT technology under the proposed peaking operational regime. Further discussion provided in **Appendix E** Section 4.2.3.

Notes: [1] Due to the need to maintain boilers in ready state, emissions intensity from applying CCGT or coal-fired generation to a peaking regime (as proposed by AGL) would likely be in excess of an order of magnitude higher. [2] Based on scope 1 emissions: Natural Gas: 51.3 kg CO_2-e/GJ (58% of Coal), Diesel Oil: 69.5 kg CO_2-e/GJ (79% of Coal) Coal: 88.4 kg CO_2-e/GJ.

As noted above, AGL proposes to implement technology that is consistent with current BAT for peaking operation. This largely precludes the application of greenhouse gas mitigation measures beyond those that are an inherent part of the Project.

An evaluation of the implementation of CCS for the Project indicates that CCS is unlikely to represent a technically or commercially feasible greenhouse mitigation measure for the Project (See ***Greenhouse Gas Assessment*** **(Appendix E)** for further detail).

AGL anticipates that additional, and currently unfeasible, greenhouse gas mitigation strategies may become more feasible during the future operation of the Facility. These are likely to be based around efficiency improvements associated with the adoption of improved technologies and componentry that are developed.

Such improvements could be implemented during routine maintenance and refurbishment of the Facility and would be in line with current Commonwealth Government policy on the introduction of a carbon priceto the Australian market, AGL proposes to investigate the feasibility of such measures as and when they become commercially feasible within the context of the development of a carbon price and market.

9.4.3 Plume Rise Assessment

Methodology

A Plume Rise Assessment was undertaken for the Project, and was conducted using The Air Pollution Model (TAPM), Version 3.07 for the purposes of assessing the potential for the Facility to create an aviation hazard. TAPM was used in conjunction with meteorological data for 2006 collected from Bureau of Meteorology Automatic Weather Station (AWS) at Goulburn Airport. These meteorological data were incorporated into TAPM to assist in generating site-specific meteorology at the location of the Facility. The model considered the plume rise from a range of exhaust stack configurations. For details, see **Appendix D**.

In this assessment, the 'Buoyancy Enhancement Factor' parameter in TAPM has been used to account for the additional plume rise due to the merging of the plumes. The approach taken is considered conservative under the majority of meteorological conditions, and appropriate for the conditions under which the greatest plume rise is predicted to occur.

The modelling considered six scenarios which are outlined in **Appendix D**. They include single turbine scenarios and plant type scenarios which are considered to represent the upper bound of the plume impact from multiple stacks, where the merging assumptions are conservative for the majority of meteorological conditions, and appropriate for conditions conducive to plume rise, when worst case impacts are predicted to occur.

Results

The modelling results show that, as expected for an open cycle gas turbine facility, the plant will produce exhaust plumes with vertical velocities that exceed 4.3m/s above the Obstacle Limitation Surface (OLS). **Table 9-11** displays the maximum, minimum and average critical plume extents. The critical vertical plume extent is the height (for a given hour modelled) at and below which, the vertical velocity (w) of the plume exceeds 4.3m/s. The critical horizontal plume extent is the total downwind translation of the plume boundary at the point at which the vertical velocity decreases to 4.3m/s. The maximum critical horizontal plume extent of 959 m was predicted to occur at a height of approximately 1860 m. This is further illustrated in **Figure 4-11** of **Appendix D**.

Table 9-11 Maximum, minimum and average critical plume extents

Scenario	Critical Plume Extent (m agl)					
	Maximum		Minimum		Average	
	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
E Class Single Turbine	688	203	50	22	105	63
E Class Stage 1	1695	530	77	77	252	220
E Class Stage 2	1821	668	99	113	326	308
F Class Single Turbine	1120	280	67	33	153	98
F Class Stage 1	1740	601	98	91	294	257
F Class Stage 2	2119	959	148	172	451	455

Table 9-12 shows the critical vertical plume extent by percentage of time, for the year 2006. For example, the result of 839 m for 0.05% for the F Class single turbine scenario indicates that for 1 in every 2000 hours, the plume velocity exceeds 4.3m/s at a height greater than or equal to 839 m.

Table 9-12 Heights below which the vertical velocity exceeds 4.3m/s by percentage of 2006

Percentage of time	Height below which vertical plume averaged velocity >4.3 m/s (m agl)					
	E Class			F Class		
	Single Turbine	Stage 1	Stage 2	Single Turbine	Stage 1	Stage 2
100%	50	77	99	67	98	148
90%	59	121	161	83	148	237
80%	63	142	189	93	172	273
70%	68	162	216	101	195	309
60%	75	185	245	111	220	342
50%	84	212	276	126	249	378
40%	95	244	312	145	281	416
30%	113	281	352	171	319	467
20%	140	324	404	204	366	561
10%	185	409	532	254	473	757
9%	190	427	550	260	493	791
8%	197	444	578	268	511	826
7%	203	462	605	276	532	877
6%	210	488	645	288	567	930

Percentage of time	Height below which vertical plume averaged velocity >4.3 m/s (m agl)					
	E Class			F Class		
	Single Turbine	Stage 1	Stage 2	Single Turbine	Stage 1	Stage 2
5%	218	529	703	305	612	993
4%	227	569	773	324	676	1071
3%	242	642	857	345	762	1184
2%	269	746	1008	385	883	1316
1%	319	928	1194	454	1074	1484
0.5%	377	1067	1327	537	1216	1673
0.3%	421	1156	1404	626	1282	1760
0.2%	463	1213	1486	674	1345	1796
0.1%	539	1437	1675	747	1592	1863
0.05%	606	1547	1720	839	1647	1976

The assessment has considered six scenarios, which have indicated that thermal plumes from the Facility would penetrate the Obstacle Limitation Surface (OLS) of 110 m above ground level (agl) at velocities greater than the CASA-specified critical velocity of 4.3 m/s.

Assessment scenarios were based upon two approaches:

- **Single Turbine Scenarios -** In the single turbine scenarios, the impact of a single turbine unit was assessed independently of neighbouring plumes. This is considered representative of a single turbine in operation. This scenario is also representative of the lower bound of plume impact multiple turbines.
- **Plant (Merged Emissions) Scenarios -** For the plant type scenarios, a buoyancy enhancement factor was applied in order to account for interactions between neighbouring plumes. The selected buoyancy enhancement factors assumed that buoyancy was completely conserved until the complete merging of adjacent plumes under all meteorological conditions. Hence the plant type scenarios are considered to represent the upper bound of the plume impact from multiple stacks.

Given the greater degree of buoyancy enhancement that occurs under meteorological conditions conducive to plume rise, the merged emissions scenarios are considered most appropriate for maximum vertical extents, and conservative for the remainder of meteorological conditions.

Consideration should be given for the plant to be designated a potential hazard to aircraft operators in the area. The implementation of such designation is at the discretion of the Civil Aviation Safety Authority (CASA). Further consultation with CASA would be undertaken following the detailed design stage. It is understood that CASA would require confirmation of any changes to the design that may affect the plume rise assessment. Prior to operation of the facilities, AGL would provide CASA with the following information:

- “As constructed” coordinates in latitude and longitude of the Facility;
- Final height (in AHD) of the buoyant sources; and
- Ground elevation of the site (in AHD).

Aviation Safety

Due to the plume rise from the stack emissions, an aviation hazard analysis based on the predicted impacts of the proposed facility has been performed, and is shown in **Appendix D**. The statistics have been compiled in accordance with the Civil Aviation Safety Authority’s (CASA) Advisory Circular *“Guidelines for Conducting Plume Rise Assessments”* (June, 2004). Where there is potential for an exhaust plume with a vertical velocity greater than 4.3 m/s at the Obstacle Limitation Surface (OLS) of 110 m, a hazard analysis is required. As part of this analysis, a search of CASA registered aerodromes within a 15 km radius was undertaken. Furthermore, a desktop search of other unregistered landing strips was also undertaken. The results of these surveys indicated that there are no known landing strips within a 15 km radius of the Project site.

This assessment involved use of the TAPM model which was used to create site-specific meteorological data, including meteorology for the upper atmosphere. TAPM was also used to calculate plume rise trajectories for the turbine emissions.

The modelling results show that as typically found with an open cycle gas turbine facility, the plant would produce exhaust plumes with vertical velocities (*w*) that exceed 4.3m/s above the OLS for a significant proportion of the year (base upon the plant running at full load all hours of the year). The maximum, minimum and average heights at which the plume velocity is greater than 4.3 m/s are provided in **Table 9-13** and **Table 9-14** for Stage 1 and Stage 2 respectively.

Table 9-13 Stage 1 - Maximum, Minimum and Average Critical Plume Extents

Statistic	Critical Vertical Plume Extent (m agl)	Critical Horizontal Plume Extent (m)
Maximum	1740	601
Minimum	98	91
Average	294	257

Table 9-14 Stage 2 - Maximum, Minimum and Average Critical Plume Extents

Statistic	Critical Vertical Plume Extent (m agl)	Critical Horizontal Plume Extent (m)
Maximum	2119	959
Minimum	148	172
Average	451	455

A plume rise assessment was performed which showed that the peaking power plant would produce exhaust plumes with vertical velocities that exceed 4.3m/s above the Obstacle Limitation Surface.

Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, the Civil Aviation Safety Authority (CASA) may choose to designate this to be a potential hazard to aircraft operators in the area.

9.5 Conclusion

9.5.1 Emissions during Construction

The distance to the nearest residential dwelling is approximately 2 km which is considered to provide a sufficient buffer zone between the main work area to prevent nuisance dust impacts. The minimisation and control of dust emissions during the construction period would be implemented using procedures contained in the Construction Environmental Management Plan (CEMP) for the Project.

9.5.2 Emissions during Operation

Air Quality

The potential air quality impact of the Dalton Power Project has been assessed using the Calpuff dispersion modelling package. The pollutants assessed included nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter (PM_{10}) and formaldehyde. The dispersion modelling has used a largely conservative approach, in accordance with the DECCW (2005) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*. In order to assess the cumulative impact of the plant emissions on the local air quality, background concentrations of the criteria pollutants were obtained from the relevant OEH and TMS monitoring stations.

The results of the dispersion modelling showed that the predicted impacts on ground level concentrations of NO_2, PM_{10}, CO and SO_2, when added to peak background concentrations, were within the OEH regulatory criteria. In addition, the predicted incremental concentrations of formaldehyde were found to be within OEH criteria. This analysis has also assumed that all oxides of nitrogen (NO_x) exist as nitrogen dioxide.

Greenhouse Gases

The greenhouse gas inventory has focused on scope 1 and scope 3 emissions associated with natural gas combustion in the open cycle gas turbine generators. The principal greenhouse gas emission from the Facility is carbon dioxide (CO_2), which is a product of natural gas combustion. Minor quantities of other greenhouse gases may be emitted and have been represented in this assessment, as carbon dioxide equivalent (CO_2-e).

The assessment has considered four potential plant configurations, each with an operating duty of 15% of the year.

Total annual emissions were estimated to be in the range of 0.67 to 1.47 Million tonnes of carbon dioxide equivalent (Mt CO_2-e). The associated emissions intensity of generation was calculated to be approximately 800 kilograms of carbon dioxide equivalent per megawatt hour of electricity generated (kg CO_2-e/MWh).

Based on a project life of 30 years, the total lifetime emissions for the four plant configurations considered were estimated to be between 20.0 and 44.0 Mt CO_2-e.

A comparison of emissions from the Facility to state and national greenhouse gas inventories was also made. Emissions from the project were estimated to be in the range of 0.41-0.90% and 0.11-0.25% of the state and national inventories, respectively. In addition, emissions from the project were estimated to be in the range of 0.85-1.85% and 0.23-0.49% of stationary energy emissions from the state and national inventories, respectively.

AGL anticipates that the implementation of the Carbon Pollution Reduction Scheme (CPRS) in 2011 would be a significant consideration in the selection of plant size and type and ultimately the greenhouse efficiency of the Facility.

Plume Rise Assessment

A plume rise assessment was performed which showed that the peaking power plant would produce exhaust plumes with vertical velocities that exceed 4.3m/s above the Obstacle Limitation Surface.

Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, the Civil Aviation Safety Authority (CASA) may choose to designate this to be a potential hazard to aircraft operators in the area. Further consultation between AGL and CASA is currently proceeding. Should CASA determine that the Facility represents a risk to aircraft operations in the area, the risk would be mitigated. Typical mitigation measures include the notification of aircraft in the region of the emission source, through the routine distribution of NOTAM (Notice to Airmen) notices.

9.6 Summary of Mitigation Measures

Table 9-15 presents a summary of the air quality mitigation measures.

Table 9-15 Summary of Mitigation Measures

Mitigation Measures	Implementation of mitigation measures		
	Design	Construction	Operation
Air Quality			
As part of the detailed design of the development, the assumptions and emission estimates used in this assessment would be reviewed and should the expected emission rates or stack details increase over the values used here, the modelling would be revised to ensure that OEH air quality standards and goals would be met.	✓		
Liaise with CASA to address the issue of potential aviation hazard of the plant.	✓		
Any emissions of dust particulates during construction would be specifically controlled through the implementation of mitigation measures, which would be incorporated into a Construction Environment Management Plan (CEMP).	✓	✓	
The CEMP would consider the most appropriate dust mitigation method suited to the activity and circumstances. This may include: – watering, spraying or covering earthworks during excavation and handling and on exposed surfaces and stockpiles; – scheduling activities for more favourable meteorological conditions; – ceasing earthmoving activities when wind speeds exceed 30 km/hr; – covering or limiting truck soil loads; – reducing speed limits on unsealed surfaces; – cleaning soil off the undercarriage and wheels of trucks; – any long-term soil stockpiles would be stabilised using measures such as fast seeding grass or synthetic cover spray.		✓	
Monitoring of air emissions during operation would be undertaken in accordance with the Environment Protection Licence.			✓
Greenhouse Gas			
Install plant that achieves a thermal efficiency that is consistent with Best Available Technology (BAT) as defined in the Generator Efficiency Standards (AGO,2006).	✓	✓	
Conduct efficiency audits in accordance with both AGL's internal directives, and regulatory requirements under the *Energy Efficiency Opportunities Act 2006* (EEO - as amended), conducting environmental audits to ensure that plant is being operated efficiently, and to identify		✓	✓

Mitigation Measures	Implementation of mitigation measures		
	Design	Construction	Operation
Air Quality			
opportunities to improve efficiency and reduce emissions intensity e.g.: • restoring the plant to design condition – e.g. replacing filters and removing fouling; • changing operational settings – e.g. ensuring control systems are operating correctly; • investigating and implementing retrofit improvements, and other mitigation options – e.g. turbine blades capable of withstanding higher combustion temperatures, CCS and waste heat brine concentration.			