9. PLUME RISE

This chapter describes the supplementary plume rise assessment undertaken to address changes made to the project description as a result of detailed front-end engineering design (FEED) completed after the Arrow LNG Plant EIS (Coffey Environments, 2012) was finalised and exhibited. The chapter presents the findings of the supplementary plume rise assessment completed by Katestone Environmental Pty Ltd (Katestone), which is attached as Appendix 2.

The Arrow Energy LNG plant site on Curtis Island is located approximately 9 km north of Gladstone Airport, and airspace restrictions apply above the site. The LNG plant includes a number of stacks (including the flare stack) that will emit buoyant, gaseous vertical plumes above the plant. The plume rise assessment identifies the potential hazard to aviation posed by these plumes.

The risk to aircraft associated with a vertical plume is determined by the Civil Aviation Safety Authority (CASA).

The guidelines developed by CASA for assessments have changed since the previous plume rise assessment was completed for the EIS. While this alone does not constitute grounds for reassessment, the latest CASA guidelines were followed for the supplementary plume rise assessment. The results of the assessment discussed in this chapter supersede the results of the plume rise assessment discussed in the EIS.

9.1 Studies and Assessments Completed for the EIS

This section provides an overview of the plume rise assessment completed for the Arrow LNG Plant EIS and the main conclusions from that assessment. Katestone was engaged to conduct the plume rise assessment, which is included as Appendix 15 of the EIS. Chapter 29, Hazard and Risk, of the EIS summarises the findings of the plume rise assessment.

The plume rise assessment was prepared in accordance with the CASA (2004) Guidelines for Conducting Plume Rise Assessments. The assessment found that the exhaust plumes from the power generator stacks were likely to exceed the Procedures for Air Navigation Services – Aircraft Operational Surfaces (PANS-OPS) thresholds above the project site during routine operations and that the exhaust plumes from the cold dry gas flare were likely to exceed PANS-OPS during non-routine operations. The results of the assessment were then available for CASA to assess the potential risk posed to aviation.

Table 9.1 lists the commitment Arrow Energy made in the EIS to mitigate the project impacts of plume rise.

Table 9.1 EIS plume rise commitments

No.	Commitment
C28.08	Provide a share of funding toward the new instrument landing system at Gladstone Airport upon project FID.

9.2 Study Purpose

The supplementary plume rise assessment addresses changes to the project description that have arisen as a result of FEED. Project description changes relevant to the supplementary plume rise assessment include:

- Changes to the layout of the LNG plant: The relocation of the gas turbine compressors and gas turbine generators from the east side of the LNG trains to the west side and relocation of the flare to directly south of the LNG trains (see Figure 4.2).
- Changes to source characteristics:
  - Flare data has changed with the removal of the operational flare and a revised worst-case flaring scenario. Parameters for the fin fans have also changed (exhaust air velocity reduced from 7.6 m/s to a maximum of 2.7 m/s and temperature increased from 12.5°C to a maximum of 81.8°C above ambient).
  - While the flare stack itself has increased in height from 110 m to 115 m above ground level, the elevation of the site on which the stack will sit is now lower. Accordingly, the relative level of the exit point of the flare stack is similar to the level assessed in the EIS.
  - The power generation options for the LNG plant have been revised. The all electrical option has been removed, and the mechanical/electrical option (also referred to as ‘partial auxiliary power import mode’) has been modified. The all mechanical option (also referred to as ‘power island mode’) remains as the base case. This option was modelled in the EIS and, as the worst case in terms of plume rise, was the only power option modelled as part of the supplementary plume rise assessment.

9.3 Legislative Update

The plume rise assessment for the EIS was conducted using the method described in the Advisory Circular 139-05(0), Guidelines for Conducting Plume Rise Assessments (CASA, 2004). CASA has since revised these guidelines and the assessment criteria within them. The revised guidelines, released in 2012, are currently in draft form (CASA, 2012). CASA advises that all plume rise assessments should follow the revised method.

CASA requires that plume rise assessments determine the height at which a plume or plumes could exceed the average in-plume vertical velocity thresholds of 10.6 m/s and 4.3 m/s. Previously, only the 4.3 m/s threshold velocity was considered, with the new approach allowing a more staged determination of risk. Where applicable, the heights at which these vertical thresholds are exceeded are presented in section 9.5.

9.4 Study Method

The supplementary plume rise assessment modelling was completed in accordance with the draft revised CASA guidelines (CASA, 2012). The detailed method used in the assessment is set out in Section 5 of the Supplementary Plume Rise Report prepared by Katestone (Appendix 2).

The modelling considered the physical stack parameters (location, relative height, emission point diameter) and the characteristics of the emissions (exit temperature, exit velocity and exhaust buoyancy). The plume characteristics were determined on the basis that exhaust gases are warmer and less dense than the ambient air and that the combination of this buoyancy and the momentum on exit causes the plume to rise. The temperature and velocity of exhaust gases are used to calculate plume rise, which is added to the physical stack height to calculate the effective stack height of the plume. The exhaust gas characteristics were then modelled using the CASA Plume Rise Screening Tool (PRST) to predict the height and extent of the plume.

Flares are not typical stack sources and cannot be modelled in the same way as conventional stack sources. The U.S. Environmental Protection Agency–approved SCREEN3 method was used to calculate the flare source characteristics, so the flare plume could subsequently be modelled using the CASA PRST.

Routine and non-routine operating scenarios for the Arrow Energy LNG plant were assessed. Routine operations included the plumes from the compressor gas turbines, the power generating gas turbines, and the pilot flare, with a worst-case scenario of 100% load. The fin fan exchangers were not considered in the plume rise assessment for routine operations, as the exit velocity of the exhaust gases (maximum 2.7 m/s) is below the lower threshold level for the assessment (4.3 m/s).

Non-routine operations included the worst-case flaring scenario (i.e., simultaneous release from the warm wet and cold dry relief flares).

The potential for plumes from within the plant to merge was modelled for four combinations of sources at the LNG plant. Merging of plumes from other LNG plants on Curtis Island with that from the Arrow Energy LNG plant was considered unlikely due to the separation distances and was not included in the assessment. The stack sources considered for the supplementary plume rise assessment are summarised in Table 9.2.

Table 9.2 Stack sources considered for the supplementary plume rise assessment

Operating Scenario	Process or Emission Point	Physical Stack Height (m)	Numbers of Stacks (Based on Four Trains)	Worst Case for Plume Velocities	Potential for Plumes to Merge
Routine	Compressor gas turbine	40	8	100% load	Potential for two turbine plumes to merge
	Power generation gas turbine	25	8	100% load	Potential for five turbine plumes to merge
	Pilot Flare	115[a]	1 (shared)	100% load	None
Non-routine	Cold dry flare	115[a]	1 (shared)	Emergency	Merging will depend on the probability of simultaneous flaring.
	Warm wet flare	115[a]	1 (shared)	Emergency	
	Storage and loading flare	115[a]	1 (shared)	Emergency	

a. The Plume Rise Assessment Report modelling results are based on an ‘effective’ stack height of 116.05 m, which marginally exceeds the physical stack height.

The modelled plume was considered against the PANS-OPS, which sets a height above which obstructions (including plumes) are considered hazards to aviation. For the Arrow Energy LNG plant site, this height ranges between 300 m AHD and 350 m AHD. The minimum of 300 m AHD was used in the plume rise assessment.

9.5 Study Findings

The supplementary plume rise assessment predicted critical plume heights for the routine and non-routine scenarios. Table 9.3 presents the results to the modelling.

Table 9.3 Predicted critical plume heights

Source	PRST Predicted Critical Plume Height[a] (m AHD)	
	4.3 m/s Threshold	**10.6 m/s Threshold**
Routine Operations		
Compressor gas turbine (x1)	262	62
Compressor gas turbine (x2 - 100 m separation)	**358**	62
Compressor gas turbine (x4 - 200 m separation)	**358**	62
Power generation gas turbine (x1)	274	49
Power generation gas turbine (x3 - 30 m separation)	**594**	50
Power generation gas turbine (x5 - 30 m separation)	**692**	50
Pilot flare	148	135
Non-routine Operations		
Upset flare (peak energy output from cold dry flare and warm wet flare)	**1,641**	**725**

a. PRST critical plume height is the height at which the average vertical velocity across the plume is less than 4.3 m/s or 10.6 m/s. Critical height is presented in metres Australian Height Datum (m AHD) and includes stack height and base elevation.

For routine operations, the higher threshold velocity of 10.6 m/s was not exceeded in any of the scenarios assessed. The lower threshold velocity of 4.3 m/s was exceeded at heights above the PANS-OPS in four of the seven scenarios assessed. The worst-case scenario was the operation of five power generation gas turbines where the plumes merged. In this scenario, the critical plume height exceeded the 4.3 m/s threshold at heights below 692 m AHD.

For non-routine operations, both threshold velocities were exceeded at heights above the PANS-OPS under all conditions of release from a flare. The critical plume height exceeded the 4.3 m/s threshold at heights below 1,641 m AHD and exceeded the 10.6 m/s threshold at heights below 725 m AHD.

9.6 Conclusion

The results of the supplementary plume rise assessment present threshold exceedences at lower heights than were presented in the EIS. This is due to the changes in method that have arisen through application of the revised CASA guidelines and use of the CASA PRST tool. The results of the supplementary plume rise assessment are not directly comparable to the results of the plume rise assessment undertaken for the EIS, and the results presented in this chapter supersede those presented in the EIS.

As stated in the EIS, due to the likely exceedence of the PANS-OPS, Arrow Energy will be required to submit an application for operational assessment of a proposed plume rise to CASA. Arrow Energy will liaise with CASA to ensure that all relevant requirements are met and that appropriate management measures are adopted. The risk that the plumes pose to aviation will be assessed by CASA.

9.7 Commitment Update

There are no changes to the management measures (commitments) relevant to plume rise presented in the EIS and included in Attachment 7, Commitments Update.