Plume Validation Monitoring Program

Tallawarra B Power Station

EnergyAustralia
LIGHT THE WAY

PROJECT	Plume Validation Monitoring Program	**DATE**	6 November 2025
GROUP	Tallawarra B Power Station	**STATUS**	FINAL
AUTHOR	Ivan Currie	**REVISION**	E
COMPANY	EnergyAustralia	**FILE NUMBER**	
FILE NAME	Tallawarra B Plume Validation Monitoring Program		

Version History

Version	Date	Author	Reason
A	12 October 2023	Simon Welchman	Initial draft
B	3 November 2023	Ivan Currie	Draft revision
C	17 June 2024	Ivan Currie	Draft revision
D	8 July 2024	Ivan Currie	Finalised document
E	6 November 2025	Ivan Currie	Document review to reflect updated CIP TARP

Glossary

Units

°C degrees Celsius

ft feet

K Kelvin

kg/s kilogram per second

km kilometre

m metre

m/s metres per second

MW megawatt

Abbreviations

AC Advisory Circular

AGC Automatic Generation Control

AIA Aviation Impact Assessment

AMSL	Height Above Mean Sea Level
CASA	Australian Government Civil Aviation Safety Authority
CFD	Computational Fluid Dynamics Model
CIP	Combined Influence Parameter
DCS	Distributed Control System
DPHI	NSW Department of Planning, Housing and Infrastructure (previously NSW Department of Planning and Environment)
EA	EnergyAustralia
NSW	New South Wales
PDD	Plume Dispersion Device
SCC	Shellharbour City Council
TAPM	The Air Pollution Model
TARP	Trigger Action Response Plan
TBPS	Tallawarra B Power Station

1. Introduction

1.1 Overview

Tallawarra B Power Station (TBPS) is a peak load gas-fired power station with a nominal output of up to 320 megawatts (MW) in open cycle. The power station was granted approval by the then NSW Department of Planning in 2010 following the completion of an Environmental Impact Statement (EIS).

The TBPS design includes an exhaust stack Plume Dispersion Device (PDD) to minimise the vertical velocity of the exhaust plume and, therefore, minimises the risk to the safety of aircraft using the nearby Shellharbour Airport. The PDD reduces the vertical velocity of the plume by splitting the exhaust stream into a number of smaller components that are discharged at or below horizontal. This has the effect of removing the initial momentum and reducing the buoyancy of the plume by entraining cool air into the plume and reduces overall plume height (compared to a vertical release without a PDD).

The approval of TBPS is subject to various conditions including the following, which requires EnergyAustralia to implement a Plume Validation Monitoring Program:

> *Submission of an ongoing Plume Validation Monitoring Program to be implemented during operations, incorporating a trigger-action-response plan.*

This document is the Plume Validation Monitoring Program in response to this condition. It includes the details of the in-atmosphere plume monitoring methodology required to show that the plume complies with the plume velocity limits, and also a Trigger Action Response Plan (TARP).

The existing conditional approval dated 22 March 2024 gave an extension for submission of the plume validation monitoring program from 1 April 2024 to 30 April 2024 to allow for further consultation with CASA on the in-atmosphere plume monitoring options and the proposed methodology for a fly-through option.

A further extension for the submission of the plume validation monitoring program to 30 July 2024 was granted on 2 May 2024 to allow EnergyAustralia to complete investigations for the selected fly-through plume monitoring method and provide a recommendation for a one-off validation exercise to be undertaken by the end of September 2024.

This document was updated in June 2024 to reflect the details of the in-atmosphere plume monitoring selected 'fly-through' option, as well as amending the alarm names associated with the TARP.

A further update has been completed in September 2025 to reflect the updated TARP. This review was initiated following observations that the previous TARP configuration may have excessively reduced the machine's load, potentially accelerating equipment wear and tear. These concerns were confirmed during the assessment. The revised TARP now reduces the machines load in a manner that decreases the wear and tear on equipment whilst operating within acceptable limits.

1.2 Consultation

Community and stakeholder engagement is an integral part of any EnergyAustralia project and TBPS, and the PDD in particular, are no exception. This has included an initial program of stakeholder engagement activities, alongside targeted site investigations to understand the specific environmental, cultural and social risks associated with development of the project. Meetings were held with CASA, SCC and interested stakeholders from 2018 to 2024.

During the project's construction, EnergyAustralia has designed and implemented a bespoke, dedicated engagement strategy specifically around the PDD which has targeted key stakeholders in the lead up to receiving approval under Condition 1.6 to install the PDD.

EnergyAustralia has invested significant time and effort in making information publicly available to ensure that an informed conversation about the PDD and aviation can be had. This includes multiple fact sheets and FAQ documents on the project's website on topics included the PDD and CASA Advisory Circulars.

A large portion of the engagement to date has been with the aviation community and Shellharbour City Council (SCC), given the project's close proximity to Shellharbour Airport. Given the importance of this stakeholder, SCC was provided with a number of briefings on the CFD modelling and GHD final report prior to its lodgment with DPE. The project team has continued regular engagement with SCC, Airport Management, and aviators at Shellharbour Airport.

During a meeting with DPHI and CASA on 11 April 2024, EnergyAustralia described its investigations and potential options for in-atmosphere plume monitoring and that the fly-through option was EnergyAustralia's preferred methodology. The fly-through option is generally supported by CASA. This fly-through option is explained in detail in Section 5.

The project team continues to undertake targeted engagement in order to satisfy condition 1.6 of the TBPS approval. A summary of all engagement on the PDD has been captured in an Engagement Summary Report.

2. Tallawarra B Power Station

2.1 Overview

TBPS is to the immediate east of EnergyAustralia's Tallawarra A Power Station (TAPS) on the western edge of Lake Illawarra, approximately 4.5km northeast of Shellharbour Airport, as shown in Figure 1.

Figure 1 Location of Tallawarra B Power Station

2.2 TBPS infrastructure

TBPS is a single F-Class open cycle gas turbine (OCGT). OCGT is proven technology that is commercially viable and suited to providing for peak load requirements, with high reliability and safety, good efficiency and environmental performance and able to perform fast start ups. EnergyAustralia estimates usage of the TBPS to average about 10 percent per annum.

The exhaust gases from the OCGT are discharged via a stack. The exhaust stack is fitted with a PDD to reduce the plume vertical velocity and consequently minimise the potential impacts to the safety of aircraft using the nearby Shellharbour Airport. The PDD is shown in Figure 2 and Figure 3.

The PDD design has 12 rectangular outlets with six discharging horizontally alternating with six discharging below horizontal (the top of the rectangular outlet is angled down 23° and the bottom is angled down 20°). Exhaust gases from the gas turbine will travel through the stack and discharge via the PDD outlets.

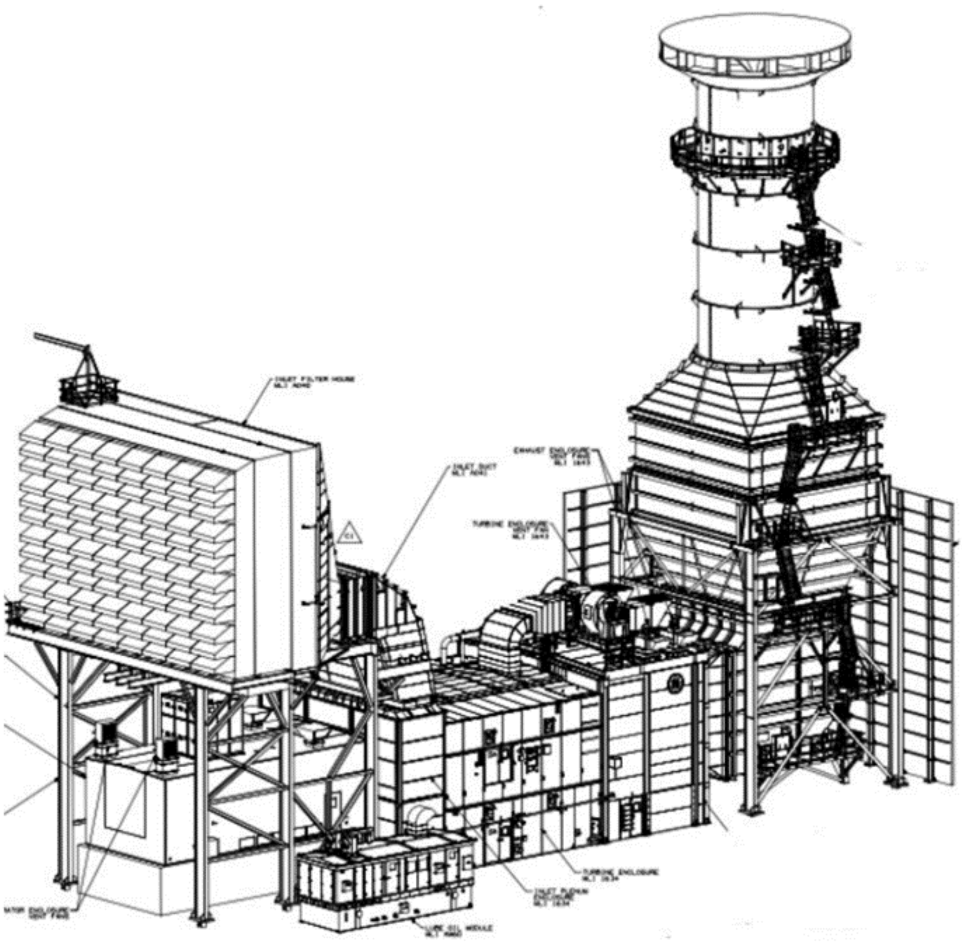

Figure 2 Tallawarra B Gas Turbine with PDD

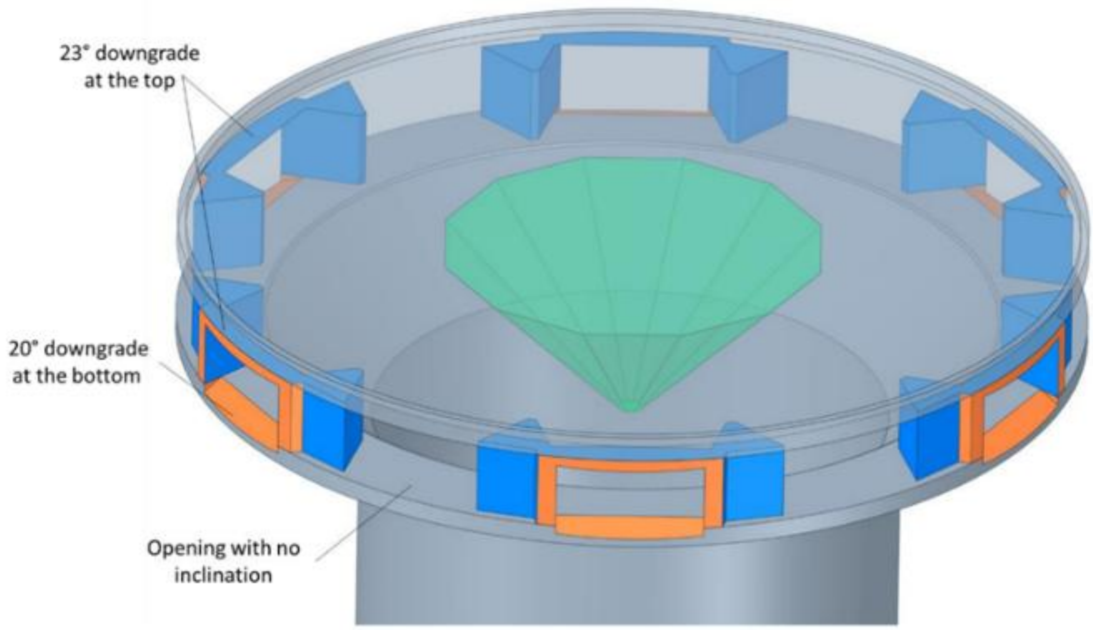

Figure 3 Tallawarra B Gas Turbine PDD design

2.3 Exhaust Characteristics

The TBPS gas turbine will operate as a peaker plant, providing additional capacity to the network during peak demand. The gas turbine will operate over a range of electricity generating loads (0-100%) and in varying ambient temperatures (-2°C to 45°C – exhaust mass flow will drop as ambient temperature increases). This will result in turbine exhaust plumes that have varying mass flow rates, temperatures, and velocities which, as a consequence, will affect the characteristics of the plume.

The TBPS PDD design was evaluated against CASA's aviation requirements using a single set of worst-case exhaust and atmospheric conditions that were chosen to represent the fastest exhaust plume to estimate worst-case potential impacts for aviation safety (PDD Design Point).

The PDD Design Point was selected as follows:

- 100% load – this generates the largest exhaust gas flow.
- Ambient conditions of 15°C
- Additionally, the exhaust mass flow and temperature were increased by an additional margin of safety so that the CIP of the PDD Design Point was above the range of ambient operating conditions from -2°C to 45°C.

The exhaust characteristics of the TBPS with PDD that have been used as input in the plume rise model are provided in Table 1. It is noted in this table that the values of the PDD exit temperature and mass flow rate were increased from the expected values by 0.9% and 1.3% respectively to provide an additional factor of safety in the design point exhaust characteristics (shown as orange square on Figure 4 - CIP graph).

Table 1 Tallawarra B Power Station design exhaust characteristics

Parameter	Units	Value
Site elevation AMSL	m	3.2
PDD exit height AMSL	m	48.2
Number of PDD outlets	#	12
Total PDD outlet area	m2	22.1
PDD outlet angle (from vertical)	°	90 113 (every 2nd opening)
PDD average outlet exit velocity	m/s	89.15
PDD Exit Temperature	°C	639.3[1]
Mass flow rate	kg/s	760.9[2]
Note: [1] **Increased by 0.9% to provide an additional safety margin** [2] **Increased by 1.3% to provide an additional safety margin.**		

Exhaust characteristics across the operating range of TBPS are shown in Table 2. These are used to calculate the Combined Influence Parameter (CIP), which is plotted in Figure 4. The CIP has been defined by GECL using the major factors that will influence plume rise. The CIP is calculated as follows:

$$CIP = \dot{M}.(T_e - T_a)$$

Where:

$\dot{M}$ is the exhaust mass flow from TBPS in kg/s

T_e is the exhaust temperature in °C

T_a is the ambient temperature in °C.

Table 2 shows the calculated CIP values for the expected operating range of the Tallawarra B unit. The values in the bottom left of Table 2 are the exhaust flow and exhaust temperature for the design point (shown as orange square on Figure 4 - CIP graph)

Table 2 Design exhaust characteristics across the operating range of the TBPS

100% Fuel Gas - NO H2																	
ESTIMATED PERFORMANCE 100% Fuel Gas - NO H2	Units	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11	Case 12	Case 13	Case 14	Case 15	
Load Condition	%	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	BASE	
Ambient Temperature	deg C	-2	-1	10	15	15	20	25	25	30	35	35	40	40	45	45	
Ambient Relative Humidity	%	70	70	60	60	60	70	70	70	40	30	50	50	20	20	20	
Evap. Cooler Status		Off	Off	Off	Off	On	Off	Off	On	Off	On	On	Off	Off	Off	On	**PDD**
Exhaust Flow	kg/s	759.1	758.6	753.7	751.4	752.0	749.8	748.3	747.7	749.6	742.8	740.6	704.8	700.4	666.8	741.4	**760.9**
Exhaust Temperature	deg C	618.8	619.8	629.2	633.4	631.1	635	636.6	636.6	636.3	647.3	649.2	652.9	650.1	657.2	648.8	**639.25**
	CIP (Fuel Gas) =	471273	470929	466705	464676	463290	461130	457647	457307	454456	454837	454900	431975	427307	408184	447634	**474992**

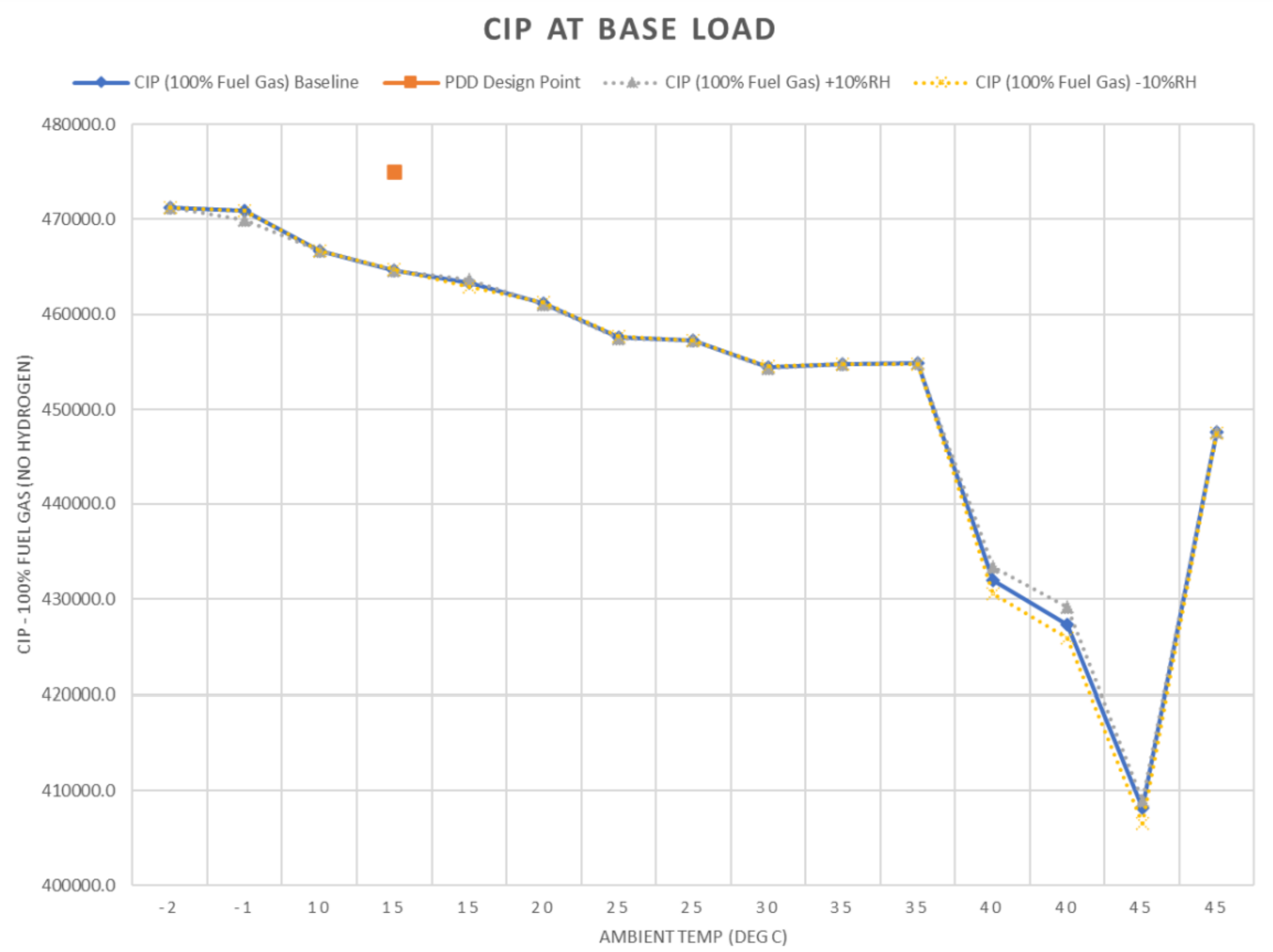

Figure 4 Tallawarra B Power Station – CIP at Base Load (GECL Design Basis)

Figure 4 shows that the PDD Design Point CIP (474,992 kg°C/s) is higher than the CIPs calculated across the operating range of the TBPS. If the TBPS CIP is below the PDD Design Point CIP, the vertical velocity of the plume will be less than the vertical velocity at the PDD Design Point. Real time CIP calculations will occur during operation using real ambient conditions.

2.4 Plume velocity characteristics at 700ft and above based on CFD modelling

Stacey Agnew was engaged by EnergyAustralia to review GECL's CFD modelling and to complete independent CFD modelling of the TBPS plume. Stacey Agnew's CFD modelling was subsequently peer reviewed by GHD.

The plume peak and average vertical velocity at 700 ft and 1,000 ft (AMSL) for the TBPS with PDD determined by CFD modelling commissioned by EnergyAustralia are provided in Table 3. In accordance with CASA's requirements, the peak vertical velocity that is calculated using a CFD model is divided by 2 to produce an average velocity for comparison with CASA's CPV of 6.1m/s.

Table 3 Plume peak and average velocity at 1,000 and 700 ft (AMSL) (GHD, 2023 and Stacey Agnew, 2023)

Scenario	Case	Peak/average plume vertical velocity (m/s)		
		700 ft	1,000 ft	> 1,000 ft
CFD 1	Previous (Stacey Agnew, 2020)	9.6 / 4.8	10.8 / 5.4	11.0 / 5.5
CFD 2	Calm wind	8.8 / 4.4	8.3 / 4.15	8.6 / 4.3
CFD 3	Hypothetical worst-case	10.1 / 5.05	11.6 / 5.8	11.9 / 5.95

The vertical velocity profile across the plume at heights of 700ft and 1,000 ft (AMSL) are shown in Figure 5 and Figure 6 for the CFD 1 scenario. The plume envelope is shown in Figure 7.

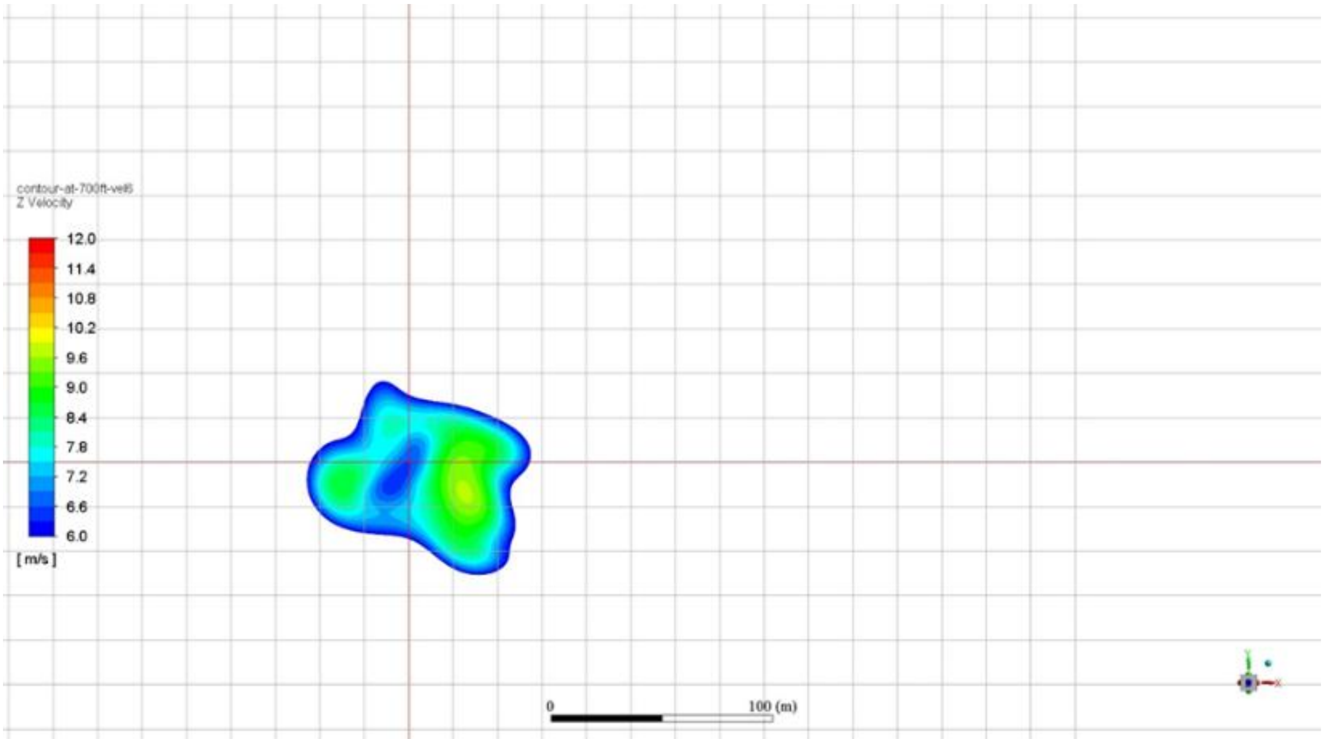

Figure 5 Vertical velocity in a horizontal plane at 700 ft (AMSL) from the TBPS with PDD (each grid is 20m x 20 m)

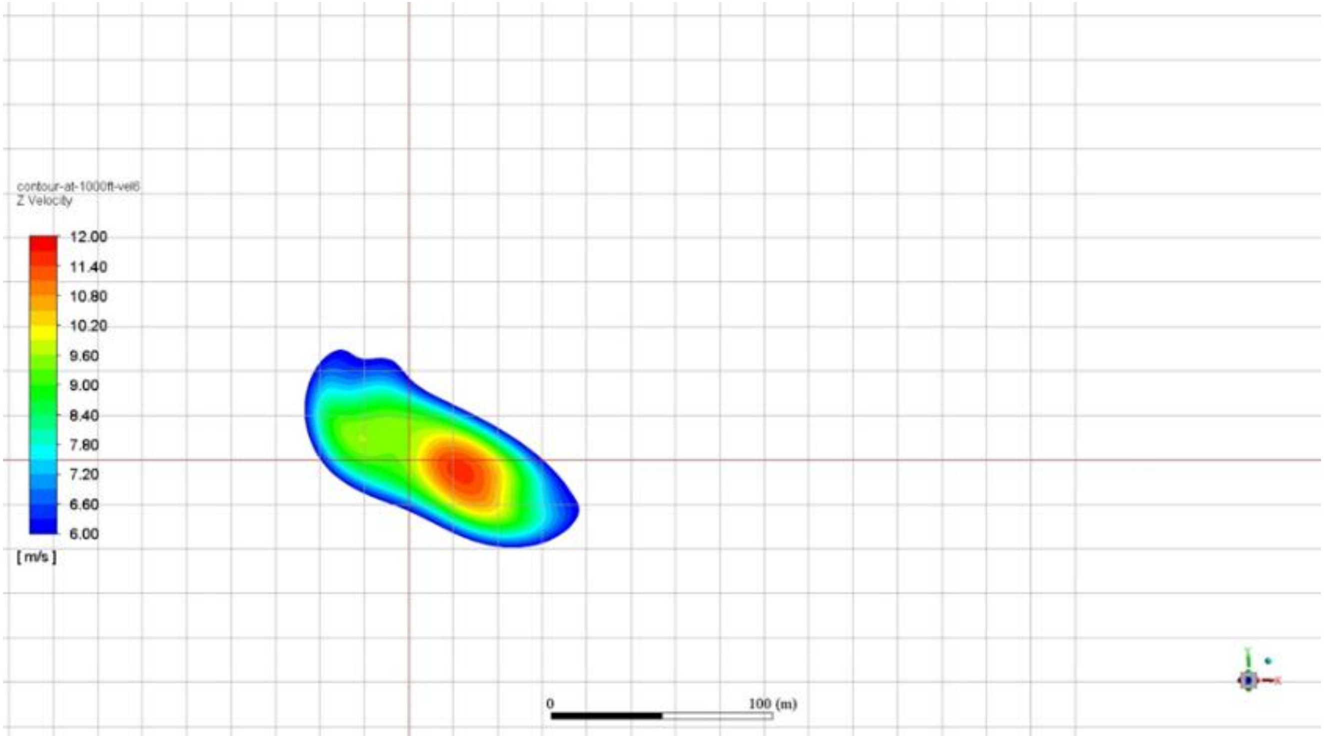

Figure 6 Vertical velocity in a horizontal plane at 1,000 ft (AMSL) from the TBPS with PDD (each grid is 20m x 20 m)

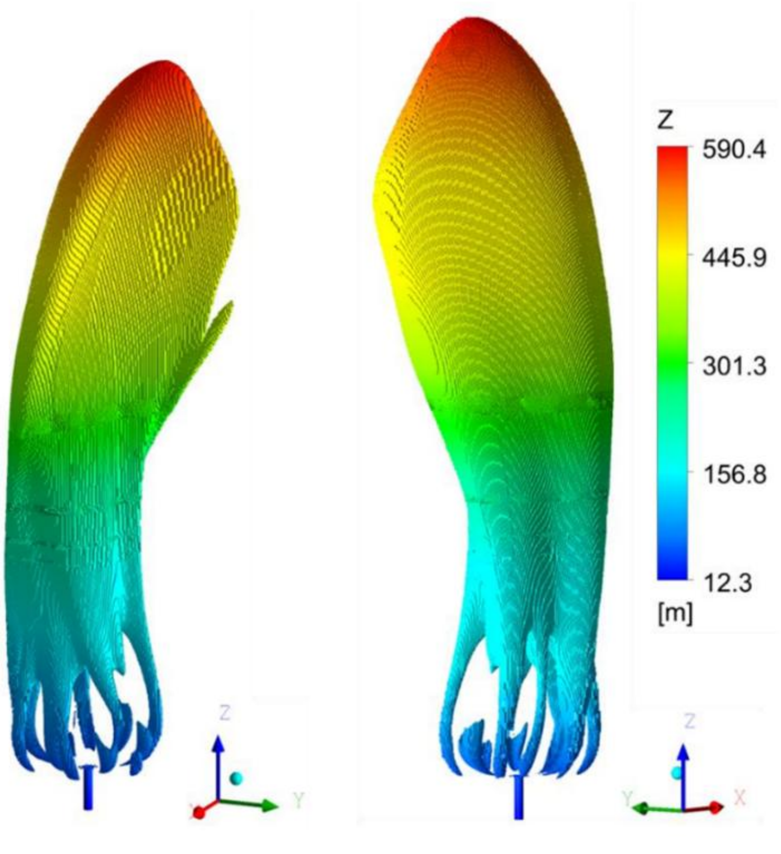

Figure 7 Plume envelope where the plume rise velocity is 6 m/s - colouring of the envelope depicts the plume height in metres

2.5 CASA response

In response to the TBPS, CASA wrote to DPHI on 27 August 2021 stating that the proposed TBPS would achieve an acceptable level of safety:

> *CASA notes that the design is first of type and based on the CFD modelling provided by Energy Australia, the plume rise velocity is expected to be below 6.1ms by 700ft AMSL Noting the information and conclusions provided in the latest EA report and based on an expectation that the final design and location will not change, CASA confirms it's previous advice that a plume rise velocity lower than 6.1ms by 700ft AMSL regardless of the plant design would achieve an acceptable level of safety for aviation.*

2.6 Mitigation measures

Whilst the TBPS meets CASA's requirements, EnergyAustralia has implemented the following measures to ensure the risk to aviation safety is further minimized:

- Implementing this plume validation monitoring program
- Alerting through AIP-ERSA (Aeronautical Information Package – En Route Supplement Australia via Airservices Australia)
- Alerting through marking and lighting
- Pilot awareness and operating procedures.

An Aviation Mitigation Activities Report (Aviation Projects, 2023) details EnergyAustralia's compliance with these commitments as per the Project approval requirements.

3. Relevant Approval and Contractual Conditions

Industrial facilities are primarily designed to ensure that exhaust gases are released such that they are adequately dispersed into the atmosphere and do not result in high concentrations of exhaust gases at ground-level. Typically, industrial facilities release exhaust gases vertically into the atmosphere from stacks. The higher the velocity and temperature of the release, the more buoyant the exhaust plume and the higher it can rise. Whilst this will lead to better dispersion of exhaust gases in the atmosphere, it also results in invisible exhaust plumes that have a potential to affect aviation safety.

CASA requires consideration of all potential hazards to the safe operation of aircraft, particularly when in proximity to airports.

Condition 1.6 of the Approval for the Tallawarra B Power Station states:

> *Nothing in this approval permits the construction and operation of an open cycle gas turbine plant, unless the Proponent has submitted a report to the Secretary which demonstrates that operation*

of an open cycle gas turbine plant will not have an adverse impact on aviation safety. This report must be prepared in consultation with Shellharbour City Council, and its conclusions and recommendations must have been agreed to by the CASA prior to submission to the Secretary. The report must be approved by the Secretary before commencement of construction of an open cycle plant.

In response to this condition, EnergyAustralia submitted an Aviation Impact Assessment report known as the *Tallawarra B OCGT Aeronautical Impact Assessment* (AIA), which was completed in February 2020 in consultation with Shellharbour City Council.

The AIA, with its recommendations around aviation mitigation activities, was submitted to CASA and agreed to, before receiving approval from the DPHI Secretary.

To assess the potential hazard to aviation from industrial exhaust plumes, CASA developed an advisory circular (AC) for plume rise assessments. The TBPS was initially assessed under AC 139-5(3) Plume Rise Assessments (CASA, 2019).

AC 139-5(3) defines CPH as follows:

Means the height up to which the plume of critical velocity may affect the handling characteristics of an aircraft in flight.

AC 139-5(3) defines CPV as follows:

A critical plume velocity of 6.1 m/s is the velocity at which a vertical plume rise can affect the handling characteristics of an aircraft in flight.

AC 139-05 v3.0 was superseded by AC 139.E-02v1.0 in March 2023. Under Section 2.5.3 of the new AC, the critical plume velocity (CPV) of 6.1 m/s can be used to assess developments with engineering modifications (such as a PDD). The assessment is made using a CFD modelling approach and by dividing the peak vertical velocity (that is determined by CFD modelling) by 2 and comparing the resulting value with the CPV of 6.1 m/s.

If the vertical velocity is found to exceed the CPV of 6.1 m/s at any of the flight protection surfaces associated with an airport, CASA may determine the risk is unacceptable in which case the development cannot proceed or alternatively that mitigation measures may be required at the airport.

Potential mitigation measures at the airport include:

- Changes to Terminal Instrument Flight Procedures (TFP)
- Publication of the plume in AIP/charts
- Changes to air routes and lowest safe altitudes.

Under the AC, CASA does not rely upon the approval conditions of the industrial facility to ensure safe operation of aircraft. AC 139.E-02v1.0 and the preceding ACs relating to plume rise assessments do not suggest the imposition of monitoring or operating restrictions on plumes if their design is demonstrated to comply with the CPV. Consequently, the ACs do not provide a standard method for measuring the vertical velocity of the plume associated with an industrial facility.

Relevant contractual conditions are shown in the following Table 4.

Table 4 Tallawarra B - contractual conditions relating to plume velocity and the PDD

ID	Doc	Section / Item Reference	Requirement
1	Annexure A: Owner's Technical Specifications, 03May21	4.1.12, p. 57	The exhaust stack must be fitted with a PDD to reduce the Plume Vertical Velocity to meet condition 1.6 of the Government Approval.
2	Annexure A: Owner's Technical Specifications, 03May21	4.1.20, p. 60 - 63	The Contractor must design the gas turbine exhaust system to achieve the Plume Velocity Guarantee as detailed in Annexure I. Note: Section also contains additional, specific requirements pertaining to the PDD Depicts 6.1m/s at 650ft AMSL
	Annexure A: Owner's Technical Specifications, 03May21	8.1	General (Commissioning, Operations and Testing)
3	Annexure A: Owner's Technical Specifications, 03May21	8.6, p.134	Tests and inspections on Commercial Operation and Final Commercial Operation, and
4	Annexure A: Owner's Technical Specifications, 03May21	8.9, p.142	Plume Velocity Test
5	Annexure A: Owner's Technical Specifications, 03May21	Appendix I.3	Critical Documents for Review/Approval Note: Extracted pages reference specific PDD submissions that need to be made to EA; To include the submission requirements noted in Section 4.1.20, p. 60-63
6	Annexure A: Owner's Technical Specifications, 03May21	Appendix L, 1.6	Conditions of Approval
7	Annexure A: Owner's Technical Specifications, 03May21	Appendix T	Detailed Ambient Data for CFD modelling of PDD
8	Annexure I	Annexure I	Performance Guarantee Schedule Note: The Contractor guarantees that the average vertical velocity of the plume, induced by the gas turbine exhaust gas from the plume dispersion device, will not exceed 6.1 m/s at or above 700 ft AMSL under any operating condition of the New Plant and/or under any site ambient conditions.

4. Trigger Action Response Plan

4.1 Overview

There are three test procedures that will be conducted on the TBPS to determine compliance with the CPV of 6.1 m/s under the Trigger Action Response Plan (TARP), namely:

- Contract performance test procedure
- Ongoing performance review procedure
- CFD test procedure.

These test procedures are aligned with the contractual obligations between EnergyAustralia and GECL. These test procedures are described below. The outcome of testing that is conducted in accordance with the procedures is compared against the triggers that are specified in Section 4.3. The responses that will be implemented depending on the result of the test are specified in Section 4.4.

4.2 Test procedures

4.2.1 Contract performance test procedure

The contract with GECL requires a plume velocity test to be conducted to demonstrate that the vertical velocity complies with the limit of 6.1m/s above 650ft. Testing will be conducted in accordance with GE Plume Dispersion Device Design and Testing Methodology, which cites ASME PTC 22[1].

The contract test includes the following components:

(i) Measurement of exhaust gas condition:

- Exhaust mass flow calculated using Mark VI as follows:
    - Exhaust mass flow = Fuel flow + Compressor inlet mass flow – IBH mass flow + Water injection flow
- Exhaust temperature measured using field instrumentation (exhaust thermocouples).

(ii) Basis of gas turbine exhaust condition to meet plume velocity guarantee – data to be used as input to the CFD model to evaluate compliance with the Plume Velocity Performance Guarantee.

(iii) Determination of pass / fail for the guarantee – plume velocity computed using the CFD model with inputs measured / calculated and corrected as per correction curves supplied by GECL.

(iv) Determine the peak vertical velocity using the CFD model at 650ft and above. Divide the peak vertical velocity(s) by 2 to calculate the average vertical velocity and compare the resultant value(s) to the trigger in Section 4.3.

[1] ASME PTC 22-2023, Gas Turbines, Performance Test Codes, The American Society of Mechanical Engineers

All measurements and corrections are done per ASME PTC 22[2]. All tests to be completed at rated load and thermally stable condition.

The contract performance test was conducted on 25 March 2024 during the commissioning phase of TBPS, with two individual performance runs completed. Both runs produced CIP 'Pass' results for exhaust temperature and the exhaust flow of the gas turbine. The final Tallawarra B GT Exhaust Plume Velocity Validation Test Report was submitted to DPHI on 24 April 2024.

4.2.2 Ongoing performance review procedure

The ongoing performance review will involve measurement and storage of the following parameters in the TBPS historian:

Exhaust mass flow ($\dot{M}$)

Exhaust temperature (T_e)

Ambient temperature (T_a).

CIP will be calculated in the Distributed Control System (DCS) for each exhaust mass flow measurement (representing thermally stable conditions) using the following formula:

$$CIP = \dot{M}.(T_e - T_a)$$

Where:

$\dot{M}$ is the exhaust mass flow from TBPS in kg/s

T_e is the exhaust temperature in °C

T_a is the ambient temperature in °C.

On a continuous basis, the performance of the TBPS will be evaluated by assessing the CIP against the trigger level in Section 4.3.

4.2.3 CFD modelling procedure

CFD modelling will be conducted to determine the vertical velocity of the plume as part of the contract performance test and in circumstances where the CIP exceeds the trigger as described in the **Response Plan** in Section 4.4 to assess compliance with the vertical velocity trigger specified in Section 4.3 at elevations above 650ft.

CFD modelling under this TARP will be conducted in accordance with the following:

- CFD model configuration as per Stacey Agnew (6 July 2023)[3]

[2] ASME PTC 22-2023, Gas Turbines, Performance Test Codes, The American Society of Mechanical Engineers

[3] Stacey Agnew, 2023, Tallawarra B Power Station CFD Plume Modelling – GE Modified PDD Design Version 3B, Summary Report, 6 July 2023, Ref 2001

- Boundary conditions as per Stacey Agnew (6 July 2023) except meteorological data (see below)
- Geometric parameters of the stack and plume dispersion device (PDD) as per design version 3B
- Stack flow and outlet conditions – as determined by MarkVI Turbine Control
- Terrain: 30 x 30 km grid at 1 km resolution
- Meteorological data profiles (wind speed, wind direction and potential temperature from ground-level to 2000 m) either:
  - For contract performance test: according to CFD 1 conditions as per Stacey Agnew (6 July 2023); or
  - If triggered in the **Response Plan** by elevated CIP in the ongoing performance review: meteorology representative of prevailing conditions at the time of exhaust measurement.

4.3 Triggers

The following triggers are defined for this TARP:

- CIP triggers:
  - High: 472,000 kg.°C/s
  - High High: 474,000 kg.°C/s
- Critical plume velocity (CPV): average 6.1 m/s
- Proposal to modify the gas turbine in any way that would increase exhaust flow or temperature.

4.4 Response plan

The responses that will be implemented under this plan as a result of testing conducted under Section 4.2 and Section 4.2.2 and the triggers detailed in Section 4.2.3 are detailed in Appendix A.

- CIP triggers - Figure A1
- CFD trigger - Figure A2.

4.5 Timing and Reporting

Reporting to DPHI will be as follows:

- PDD Design Point CIP (474,992 kg.C/s) exceedances – as soon as possible following non-conformance and, as a minimum, within 48 hours of becoming aware of the exceedance

- CFD modelling – as required under this PVMP or in accordance with a direction from DPE
- Provision of non-compliance report – as required or in accordance with a direction from DPE
- Performance guarantee test report – within 2 weeks after completion.

4.6 Roles and responsibilities

Roles and responsibilities under this TARP are as follows:

- Site Leader is Accountable for compliance with the obligations under the PVMP
- Operations Leader is Accountable for the procedure which specifies the response to alarms, investigation process
- Operator is responsible for following the procedure and implementing the response to alarms and instigation of investigations.

5. In-atmosphere Plume Monitoring

Under the AC, CASA does not require monitoring or validation of plumes in operation. The AC does not rely upon approval conditions of the industrial facility to ensure safe operation of aircraft. Consequently, the ACs do not specify a standard method for plume validation or measuring the vertical velocity of the plume associated with an industrial facility. A similar approach is adopted in the United States.

EnergyAustralia's contract with GECL cites the contract test procedure detailed above, which uses direct measurement of the plume exhaust and CFD modelling (consistent with the methodology in CASA's AC and the basis of approval), that was independently verified to ensure that the vertical velocity requirements were met.

A number of technologies could be deployed to measure the vertical velocity of the plume induced by TBPS. These technologies include LiDAR, SoDAR, Radar, drone or unmanned aircraft, tethered blimp or balloon, and manned aircraft (fly through).

To evaluate these technologies for use in this PVMP, DPHI's requirements are relevant, namely:

> *Submission of an ongoing Plume Validation Monitoring Program to be implemented during operations, incorporating a trigger-action-response plan.*

Key specifications are as follows:

- The PVMP must be ongoing during operations of TBPS
- The PVMP must incorporate a trigger-action-response plan
- Measurement techniques must be relatable to EnergyAustralia's contract with GECL.

The technologies are summarised and compared in Appendix B.

After consultation with DPHI and CASA where it was established that both parties were technology agnostic for plume measurement, it was determined that in-stack measurement and the fly-through plume option were EnergyAustralia's preferred methods to demonstrate the vertical plume velocity for plume validation purposes and were deemed suitable applications for the Talla B plume validation obligation.

At the Shellharbour Airport Users briefing with pilots on 29th of April, the pilots were very clear in their support for fly-through. The pilots agreed that if we fly as per the proposal and find the results we expect, the issue of aviation safety will be proven to not be a concern.

5.1 Fly through plume measurement

EnergyAustralia has contracted Turbulence Solutions to undertake the fly-through plume measurement in 2024. Turbulence Solutions are based in Austria and are very experienced in measuring flow characteristics with airborne sensors and are the leading expert for inflight flow measurements, Turbulence Solutions and EnergyAustralia are very confident that in-flight data gathering from the horizontal perspective enables the pilot to focus on measurement below/at/above the inversion. This is not the case for ground based LiDar measurement.

EnergyAustralia believes both fly- through and Lidar solution will give us vertical velocity to a similar level of accuracy and prove compliance with development consent – however, only fly-through will address the actual community issue.

6. Review and revision

This plume validation monitoring program will be reviewed on an annual basis or more frequently if required and revised and updated as necessary. If revised as a result of the annual review, the revised plume validation monitoring program will be submitted to DPE.

7. References

ASME PTC 22-2023, Gas Turbines, Performance Test Codes, The American Society of Mechanical Engineers

Australian Government Civil Aviation Safety Authority Advisory Circular 139-05 v3.0, Plume rise assessments, January 2019

Australian Government Civil Aviation Safety Authority Advisory Circular 139.E-02 v1.0, Plume rise assessments, March 2023

Aviation Projects, Tallawarra B OCGT, Aviation Impact Assessment, Prepared for EnergyAustralia Developments Pty Ltd, Version 1.1, 13 February 2020

Aviation Projects, Tallawarra B Aviation Mitigation Activities, Prepared for EnergyAustralia Developments Pty Ltd, Version 1.0, 9 October 2023

GECL, Plume Dispersion Device – Design Basis, Tallawarra B Power Station, Revision F, 21 July 2023

GE, EnergyAustralia Tallawarra B Project, GE Plume Dispersion Device Design and Testing Methodology, 17 November 2020, Rev 1.

Stacey Agnew, Tallawarra B Power Station CFD Plume Modelling – GE Modified PDD Design Version 3B, Summary Report, 6 July 2023, Ref 2001

Appendix A

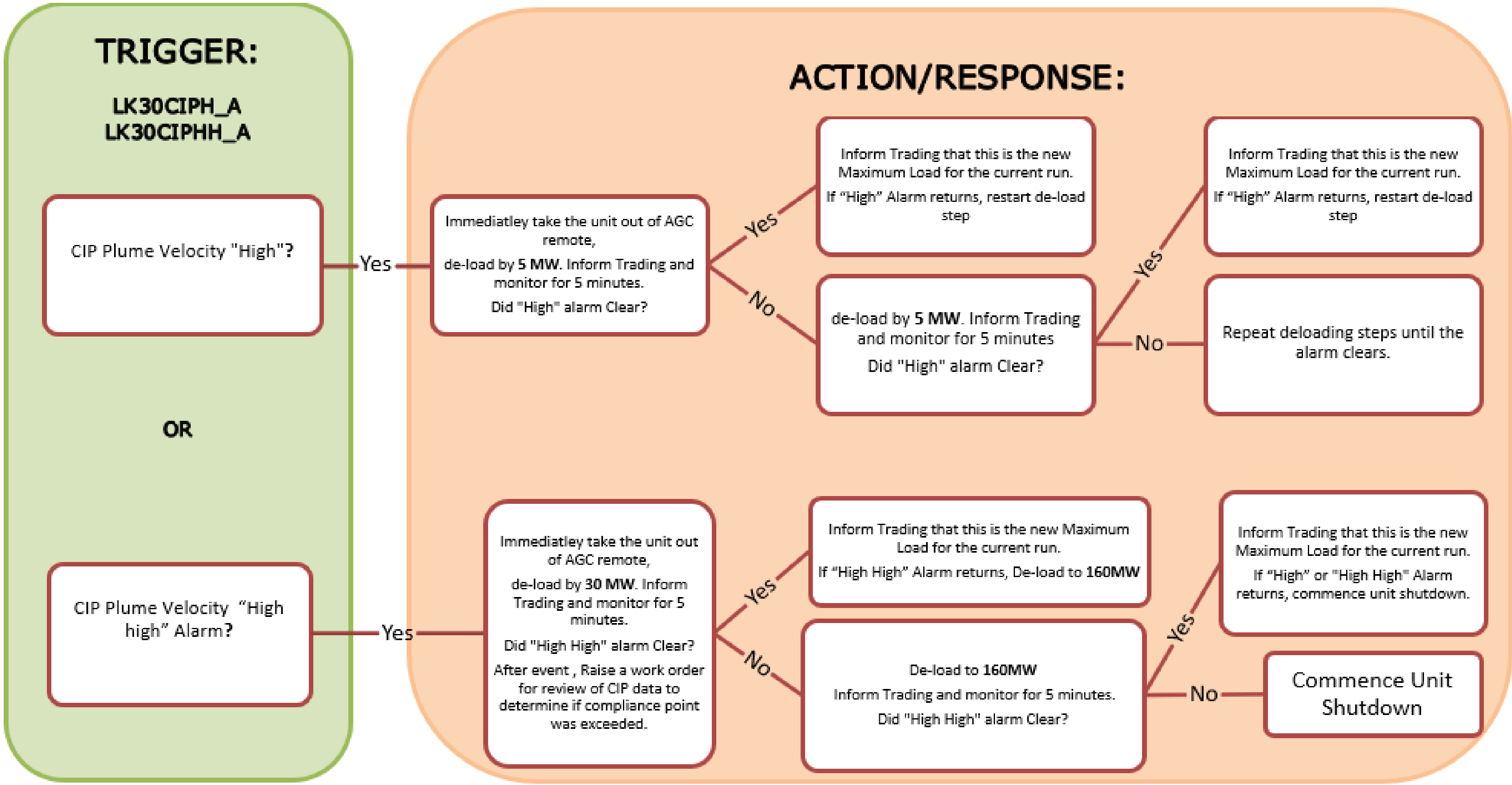

Figure A1 Combined Influence Parameter Trigger Action Response Plan

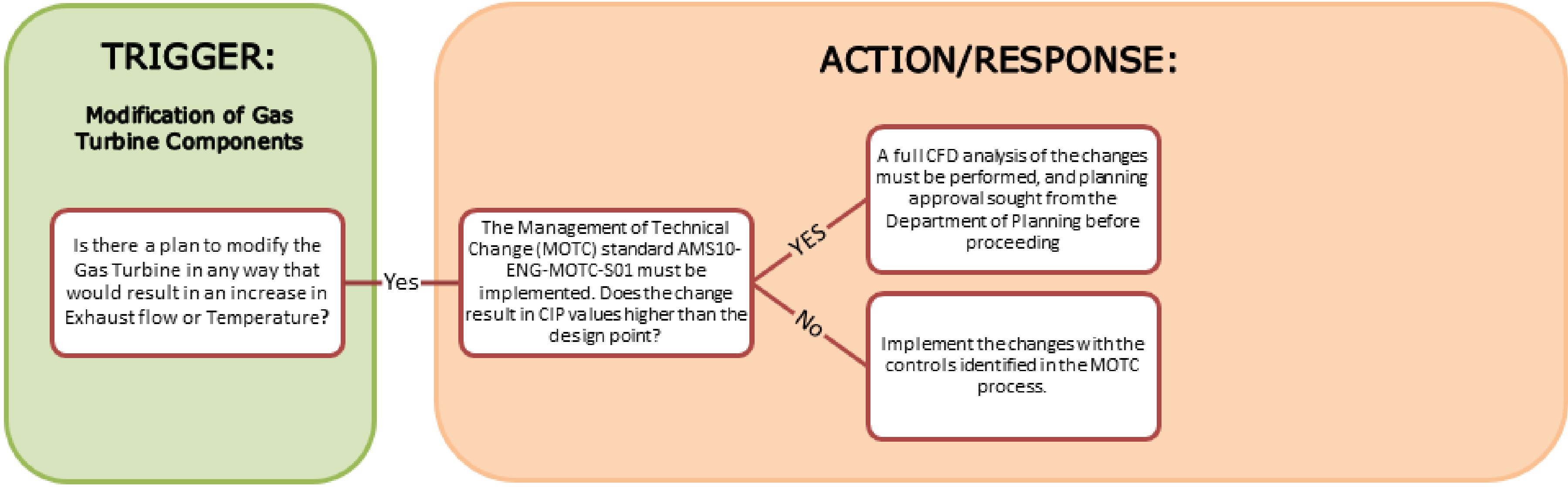

Figure A2 CFD exceeds 6.1m/s Trigger Action Response Plan

Appendix B

Comparison of alternative options to measure plume velocity

Method	Pro	Con
In stack measurement of exhaust	• Measurement is based upon the methodology approved by CASA and independently verified - direct measurement of planned versus approved parameters. • Real time results without post processing when in service. • Can make valid performance guarantee test without further modelling. • Simple measurement with equipment installed for normal power station operational control - no additional cost or reliability impact. • Functions independent of weather conditions. • Consistent with test procedure cited in contractual obligations between EnergyAustralia and GECL.	• Does not directly measure velocity at 700 ft or above.
LiDAR	• High sample density • Does not have geometry distortion. • Depending on the configuration, may be cheaper than a RADAR system	• Can be affected by heavy rain or low clouds. • Data will degrade in areas with high reflection. • Data requires post processing and can take time to analyze - not real time. • No international protocols to guide collection and analysis of data in the context of the AC and plume velocity. • Requires additional modelling to make valid performance guarantee test. Not readily applicable to a TARP. • Additional equipment, introduces reliability and availability issues. • Is not consistent with test procedure cited in contractual obligations between EnergyAustralia and GECL. • High costs
RADAR	• Is not sensitive to cloud, fog, or mist. Radar signals can penetrate through aerosol cloud droplets, which means data can be collected in adverse conditions. • Can penetrate insulators, such as rubber or plastic. • Can measure distance and velocity of a target, and whether or not an object is stationary. • Allows for repetitive coverage	• Very high costs • Beams are not target-specific. • Large objects close to the transmitter can saturate the receiver. • Objects and mediums in the air can interfere with the signal. • Signal can be interrupted by other signals in the area. • Users must be trained to interpret the data - will not provide automated real time feedback for operator action. • Limit of a radar signal is 200 ft • Requires additional modelling to make valid performance guarantee test. Not readily applicable to a TARP. • Additional equipment, introduces

Method	Pro	Con
		reliability and availability issues. • Is not consistent with test procedure cited in contractual obligations between EnergyAustralia and GECL.
SoDAR	• Potentially lower cost than radar or LiDAR • Hardware is simpler and more reliable. • Power consumption is low; they can operate from solar panels.	• Cannot operate if ambient acoustic noise is too high. • Slightly lower precision than LiDAR • They cannot operate very close to large obstacles. • Performance is dependent upon weather conditions due to the way sound is attenuated in the atmosphere. • Poorly designed systems can be affected by rain, which generates acoustic noise. • Requires additional modelling to make valid performance guarantee test. Not readily applicable to a TARP. • Additional equipment, introduces reliability and availability issues. • Is not consistent with test procedure cited in contractual obligations between EnergyAustralia and GECL.
Drone / unmanned	• Data collection can be very precise in terms of collection area and height of interest. • Flight location can change depending on needs on the day.	• Measurements are restricted to periods when the drone is aloft. • Requires a permit to operate; may not be permitted to fly at height within proximity to the airport or flight path. • Requires specialist skill to fly. • Drone-ready instrumentation options may be limited due to weight or balance restrictions. • Requires additional modelling to make valid performance guarantee test. Not readily applicable to a TARP. • Additional equipment, introduces reliability and availability issues. • Is not consistent with test procedure cited in contractual obligations between EnergyAustralia and GECL.
Tethered blimp / balloon	• A permit is not required to fly or launch a balloon. • Measurements can be precise; the instrumentation must simply be small and light enough to fly. • Requires significantly less skill to fly than other airborne systems.	• Measurements are restricted to periods when the balloon is aloft. • Measurements occur at one point only. It does not provide a complete vertical or horizontal profile of the atmosphere. • Presence of a balloon may interfere with the approach/landing pattern of nearby aircraft. • Requires additional modelling to make valid performance guarantee test. Not readily applicable to a TARP. • Additional equipment, introduces reliability and availability issues. • Is not consistent with test procedure cited in contractual obligations between EnergyAustralia and GECL.

<table>
<tr><th>Method</th><th>Pro</th><th>Con</th></tr>
<tr><td>Manned aircraft</td><td>Data collection can be very precise in terms of collection area and height of interest.
Flight location can change depending on needs on the day</td><td>Measurements are restricted to periods when the aircraft is aloft.
Requires a permit to operate at height within proximity to the airport or flight path.
Requires specialist skill to fly.
Requires additional modelling to make valid performance guarantee test.</td></tr>
</table>

EnergyAustralia Pty Ltd ABN 99 086 014 968.
Locked Bag 14060, Melbourne, Vic. 8001

EnergyAustralia
LIGHT THE WAY