Brady Heywood.

Technical and Organisational Investigation of the Callide Unit C4 Incident

Month Year

CONTENTS

This page is intentionally blank

1 EXECUTIVE SUMMARY

1.1 Summary of Organisational Findings

The key organisational factor that contributed to the incident was a failure to implement effective process safety practices that would have increased the likelihood of identifying and managing the risks associated with replacing the new Unit C4 battery charger and bringing it into service.

Organisational factors contributing to the incident included: a failure to apply effective management of change (a common risk factor in process safety incidents), a failure to assess risk from a process safety perspective, and a failure to develop a detailed understanding of the Callide C site's risks and controls (in the case of CS Energy through undertaking bowties or HAZOPs).

The messaging surrounding this program, both internal and external to the organisation, is likely to have given the impression that process safety was well established in CS Energy's day-to-day operations.

This was not the case. This program failed to meaningfully improve CS Energy's risk competence in better understanding their risks, and it had a minimal impact on the practical management of risk at the Callide C power station.

1.2 Detailed Organisational Findings

The organisational investigation findings relating to the incident response include:

(a) The causative events of the incident, namely the opening of the interconnector, the collapse and loss of DC supply, and the loss of AC supply, all occurred within a 2 second timeframe. The unit would have transitioned from a normal operating state (exporting power), to motoring (importing power), with a complete loss of protection, before any intervention was possible.

(b) Once in this state, the operators could only disconnect Unit C4 by requesting Powerlink to open a circuit breaker at Calvale Substation. However, in order to do so, CS Energy had to satisfy themselves that Unit C4 was indeed motoring and not exporting power.

(c) The ability to confirm the operating status of Unit C4 was hampered by a number of issues. Control room screens were dark for approximately the first 20 minutes of the incident. When the screens worked again, data indicated Unit C4 was exporting power, however, conversations with Powerlink made that import/export status unclear. The operators could not physically verify the status of the turbine steam inlet valves – a critical piece of information that would confirm the Unit import/export status and whether Unit C4 was in a state of motoring.

(d) The decision not to immediately open the Calvale Substation circuit breaker was reasonable given the information available. If Unit C4 had been exporting, disconnection from the grid would likely have led to an overspeed event, and the destruction of the unit.

(e) From the perspective of the evacuation, first responders to the Unit C4 incident did not have important risk information before they arrived at the turbine hall. Only when entering and observing the flames did they recognise the presence of a hydrogen gas fire, prompting a retreat to achieve a minimum safe distance as defined in the HB76 Manual.[1]

(f) Unreliable information and communication hampered efforts in confirming data coming from evacuation muster points during the evacuation. By the time the incident culminated in the destruction of Unit C4, the Crisis Management Team did not have confirmation whether all 236 people had been safely evacuated from the site.

The organisational findings relating to CS Energy's organisations and culture are as follows:

(a) CS Energy operates in the context of significant constraints, including its status as a government owned corporation, the joint venture ownership of Callide C power station, a highly regulated energy market and the impacts of climate change. These constraints influence investment and cost cutting, organisational focus, and decision making.

(b) The Shareholder Mandate drove focus on cost savings, whilst at the same time placing constraints on CS Energy's investment strategies, including into its existing assets.

(c) The metrics focused on by the CS Energy board did not include a focus on the management of process safety. Instead, they were focused on personal injury, plant availability and financial performance.

(d) Between 2017 and the incident in 2021, Callide experienced significant turnover of key roles. This turnover would make it difficult to maintain a process safety focus.

(e) CS Energy implemented a swirl of at least 6 major initiatives across the organisation which impacted sites in a short period of time prior to the incident. This would also make it difficult to focus on process safety.

(f) In this type of environment, it is arguably very difficult to foster a focus on process safety, especially when the metrics at a corporate and organisational level have no such focus. There were likely competing tensions between cost reduction and process safety, and while process safety was discussed in the organisation, it did not result in any meaningful improvement in how major accident risks were managed within operations.

The organisational findings relating to the Critical Risk Program, the program intended to embed process safety in the organisation, are:

(a) By the time of the incident in 2021, process safety had been introduced as a concept within the business since 2016. It was launched as a formal process safety program (called the Critical Risk Program) in 2017.

(b) The Critical Risk Program, however, changed strategic approach in 2018 and ended the work needed to develop the appropriate foundation in risk competence related to the understanding of Major Accident Hazards risks, and the controls required to manage them.

(c) The process safety program was under resourced and starved of funding. There was effectively no process safety team from April 2019 to July 2020.

[1] Australian Emergency Response Guide Book.

(d) In mid-2020 CS Energy shifted away from its initial detailed suite of bowties to a high level approach to bowties that would fail to provide CS Energy with detailed insight into the health of its controls.

(e) CS Energy also adopted at this time a single Process Safety Frequency Rate (PSFR) metric, a lag indicator that had the tendency to support a confident, but unfounded, view of the health of CS Energy process safety systems.

(f) Internal messaging to the board provided a false sense of confidence that its approach to process safety, whilst in need of improvement, could deliver effective process safety outcomes.

(g) Corporate and board don't have competency to assess the risk. In the absence of completed bowties across its sites, it was simply not possible for CS Energy to develop the necessary understanding and competency of process safety risks at a corporate and board level.

The organisational findings relating to the health of key systems are:

(a) In the years leading up the incident, CS Energy's assurance program had identified systemic issues with multiple systems, including plant modifications.

(b) The actions that were taken in response to the issues raised by the assurance reviews were predominantly focused on addressing the symptoms and not their root cause.

(c) It was assumed that the actions taken in response to these audits would manage those systemic risks to acceptable levels, despite in some cases these issues reoccurring across multiple audits.

The organisational findings relating to learning from incidents are:

(d) At Callide, effective learning was achieved for only a very limited number of process safety incidents.

(e) The lack of organisation risk competency meant that CS Energy did not have the basis to effectively identify warning signs of process safety risks.

(f) Learning opportunities were limited by several factors, including a narrow set of incidents that qualified for investigation and warning signs lost in other systems.

(g) CS Energy's system for learning from process safety incidents was not working effectively at Callide.

The organisational findings relating to the switching process being undertaken at the time of the incident include:

(a) There was no formal risk assessment (from a process safety perspective) for the preparation or execution of the switching process to bring the battery charger into service.

(b) The governing process used for switching[2] does not require any risk assessment in the development and execution of switching. Furthermore, the CS Energy Permit to Work process[3] used to manage the permitted work activity, including isolation of energy sources

[2] Multiple Supply Electrical Equipment Isolation and Access (CS-OHS-53) 2016 (CSE.001.103.0129)

[3] CS-PTW-01 - Permit to Work (PTW) Manual 2016 (CSE.001.047.0015)

from the workers, requires only a job safety and environmental analysis (JSEA) for the work being performed. It does not require any consideration of the risks of removing isolations to bring equipment into service.

(c) A plant design protection mechanism to prevent overloading the DC system with two batteries being connected concurrently (i.e., in parallel) is the use of keyed interlocks. This results in predetermined steps for switching with the Unit C4 battery charger being the sole source of supply to Unit C4 following disconnection of Station and connection of the Unit C4 battery. This required the charger to deliver instantaneous DC supply to the unit upon removal of the Station supply.

(d) The original plan for the battery charger installation and commissioning was to complete the work during a Unit C4 outage. Project delays resulted in the unit being online and exporting at the time of bringing the new charger into service. While the keyed interlock design does allow for online switching, the Plant Manual does provide a warning that 'interruption to critical systems may occur'. There is no evidence that the potential consequences of undertaking the switching with the unit online was appreciated or considered.

(e) There appears to have been an implicit assumption in the switching process that the new Unit C4 battery charger would perform as required i.e., it would maintain the voltage in the Unit C4 DC system at a healthy level when the Station DC system disconnected. There is no evidence that this assumption was understood or communicated within CS Energy.

(f) There was a lack of awareness within the switching team regarding the status of the Unit C4 automatic changeover switch (ACS) which provides a level of DC power redundancy to the DC distribution board. The ACS is covered in detail in chapter 19. The DC distribution board provides supply to some critical safety systems. The Unit C4 ACS was inoperable in automatic mode on the day of the incident and could not provide the designed redundancy.

(g) There were issues that had to be addressed during the commissioning which included the battery charger's circuit breaker tripping and shutting down the battery charger. While these issues were relayed to the supplier prior to the incident there is no evidence that the operators and switching team were made aware of the issues.

(h) All the personnel involved in the switching sheet writing and implementation were deemed competent as per the requirements within CS Energy which included all regulatory required training.

(i) When the 25 May 2021 incident started to unfold, the actions of the switching team were consistent with industry and CS Energy expectations as reinforced in their training.

The organisational investigation findings relating to the Unit C4 battery charger replacement project are as follows:

(a) There is no evidence that the engineering team responsible for the battery charger project was aware that the battery charger was required to operate (without a battery) and maintain the voltage in the Unit C4 DC system when Station supply was disconnected, as per the switching sheet.

(b) The battery charger was not specified to meet the requirements of the switching process. Nor was it tested with respect to the requirements of the switching process. (While it had gone through a range of tests, the battery charger had not been tested for the specific requirements of this switching process).

(c) The battery charger project was a plant modification, but the CS Energy Procedure for Plant Modifications was not followed. While it was initially treated as a modification under the procedure, there was only partial compliance with the requirements.[4] Proper compliance with the procedure would have required the involvement of a wider and more diverse group to consider the project, and the process safety risks associated with it. The decision whether or not to proceed with the battery charger switching would have considered wider, and better informed, potential implications. The full and effective application of the plant modification procedure to the battery charger project would have increased the likelihood of identifying issues discussed in this section.

(d) The only evidence of process safety based risk assessment associated with the battery charger project is the completion of an Operations Plant Risk Assessment (OPRA). This OPRA, however, only considered the risk of *not* bringing the charger into service. There is no evidence of a risk assessment that considered the risks associated with bringing the new battery charger into service.

(e) The failure of the battery charger to maintain the voltage in the Unit C4 DC system when Station supply was disconnected, was set in motion by actions at the very earliest stage of the project, and compounded by lack of procedural discipline, resource shortages and time pressures, which also prevented steps being taken to identify and apprehend issues.

(f) The Plant Modification Procedure has a number of deficiencies, including the failure to require oversight of the determination that work is not a plant modification (and therefore does not need to follow the Procedure). This means works that are actually modifications, with the associated risk, can bypass the Procedure.

The key organisational findings that relate to the automatic changeover switch are:

(a) On 25 May 2021, the Unit C4 ACS was inoperable in automatic mode. It was unable to automatically respond to the voltage collapse in the Unit C4 DC system and partially restore DC supply to the unit.

(b) The Unit C4 ACS was inoperable in automatic mode because it had been damaged, its fuses had been blown (which prevented it operating in automatic mode), and these fuses were also likely removed. This damage, as well as the blown and potentially pulled fuses, likely occurred in an incident in January 2021.

(c) CS Energy appear to have made a deliberate, but undocumented, decision to leave the Unit C4 ACS in an unrepaired (and thus non-operational in automatic mode) state. There was no evidence of process safety risk management associated with this decision.

(d) Apparently separate to the Unit C4 ACS, the Unit C3 and Station ACSs were rendered inoperable following the incident in January 2021. In response to this incident an interim solution was put in place which allowed the removal of the restrictions placed on Callide C by

[4] The plant modification procedure requires a Plant Modification Quality Plan and Check Sheet to be completed at the outset, and this form is intended to be updated to track the project through the steps of the procedure, to completion of the project. The form was completed initially for all three battery charger replacements (together on the same form), and the project added to the plant modification register, but the procedure was not properly followed. The battery charger replacement exercise was also consistently referred to as a "like for like" replacement in correspondence and some formal documentation.

AEMO. CS Energy did note that this interim solution, which included the isolation of the Unit 3 and Station ACSs, resulted in the removal of designed redundancy regarding the ACSs.

(e) The interim solution should have been considered a plant modification by CS Energy, but was not. If the plant modification procedure, or a formal risk management process, had been applied to this interim solution, then it is likely to have considered the status of the Unit C4 ACS and the time period that this solution would remain in place.

(f) Fundamentally, the Unit C4, Unit C4 and Station ACSs were left inoperable in operable in automatic mode at the time of the incident without any assessment of process safety risk for this situation. CS Energy knew that this status resulted in a loss of design redundancy.

With respect to the likelihood of CS Energy identifying the risk that the loss of DC supply to Unit C4 would trigger the loss of AC supply:

(a) It is highly unlikely that the mechanisms for the loss of AC could have been anticipated (the mechanism is dependent on the specific nature of the DC collapse).

This page is intentionally blank

Brady Heywood.

Part A: Technical Investigation

2 OVERVIEW OF PART A: TECHNICAL INVESTIGATION

3 OVERVIEW OF UNIT C4

4 KEY EVENTS AND CAUSES OF THE INCIDENT

5 INTRODUCTION TO THE CALLIDE C ELECTRICAL SYSTEM

6 THE ROLE OF THE SWITCHING PROCESS IN THE INCIDENT

7 THE ROLE OF THE ELECTRICAL SYSTEM IN THE INCIDENT

8 HOW THE LOSS OF AC AND DC OCCURRED

9 THE ROLE OF UNIT C4 BATTERY CHARGER IN THE INCIDENT

10 TECHNICAL CONCLUSIONS

This page is intentionally blank

Brady Heywood.

Part B:
Organisational Investigation

11 OVERVIEW OF PART B: ORGANISATIONAL INVESTIGATION

11.1 Introduction

This chapter provides a brief overview of the investigation into the organisational factors that contributed to the incident. It provides an overview of the investigation approach, introduces the organisational investigation team, and sets out the layout of Part B of this report.

Names of CS Energy personnel and others will be removed or redacted in a subsequent draft.

11.2 Overview of Organisational Investigation Findings

The key organisational factor that contributed to the incident was a failure to implement effective process safety practices that would have increased the likelihood of identifying and managing the risks associated with replacing the new Unit C4 battery charger and bringing it into service.

11.3 Approach to Organisational Investigation

The approach taken in the organisational investigation included:

(a) **Interviews**: Conducting interviews with CS Energy personnel.

(b) **Documentation**: Examination of documentary evidence relating to CS Energy and their operations, as well as reports prepared by others.

(c) **Data Analysis**: Analysis of various corporate data sets.

11.4 Organisational Investigation Team

The organisational investigation team was primarily as follows.

11.4.2 Lead Investigator

Dr Sean Brady is a Chartered Professional Engineer and a Fellow of Engineers Australia. He is the lead investigator of this incident. While Dr Brady has supervised the work of other members of the Brady Heywood team, the opinions expressed in this report are his own.

11.4.3 Jodi Goodall

Jodi Goodall is an experienced health, safety, and environment leader with more than 18 years' expertise in mining, heavy manufacturing, munitions, chemical process plants and logistics. She holds a Master of Science (Occ. Hygiene) from the University of Wollongong.

11.4.4 Benjamin Reyes

Benjamin Reyes is a specialist in health, safety, and environment management, and for 10 years held executive roles across Australia and New Zealand, leading the implementation of critical risk management programs.

11.4.5 Stephen Pearson

Dr Stephen Pearson, Chartered Chemist, MRSC and MIOSH is an energy industry professional with over thirty years of international experience in health, safety, security, environmental and social performance management. He holds a PhD in Chemistry from the University of Reading in the UK and tertiary qualifications in Health and Safety.

11.4.6 Kiri Parr

Kiri Parr, BA LLB and GAICD, has more than 25 years' experience across legal practice, directorships and in senior executive roles. She is engaged in a variety of roles across academia and industry.

11.4.7 Daniel Hornibrook

Daniel Hornibrook is a consultant at Brady Heywood, specialising in risk management systems and data analysis. He holds a degree in Economics and Arts from the University of Queensland.

11.4.8 Ainslie Blunck

Ainslie Blunck is a Registered Professional Engineer (Queensland) and holds a Graduate Diploma in Construction Law. She has more than 25 years' experience in the design, project management, and commercial management of infrastructure projects.

11.4.9 Fiona Wingate

Fiona Wingate, BSc Eng, CEng, MIET is a Chartered Electrical Engineer. She has over 25 years' experience with an emphasis on electrical power and high voltage power generation. She has led teams investigating control systems and generating failures, and has experience in the specification, installation, commissioning and re-commissioning of generators and turbines.

Ms Wingate investigated the loss of the Unit C4 DC system and Unit C4 AC system and travelled to site to conduct tests on the Unit C4 AC system. She was assisted in her investigation by Alan Kinson and Dr Friedhelm Bonn in relation to the generator and transformer respectively.

11.4.10 Daniel Jessen

Daniel Jessen, BEng Mechatronics Engineering, specialises in electronics design and product development. He has over 20 years of experience in electronics design and practical trade experience. He has led teams and carried out design and development work on a range of power converters, including inverters and battery chargers.

Mr Jessen conducted the Unit C4 battery charger investigation, conducting onsite investigations of the battery charger, as well as conducting a range of tests on the AC and DC systems on the site.

11.4.11 Martin Boettcher

Martin Boettcher, CPEng, RPEQ, RPEV is a mechanical engineer with over 30 years' experience in power stations, including experience at Tarong North Power Station.

Mr Boettcher conducted the mechanical investigation, focusing on establishing the sequence of events of the failure of the turbine generator and other associated equipment.

11.5 Layout of Part B: Organisational Investigation Report

The body of the report is set out as follows:

Chapter 10 Summary of Organisational Investigation Findings provides a summary of the organisational factors that contributed to the incident.

Chapter 11 Incident Response explores the lead up and response of CS Energy personnel on the day of the incident.

Chapter 12 Process Safety summarises key aspects of effective process safety.

Chapter 13 CS Energy Organisation and Culture provides an overview of the history of CS Energy, which provides important context to the organisational factors that contributed to the incident.

Chapter 14 The Critical Risk Program provides a discussion of CS Energy's Critical Risk Program, and how it failed to meaningfully improve process safety.

Chapter 15 Assurance: The Health of CS Energy's Systems examines the health of CS Energy's key systems.

Chapter 16 Learning from Incidents examines the effectiveness of CS Energy's processes to learn from incidents and ensure the robustness of their engineering and process safety systems.

Chapter 17 The Switching Sequence details the organisational findings regarding the switching sequence used to bring the new Unit C4 battery charger online.

Chapter 18 The Battery Chargerr details the organisational findings regarding the Unit C4 battery charger project.

Chapter 19 The Unit C4 Automatic Changeover Switch summarises the organisational findings regarding the Unit C4 automatic changeover switch.

Chapter 20 The Loss of AC details the organisational findings with respect to the loss of Unit C4 AC supply because of the collapse of the Unit C4 DC supply.

Chapter 21 Organisational Conclusions provides the conclusions of the organisational investigation.

Organisational appendices detailing various aspects of the organisational investigation have been included. They provide an in-depth explanation of the incident and its causes. They are as follows:

B1 - tbc

12 SUMMARY OF ORGANISATIONAL INVESTIGATION FINDINGS

12.1 Introduction

This chapter presents an overview of the organisational factors that contributed to the 25 May 2021 incident.

12.2 Organisational Factors

The key organisational factor that contributed to the incident was a failure to implement effective process safety practices that would have increased the likelihood of identifying and managing the risks associated with replacing the new Unit C4 battery charger and bringing it into service.

Organisational factors contributing to the incident included: a failure to apply effective management of change (a common risk factor in process safety incidents), a failure to assess risk from a process safety perspective, and a failure to develop a detailed understanding of the Callide C site's risks and controls (in the case of CS Energy through undertaking bowties or HAZOPs).

The messaging surrounding this program, both internal and external to the organisation, is likely to have given the impression that process safety was well established in CS Energy's day-to-day operations.

This was not the case. This program failed to meaningfully improve CS Energy's risk competence in better understanding their risks, and it had a minimal impact on the practical management of risk at the Callide C power station.

12.3 A Brief Note on Process Safety

A detailed discussion of process safety is provided in Chapter 12, but a typical definition usually takes the form of: Process safety is *'about managing the integrity of operating systems by applying inherently safer design principles, engineering and disciplined operating practices. It deals with the prevention and mitigation of incidents that have the potential for a loss of control of a hazardous material or energy.'*

Core to this process is a deep knowledge and awareness of the organisations hazards, as well as using key practices that help prevent major incidents, such as the effective management of change, as well as learning from previous incidents.

12.4 A Brief Note on Causal Diagrams

A causal diagram summarising the investigation's organisational findings has been prepared and will be presented in this chapter.

This diagram visualises on a single sheet the key organisational (and technical) findings from the incident. It is read from the bottom up, starting with technical causes of the incident, before exploring the organisational factors at a site, corporate, board, external, stakeholders, regulatory and societal level that contributed to the incident. It should not be considered an exhaustive representation of all findings.

This causal diagram will be assembled in stages throughout this chapter, with the complete diagram presented at the end.

12.5 The Key Technical Causes

The four key technical causes are summarised in the causal diagram, see Figure 1.

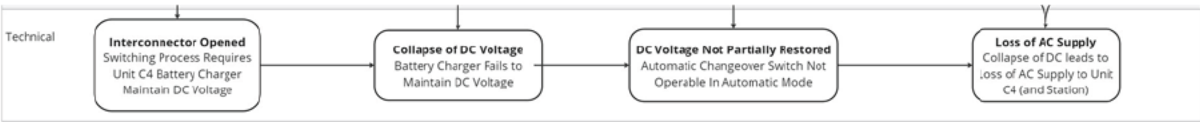


Figure 1 Key causative technical causes of the incident

The key technical causes of the incident are:

(a) **Interconnector Opened**: The switching process resulted in the Unit C4 battery charger being the sole source of DC supply to Unit C4 when the interconnector to station was opened. The opening of this interconnector initiated the event.

(b) **Collapse of DC Voltage**: The Unit C4 battery charger did not behave as required by the switching process, and it failed to maintain the voltage in the Unit C4 DC system at a healthy level. Instead, the Unit C4 DC voltage collapsed to ~120 V.

(c) **DC Voltage Not Partially Restored:** The Unit C4 automatic changeover switch was set in manual mode (and it was damaged), which meant it was unable to operate automatically and partially restore Unit C4 DC supply.

(d) **The loss of AC Supply**: The loss of DC supply to Unit C4 directly lead to the loss of AC supply. Further, the emergency diesel generator was unable to restore Unit C4 AC supply (due to the loss of Unit C4 DC supply).

The organisational causes for each of these technical causes will be discussed in turn.

12.6 The Switching

The opening of the interconnector was one of the final steps in the switching program to bring the new Unit C4 battery charger back online. Figure 2 presents the causal diagram of the organisational findings related to the switching process and opening of the interconnector.

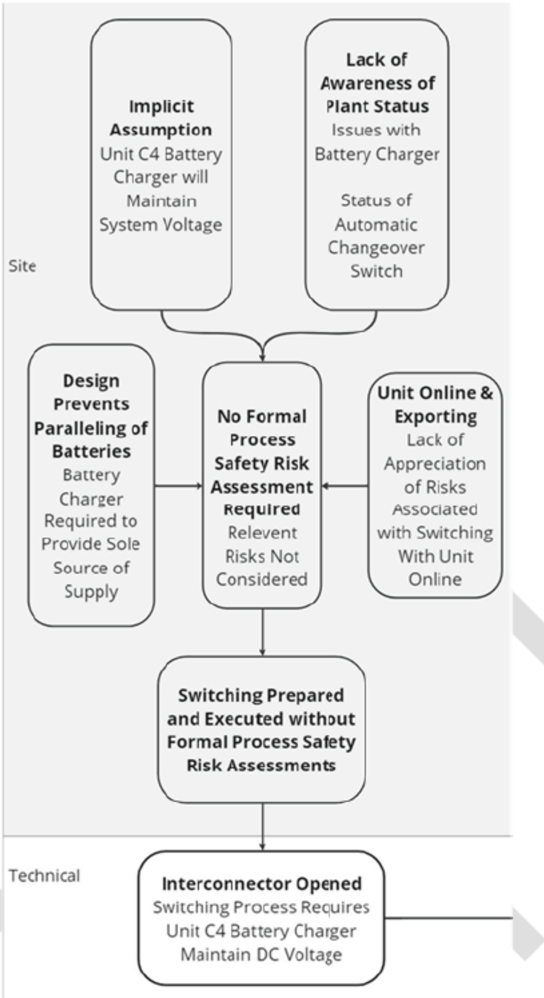


Figure 2 Organisational Causes Relevant to Switching Process

As discussed in Section X, Part A, the switching sequence implemented on 25 May 2021 required the Unit C4 battery charger to be the sole source of supply for the Unit C4 DC system when the interconnector (between Unit C4 and Station) was opened. Neither the design or execution of the switching process identified any process safety risks associated with this requirement.

The key organisational factors associated with the switching are:

(a) **Switching Prepared and Executed Without Formal Process Safety Risk Assessments:** There is no evidence of any form of risk assessment from a process safety perspective in the design and execution of the switching process to bring the battery charger into service.

No Formal Process Safety Risk Assessments Required: The switching of the battery charger into service was conducted under the Permit to Work process, which places no requirement for any process safety risk assessment in the development and execution of switching.

The Permit to Work process requires only a job safety and environmental analysis (JSEA) for the work being performed. A JSEA manages the personal safety risks associated with working under the permit. It does not require any consideration of the risks of removing isolations to bring equipment into service.[5]

(b) **Design Prevents Paralleling of Batteries:** A protection mechanism to prevent two batteries being connected to the same DC systems at the same time (i.e., in parallel) is the use of keyed interlocks. These ensure that predetermined steps are followed for switching to eliminate the risk of overloading the DC system with two batteries being connected to the same system concurrently.

This physical design resulted in the Unit C4 battery charger being the sole source of supply to Unit C4 during switching (between disconnection of station and connection of the Unit C4 battery), which thus required the charger to deliver instantaneous DC supply to the Unit upon removal of the Station supply. There is evidence that CS Energy planned to explore options to parallel batteries, but this action was closed off.

(c) **Unit Online and Exporting:** The original plan for the battery charger installation and commissioning was to complete the work during a Unit C4 outage. However, project delays resulted in the Unit being online and exporting at the time of bringing the new charger into service. While the keyed interlock design does allow for online switching, the Plant Manual does provide a warning that 'interruption to critical systems may occur'.

There is no evidence that the potential consequences of undertaking the switching with the unit online was appreciated or considered.

(d) **Implicit Assumption**: There appears to have been an implicit assumption in the switching process that the new Unit C4 battery charger would perform as required in the switching sequence, i.e., it would maintain the voltage in the Unit C4 DC system at a healthy level when the Station DC system disconnected.

There is no evidence that this assumption was understood or communicated withing CS Energy.

This implicit assumption potentially could have been identified if effective management of change (in the form of the Plant Modification Procedure) had been applied to the battery charger project, as will be discussed below.

(e) **Lack of Awareness of Plant Status**: There was a lack of awareness within the switching team of two key aspects regarding plant status, namely the status of the Unit C4 automatic changeover switch (ACS) and issues in the commissioning of the Unit C4 battery charger.

The plant design provides a level of DC Power redundancy to the DC distribution board, via the use of the Auto Changeover Switch. This switch can detect a loss of primary Unit DC power supply and automatically switch to a backup Station supply. This back up then provides supply to critical safety systems on the DC distribution board.

---

[5] In addition, the installation of the Unit C4 battery charger did not meaningfully follow the Plant Modification procedure, which does require a risk assessment for a such a change. It was ineffective in that it only considered the risk of not installing new chargers. Therefore, there was no process to communicate any additional process safety risks associated with the project into the switching design or execution.

> Since a January 2021 dual trip incident, which damaged the Unit C4 ACS, it was inoperable in automatic mode and could not provide the designed redundancy. There is no evidence that the inoperable status of the Unit C4 ACS was widely known or understood within Callide.
>
> There were also multiple issues that had to be addressed during the replacement of the battery chargers, as well as other equipment provided by the same supplier[6] at Callide B and Callide C.
>
> Specific to the Unit C4 battery charger were complications when it was switched on the day before the incident to charge the Unit C4 Battery, which included the battery charger's circuit breaker tripping and shutting down the battery charger. While these issues were relayed to the supplier the day before the incident, on the afternoon of 24 May 2021, there is no evidence that the operators and switching team were made aware of the issues.

As discussed in Section X, Part A, the switching process implemented on 25 May 2021 required the Unit C4 battery charger to be the sole source of supply for the Unit C4 DC system when the interconnector (to Station) was opened. Neither the design nor execution of the switching process identified the risks associated with this requirement.

12.7 The Battery Charger

The collapse of the Unit C4 DC voltage was a result of the Unit C4 battery charger failing to perform as was required by the switching process, see Figure 3.

[6] CSE.001.100.0007 – CS Energy issued a Notice of Defect in relation to overheating of Callide B station "B" and "D" chargers and an output fail of the Callide B2 inverter. There is correspondence as evidence of other issues with Magellan equipment.

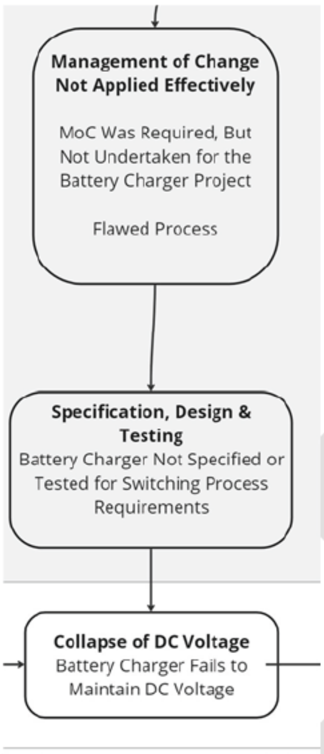


Figure 3 Organisational Factors relevant to Unit C4 battery charger

The factors relevant to the battery charger are:

(a) **Specification, Design and Testing**: The Unit C4 battery charger was not specified, designed, or tested for the requirements of the switching process, i.e., that the battery charger would be able to maintain the Unit C4 DC system voltage when the interconnector was opened. The specification, design and testing of the Unit C4 battery charger was consistent with testing the battery charger in its typical operational state and not as part of a system that required it to perform under different configurations as well.[7]

There is no evidence that the battery charger project team understood that the battery charger, when used in the manner set out in the switching process, would be required to maintain the voltage in the DC system without a battery.

(b) **Management of Change**: CS Energy's plant modification procedure[8] was not effectively implemented in the delivery of the battery charger project.[9] There is evidence that the battery charger project was considered a like for like replacement (and therefore not subject to the plant modification procedure), but there is also evidence that the battery charger project was treated as a plant modification (the project commenced in accordance with the

[7] There is no evidence that the battery charger was tested for responsiveness to all the demands it would be required to respond to as an integrated part of the DC system as a whole.

[8] CS Energy Procedure for Plant Modifications, CS-AM-010, dated 6/10/2016 (CSE.001.243.9479).

[9] While there is some evidence that some aspects of the plant modification procedure were complied with at the early stages of the battery charger project, it was not done properly, nor followed through to completion.

modification procedure, but there is little evidence of following the procedure past the early stage of the project.)

While following this procedure, (which has a number of significant flaws, as discussed in Section X), would not guarantee the incident would have been avoided, it would have increased the likelihood of identifying risks associated with bringing the battery charger back into service, including issues with the performance of the battery charger in the proposed switching process.

In the absence of the battery charger project being treated as a plant modification, there is no evidence that it was subject to any formal risk assessment from a process safety perspective.[10] (As discussed in the more detailed sections of this report, there is no requirement in the Permit to Work system to assess the risk posed by new equipment to existing plant.)

While the application of the management of change would not necessarily have changed the outcome of the incident, it would have provided multiple opportunities to identify potential risks associated with bringing the battery charger back into service and increased the likelihood of identifying the causes of the incident.

12.8 The Automatic Changeover Switch

One the day of the incident, the Unit C4 automatic changeover switch (ACS) was not operational in automatic mode. If it had been functional, it may have played a role in mitigating the severity of the incident by partially restoring supply to the Unit C4 DC system, as discussed in Section X.

Figure 4 shows the organisational factors relevant to the automatic changeover switch on Unit C3, Station and Unit C4.

[10] While an Operations Plant Risk Assessment (OPRA) was undertaken as part of the plant modification procedure for the replacement of the battery chargers on Unit C3, Unit C4 and Station, this OPRA only examined the risks associated with not replacing the battery chargers. It did not assess the risks of carrying out the replacement itself, including the risk to the DC system. (It appears to have been prepared to justify the replacement of the battery chargers. There is no evidence of consideration of the risk of the battery charger failing to perform in the system as required.)

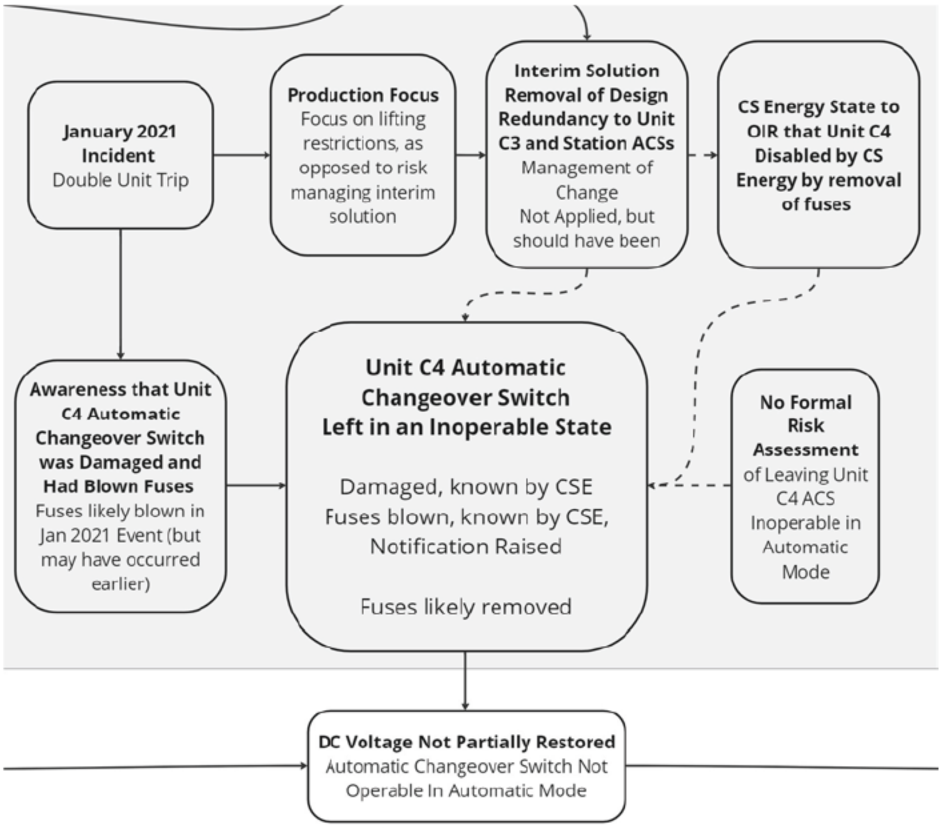


Figure 4 Organisational factors relevant to ACS Isolation

The relevant factors are:

(a) **January 2021 Incident**: On 25 May 2021, the Unit C4 ACS was inoperable in automatic mode. It was unable to automatically respond to the voltage collapse in the Unit C4 DC system and partially restore DC supply to the unit.

(b) **Awareness of Inoperability**: The Unit C4 ACS was inoperable in automatic mode because it had been damaged, its fuses had been blown (which prevented it operating in automatic mode), and these fuses were also likely removed. This damage, as well as the blown and potentially pulled fuses, likely occurred in an incident in January 2021.

(c) **Unit C4 ACS Left in Inoperable State**: CS Energy appear to have made a deliberate, but undocumented, decision to leave the Unit C4 ACS in an unrepaired (and thus non-operational in automatic mode) state. There was no evidence of process safety risk management associated with this decision.

(d) **Production Focus**: In addition to CS Energy becoming aware of the issues with the Unit C4 ACS, the January 2021 incident caused Unit C3 and Unit C4 to trip by the same causative mechanism. In response to this dual trip event, the Australian Energy Market Operator (AEMO), imposed restrictions on CS Energy's generation output until AEMO were satisfied that the risk of a further dual unit trip could be avoided.

The evidence indicates that CS Energy had a production focus on finding a solution that would satisfy AEMO and lift the imposed restrictions, as opposed to assessing the risk associated with the proposed solution.

(e) **Interim Solution**: In response to this incident an interim solution was put in place which allowed the removal of the restrictions placed on Callide C by AEMO. CS Energy did note that this interim solution, which included the isolation of the Unit 3 and Station ACSs, resulted in the removal of designed redundancy regarding the ACSs. It appears this interim solution of isolating Unit C3 and Station, which would have rendered them inoperable, was not applied to Unit C4.

The interim solution leading to a loss of design redundancy should have been considered a plant modification by CS Energy, but was not. If the plant modification procedure, or a formal risk management process, had been applied to this interim solution, then it is likely to have considered the status of the Unit C4 ACS and the time period that this solution would remain in place.

As with the battery charger project, the application of the management of change process does not guarantee the incident would have been avoided, but it would have greatly increased the likelihood of the risks associated with the interim solution being better understood and controlled.

Fundamentally, the Unit C4, Unit C4 and Station ACSs were left inoperable in automatic mode at the time of the incident without any assessment of process safety risk for this situation. CS Energy knew that this status resulted in a loss of design redundancy.

Further, there is no evidence that this removal of 'designed redundancy' was communicated more widely within CS Energy beyond the investigation team. Both operators in the control room and the switching team were unaware of the status of the Unit C4 automatic changeover switch and any associated risks.

Finally, although the actions surrounding the changes made to the ACS's for Unit C3, Station and C4 in automatic mode was making a material change to the plant, the investigation has been unable to find evidence of who directed these changes take place, and who executed them in practice. There is no evidence of work orders, switching or permit records, and no risk assessments and plant modification records for the change

12.9 The Loss of AC

Figure 5 shows the organisational factors related to the loss of Unit C4 AC supply resulting from a collapse of the Unit C4 DC supply.

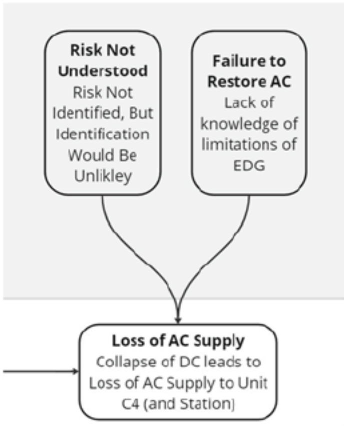


Figure 5 Organisational factors relevant to the loss of AC

The relevant factors are:

(a) **Loss of AC**: It is highly unlikely that the loss of AC could have been anticipated by CS Energy. The specific manner in which it collapsed is highly unlikely to have occurred previously.[11]

(b) **Lack of Understanding of Plant Limitations**: An emergency diesel generator was in place to restore AC to the Station and Unit C4 when it was lost. While AC supply was restored to Station, it was not restored to Unit C4 because of the loss of Unit C4 DC supply, which was required to configure the Unit C4 AC system to receive AC supply from the emergency diesel generator.

There is no evidence that this limitation was understood by CS Energy, despite regular testing of the generator.

12.10 Key CS Energy Systems

CS Energy have a number of systems critical to ensuring process safety, such as management of change, learning from incidents, etc.[12]

In order to ensure these systems are working effectively, CS Energy have an assurance function. Figure 6 sets out the systemic issues associated with these systems.

[11] While there have been losses of AC in the past, they were by a different causal mechanism. Further, there is another consideration of a loss of Loss of AC leading to Loss of DC: As discussed above, the switching sequence required that the Unit C4 battery charger be the sole source of supply to Unit C4. There is no evidence that CS Energy considered the risk that a loss of AC would pose to this scenario. If AC is lost, this will automatically result in the loss of DC supply (because the battery charger will cease operating and there will be battery present). This in turn would lead to an inability to restore AC because the switchgear would be unavailable.

[12] Management of Change (MoC) has been identified as a causal factor in a large number of major industrial accidents worldwide, including the Flixborough disaster in the UK in 1974, the Bhopal disaster in India in 1984, Piper Alpha disaster in the North Sea in 1988, Esso gas plant in Longford, Australia in 1998, Texas City refinery explosion in the USA in 2005, and Deepwater Horizon explosion in the Gulf of Mexico in 2010.

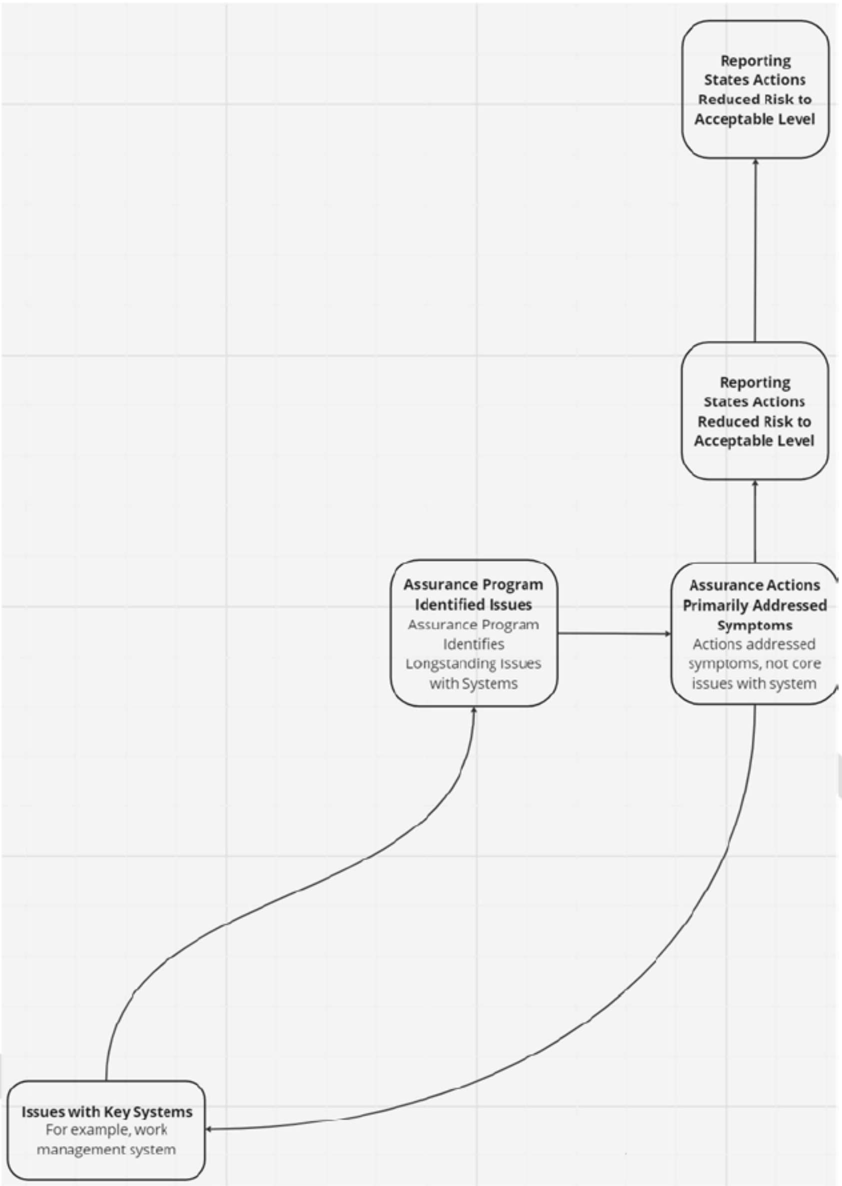


Figure 6 Organisational factors relating to key systems

With respect to these key systems:

(a) **Systemic Issues Existed**: The assurance program identified systemic issues with the CS energy systems. This investigation focused on management of change, work management, and learning from incidents. For example, there were many issues with the application of management of change (through the plant modification procedure), such as people didn't understand the system, and it was a clunky, paper-system.

(b) **Systemic Issues were Identified:** These issues were identified by the assurance function multiple times and were subject to multiple interventions, including under the Process Safety Program, Project Accelerate and the Assurance reviews.[13]

[13] These interventions are discussed further in paragraphs 13.7.4 and 15.3.

(c) **Actions Typically Focus on Symptoms Instead of Root Causes:** The actions that flowed from the assurance reviews typically treated the symptoms, as opposed to the causes of the issues.[14] These reviews raised concerns about the process being poorly understood and implemented, as well as ambiguity surrounding its approach to risk assessment. This approach led to little improvement of systemic issues.

(d) **Assurance Program only addressed symptoms:** The actions that flowed from the assurance reviews primarily focused on treating the symptoms of these reviews, as opposed to understanding and addressing the causes of these issues.

(e) **Messaging indicates actions are addressing the risk**: The messaging to a corporate and board level suggested that the actions put in place in response to the issues raised in the assurance reviews were adequately managing the risk.

(f) **No Process Safety Lens Applied to Plant Modifications Process:** No process safety lens was applied to the issues surrounding management of change. It is likely there was an under appreciation of its importance in the boarder approach to process safety.

12.11 The Critical Risk Program

In 2017, CS Energy embarked on a process safety program to embed process safety across the organisation. This program was known as the Critical Risk Program. This occurred following process safety incidents at Callide, combined with external pressure and an industry shift to this approach.

The Critical Risk Program began with a focus on developing the fundamental building blocks of risk competence in the organisation by developing a range of bowties. Bowties are tools that allow the visual representation of the causes and consequences of incidents, and the controls in place to prevent and mitigate them. Control improvement, and comprehensive reporting were also key aspects of the program.

The figure below shows the key factors of the process safety program.

[14] These 2016 and 2021 assurance audits identified compliance issues to the management of change procedures at Callide. A number of pieces of equipment were introduced to the plant without the process being adequately closed out. The reasons given for the failure to adhere to the process included that the system was not well known outside of engineering, perception that the process is too hard to follow and that there were no consequences for not following it.

While these issues were identified, the significant nature of them was not recognised by management who had responsibility for responding the audit findings, or the Audit and Finance committee, and escalated within the organisation. The actions that were put in place were predominantly cosmetic, they provided an appearance that action was being taken e.g., a focus on training, and changes to forms, systems, guidance and procedures, but which did not address the root causes of why the system was not effective. This risk was given a moderate rating in both reviews.

Systemic issues are scattered across other audits that impact process safety, including Work Management, Permit to Work, Learning form Incidents and Plant Control Systems.

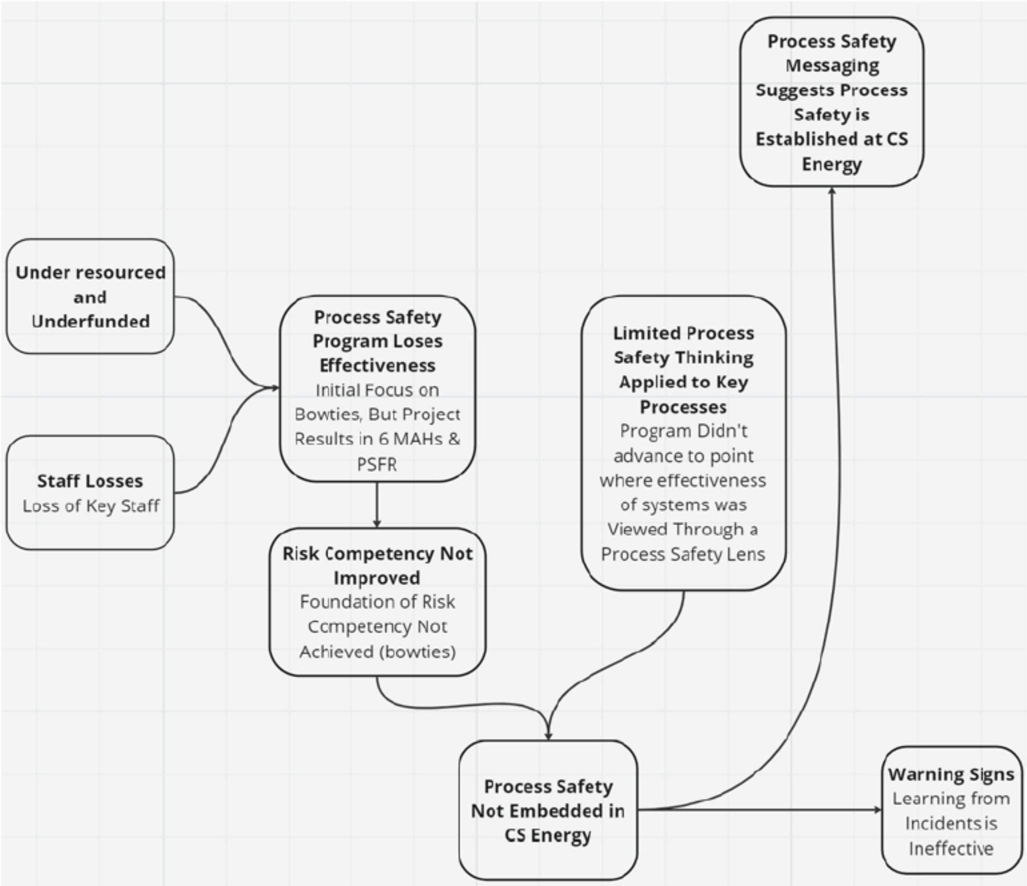


Figure 7 Organisational factors relevant to the process safety program

Process Safety was not embedded at CS Energy for a number of reasons:

(a) **Process Safety Program Loses Effectiveness**: The Critical Risk Program was introduced in 2017. Initial focus is on developing bowties to manage risk, with a later focus being on key processes. While the program started well and was consistent with leading industry practices, the project was redirected and compromised during its transition from pilot to a full program.[15]

(b) **Risk Competency Not Improved**: The substantive work on bowties came to a halt, resulting in their being limited improvement in CS Energy's ability to identify and control risk.

The program was further compromised when redesigned in 2020, leading to Callide not developing the foundational information necessary for effective process safety. This included an ability to identify their risks and ensure controls were in place.

(c) **Limited Process Safety Thinking Applied to Key Processes**: The process safety program was also compromised before it could have an impact on the key practices that drive process safety, including management of change. Whilst management of change had been identified as an area for improvement in the early stages of the program, the subsequent misdirection

[15] The demise began in 2018 when responsibility for process safety moved across to asset management. In this transition, the process safety program lost key champions, its scope of work was scaled back and focus was on more cosmetic elements of the program, such as an awareness campaign and training fundamentals.

and compromise of the program meant that the program never got an opportunity to deliver an effective management of change system.

(d) **Under resourcing, funding and Staff Loses**: The Critical risk program was subject to funding pressures and resourcing issues, as well as having its key members resign.

(e) **Messaging and Reporting**: The original roll out of the program led to ongoing statements that suggested CSE had established process safety within the organisation. The risks associated with the change in direction of the process safety program were not well understood or communicated internally.

12.12 What was Happening on the Callide Site?

Figure 8 suggests process safety was not a focus for the Callide site.

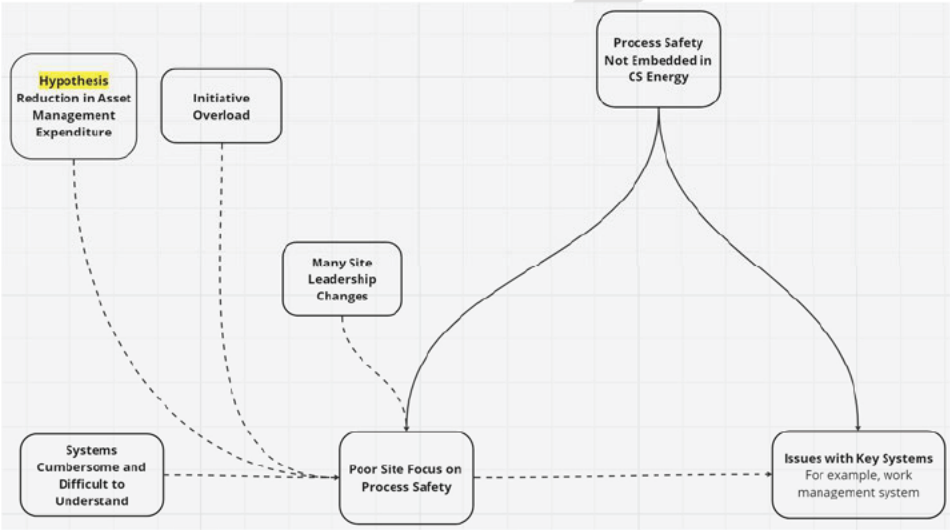


Figure 8 Callide Site Factors Impacting a focus on process safety

The relevant site factors impacting process safety were:

(a) **Issues with other systems:** Issues at the Callide site were not limited to the plant modifications procedure. There were issues with multiple other systems on site, including permit to work and the work management system.

(b) **Initiative Overload**: From 2017 to the incident in 2021, the site was subject to a number of initiatives that would have been costly in terms of time and would have provided multiple distractions to managing process safety.

(c) **Many site leadership changes**: Multiple site leadership changes occurred, both at a site manager and more functional levels.

(d) **Systems cumbersome and difficult to understand**: Systems were cumbersome and difficult to apply.

(e) **Risk Competency not improved**: Finally, the suspension of producing bowties at Callide resulted in site not having the necessary risk competency, over and above what they already possessed.

All of these created an environment where it was difficult to maintain a focus on process safety.

12.13 Learning from Incidents

A key aspect of effective process safety management is learning from incidents. Events (both those which result in a bad outcomes and those which do not) provide warning signs that systems related to process safety are weak or ineffective. Attention to these events allows an organisation to improve their organisational and engineering systems before a negative event occurs.

Effective learning requires:

(a) Understanding both the immediate technical causes and the systemic organisational causes of an incident,

(b) Implementing improvements which address both these immediate technical causes and the systemic organisational causes.

The key organisational factors with respect to learning from incidents are:

(a) **There was limited organisational learning from process safety incidents:** Process safety incidents which were reported resulted in a small amount of learning about why organisational systems were not effective.

This resulted in limited improvements which addressed systemic organisational issues.[16] Instead, the majority of process safety incidents resulted in findings and improvements which related only to the immediate technical causes of the incident.

(b) **The foundation for effective learning from incidents was lacking:** The foundation for effective learning from incidents is a fundamental understanding of the causes and controls for each major process safety risk. This allows the organisation to systematically identify warning signs for these risks and effectively learn from them. Without the completion of the bowtie project, it is unlikely this organisational knowledge existed. This likely resulted in warning sign events not being reported or not thoroughly investigated, as their importance was not understood. This limited the amount of learning opportunities.

(c) **Ineffective Process Safety Metric:** Prior to mid 2020, CS Energy did not have a process safety metric. A focus on a single lagging metric was introduced in mid 2020.

The absence of suitable leading process safety metrics would have inhibited the organisation's ability to understand the effectiveness of its process safety program. Further, the lagging metric that was used may have contributed to an impression that process safety risk was well managed in the organisation.

It is noted that the Statement of Corporate Intent at the time of the incident did not contain any targets relating to process safety.

In the context of these factors, engaged and vigorous leadership would be necessary to deliver an effective process safety program.

12.14 CS Energy's Organisations and Culture

The organisational findings relating to CS Energy's Organisations and Culture are as follows:

[16] The primary investigation method for process safety incidents was 'Learning teams'.

(a) CS Energy operates in the context of significant constraints, including its status as a government owned corporation, the joint venture ownership of Callide C power station, a highly regulated energy market and the impacts of climate change. These constraints influence investment and cost cutting, organisational focus, and decision making.

(b) The Shareholder Mandate drove focus on cost savings, whilst at the same time placing constraints on CS Energy's investment strategies, including into its existing assets.

(c) The metrics focused on by the CS Energy board did not include a focus on the management of process safety. Instead, they were focussed on personal injury, plant availability and financial performance.

(d) Between 2017 and the incident in 2021, Callide experienced significant turnover of key roles. This turnover would make it difficult to maintain a process safety focus.

(e) CS Energy implemented a swirl of at least 6 major initiatives across the organisation which impacted sites in a short period of time prior to the incident. This would also make it difficult to focus on process safety.

12.15 The Organisational Factors from the Incident

Figure 9 shows the completed causal diagram for the incident.

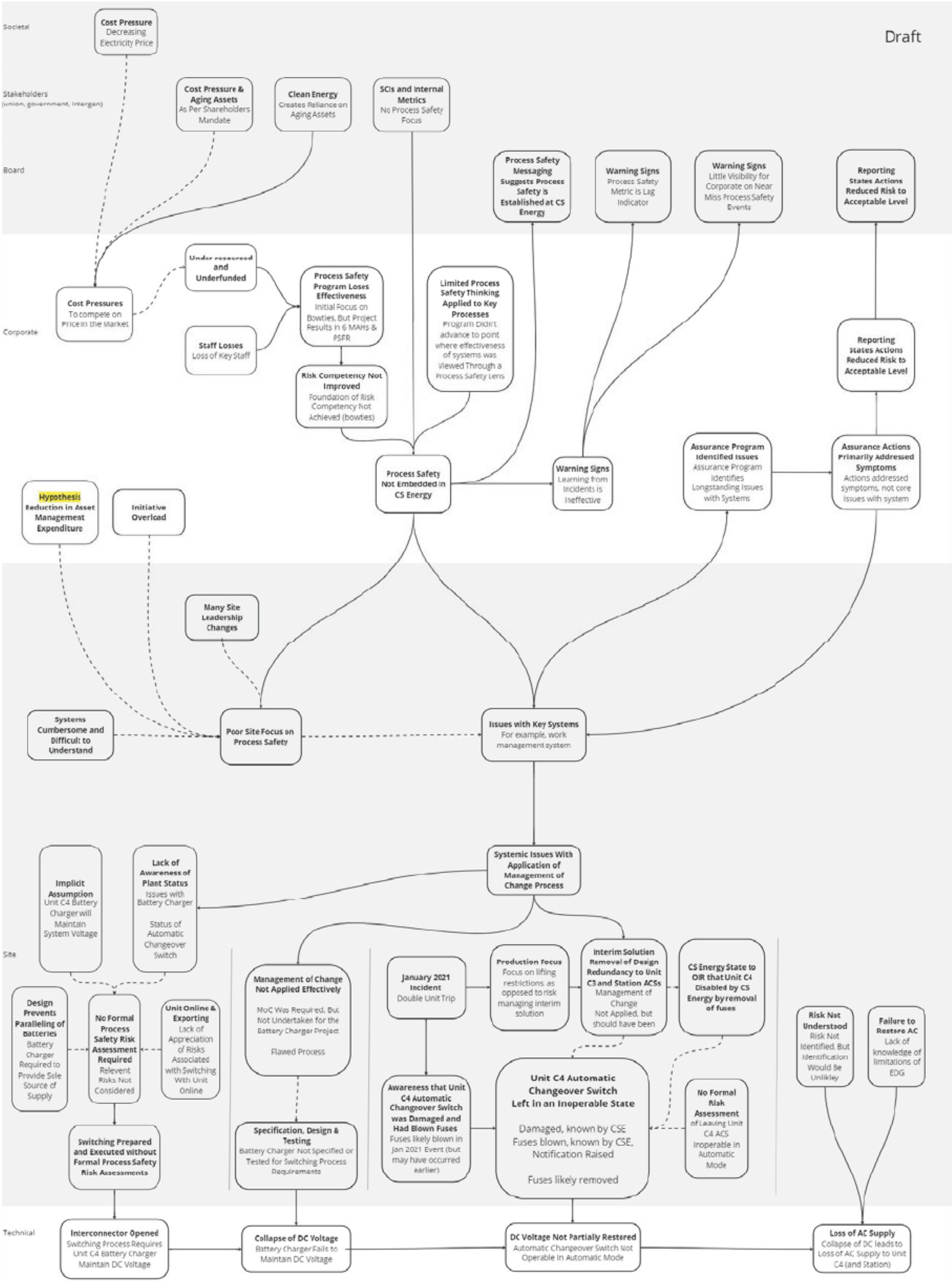


Figure 9 Organisational Factors

13 INCIDENT RESPONSE

13.1 Introduction

This chapter examines the response of CS Energy's personnel to the incident, prior, during, and immediately afterwards.

13.2 Summary of Key Findings

The organisational investigation findings relating to the incident response include:

(a) The causative events of the incident, namely the opening of the interconnector, the collapse and loss of DC supply, and the loss of AC supply, all occurred within a 2 second timeframe. The unit would have transitioned from a normal operating state (exporting power), to motoring (importing power), with a complete loss of protection, before any intervention was possible.

(b) Once in this state, the operators could only disconnect Unit C4 by requesting Powerlink to open a circuit breaker at Calvale Substation. However, in order to do so, CS Energy had to satisfy themselves that Unit C4 was indeed motoring and not exporting power.

(c) The ability to confirm the operating status of Unit C4 was hampered by a number of issues. Control room screens were dark for approximately the first 20 minutes of the incident. When the screens worked again, data indicated Unit C4 was exporting power, however, conversations with Powerlink made that import/export status unclear. The operators could not physically verify the status of the turbine steam inlet valves – a critical piece of information that would confirm the Unit import/export status and whether Unit C4 was in a state of motoring.

(d) The decision not to immediately open the Calvale Substation circuit breaker was reasonable given the information available. If Unit C4 had been exporting, disconnection from the grid would likely have led to an overspeed event, and the destruction of the unit.

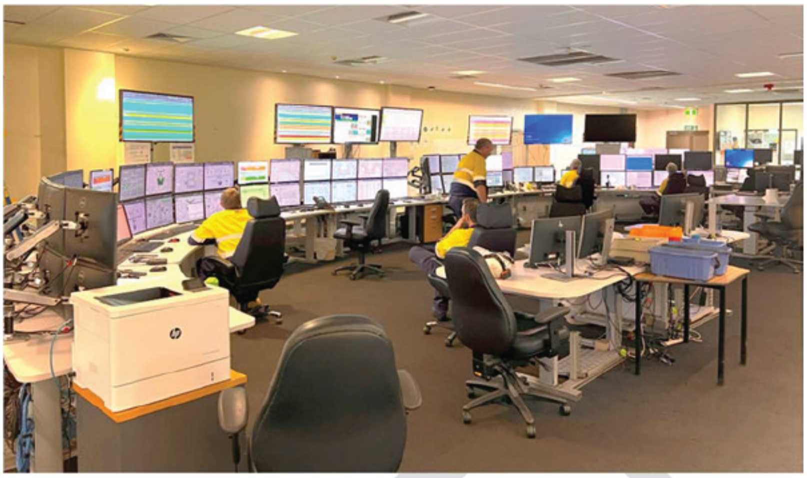
(e) From the perspective of the evacuation, first responders to the Unit C4 incident did not have important risk information before they arrived at the turbine hall. Only when entering and observing the flames did they recognise the presence of a hydrogen gas fire, prompting a retreat to achieve a minimum safe distance as defined in the HB76 Manual.[17]

(f) Unreliable information and communication hampered efforts in confirming data coming from evacuation muster points during the evacuation. By the time the incident culminated in the destruction of Unit C4, the Crisis Management Team did not have confirmation whether all 236 people had been safely evacuated from the site.

[17] Australian Emergency Response Guide Book.

13.3 Overview

13.3.1 Key Locations



CS Energy operators control Unit B1, Unit B2, Unit C3 and Unit C4 from a single control room located inside the turbine hall building. Operators stationed inside the control room monitor data fed directly from each turbine generator to specific desk panels and a series of monitors.

Figure 10 Control room

Figure 11 Turbine hall

The turbine hall at Callide houses the Unit C4 turbine generator (pictured post-incident).

Figure 12 DC switch room

Unit C4's DC system is fed from the Unit C4 DC switch room. Electrical technicians were performing switching activities in this room on the day of the incident.

13.3.2 Operational Shift Rostering

CS Energy manage operational shift rostering through a series of five shift crews named A-Shift through to E-Shift. Each shift includes supervisors, unit operators, coal plant operators, and chemical plant operators. On the day of the incident, the '2021 2022 - Operations Shift Roster Callide' identifies the following B-Shift Crew available:

Table 1 2021 2022 - Operations Shift Roster Callide 23 May 2021

B Shift Crew	***Present/Location***	***Absent/Reason***
Supervisor		On leave
Supervisor	Control Room until 1030hrs	On leave from 1030hrs
Supervisor	Step-up Supervisor from 1030hrs	
Operator		On leave
Operator		On leave
Unit B2 Operator	Control Room	
Unit C3 Operator	Control Room	
C Station Operator	Station	
Unit C4 Operator	Control Room	
Operator		On leave
Coal/Chem Plant Operator		On leave
Coal/Chem Plant Operator		On leave
Coal/Chem Plant Operator		On leave

In addition, CS Energy assign other day roster resources of coal plant and chemical plant operators as required.

Table 2 Additional CS Energy operational personnel on shift 21 May 2021

Role	***Location***
Unit B1 Operator	Control Room
Unit B1 Outage Supervisor	Control Room
Unit B2 Outside Operator	Station
Permit to Work (PTW) Officer 1	Permit Office
Permit to Work Officer 2	Permit Office
Control Systems Technician	Permit Office
Relief Chemical Plant Operator	Chemical Plant

13.3.3 Australian Energy Market Operations

The Australian Energy Market Operator (AEMO) was established in July 2009 by the Council of Australian Governments (COAG) with the purpose of managing the National Electricity Market (NEM). AEMO's ownership is shared between (state and federal) government and industry including generation, production, distribution, retail, and resources businesses across Australia.

Managing the NEM means operating the systems that allow energy to be generated, transmitted, and distributed, and operating the financial markets that sell and buy energy.

It is through the NEM where AEMO and electricity generators like CS Energy interact to sell electricity to retailers, who then on-sell to consumers.[18]

CS Energy employs traders who interact with AEMO when participating and bidding in the NEM.

13.3.4 Powerlink

The Callide units export power to Calvale substation, which is part of the Queensland grid and is operated by Powerlink. Powerlink is a Queensland Government Owned Corporation that owns, develops, operates, and maintains the high voltage (HV) electricity transmission network in Queensland.

As will be discussed in the sections that follow, CS Energy personnel lost the ability to disconnect Unit C4 from the grid (due to the loss of DC supply).

Powerlink, however, had the ability to disconnect Unit C4 from the grid and stop the motoring by opening a breaker at the Calvale substation. Numerous discussions took place between Powerlink personnel and CS energy operators in the Callide control room. These phone conversations were not recorded by CS Energy, but it is believed that they were recorded by Powerlink.

[18] AEMO (2024) AEMO. Available at https://aemo.com.au/about/who-we-are (accessed 28 February 2024).

Despite requests, Powerlink did not provide information that meaningfully assisted this investigation. The interactions with Powerlink described below are taken from interview transcripts with CS Energy personnel.

13.3.5 A Note on Data Flow

There are two independent methods of data collection and communication of active and reactive power for Unit C4:

(a) One is at the Unit C4 generator terminals.

(b) The other is at Powerlink's Calvale Substation Circuit 854.

These active and reactive power signals are transmitted between key parties: Callide Power Station, AEMO, Powerlink, Callide Power Trading (Operational Trading), and CS Energy Traders (Commercial trading).

The active and reactive power signals derived at Calvale Substation and transmitted to Powerlink's Virginia switching centre are separate and completely independent of Callide Power Station.

This means these signals would not have been affected by the loss of DC supplies at Unit C4, and provided accurate live data to Powerlink's Virginia Switching Centre, which was then sent to AEMO.

13.3.6 A Note on Motoring

Motoring is when a unit (power generator) goes from exporting power to importing power, which in the case of Unit C4, resulted in the generator operating as an electric motor and continuing to spin the turbine. The motoring of Unit C4 continued for 34 minutes.

13.3.7 A Note on an Overspeed Event

A well-known catastrophic failure mechanism in turbine generators is an overspeed event. During normal operation, when the turbine generator is connected to the grid and generating electricity, the rotation of the generator rotor is resisted by the grid. If the generator is disconnected from the grid, by opening the generator circuit breaker, this resistance is removed. If this resistance is removed while the turbine is still being driven by steam, the turbine generator rapidly speeds up and can tear itself apart within the order of 10 seconds. An overspeed event did not occur on Unit C4.

In terms of operator decision-making, in order to avoid an overspeed event, it is critical to ensure the turbine generator is no longer being driven by steam before disconnecting it from the grid. There are several ways the operators can deal with this, including confirming that the steam inlet valves to the turbine (Main Stop Valves, and Combined Reheat Valves) are closed, or in confirming power is being imported to the unit.

13.4 Prior to Initiation of Incident

13.4.1 Morning of 25 May 2021

On Tuesday, 25 May 2021, the **Unit C4 Control Room Operator** arrived in the control room at 0650 hrs. The **Unit C4 Control Room Operator** is the Unit C4 Operator on a thirteen-person crew called B Shift. Nothing notable was raised at the 0700 hrs shift meeting, but on this day, seven B Shift crew were absent. The **Unit C4 Control Room Operator** completed their routine panel checks of the control room screens (such as pressures, temperatures, and any plant-related abnormalities), and logged the information in the 'J5' electronic email diary. They also checked their emails for any operational updates from the previous shift, and then focused on checking the active daily permits.[19]

13.4.2 Step-up Supervisor

At 1000 hrs, the **B Shift Supervisor** announced they had to leave on personal matters. With eight B Shift crew members now to be absent, a supervisor assumed the role of **B Shift Step Up Supervisor**.[20] The **B Shift Supervisor** briefed the **B Shift Step Up Supervisor**, passed them the Shift Supervisor's phone, and left the control room at 1030 hrs.

13.4.3 A Short Crew

At 1245 hrs the **C Station Operator** left the control room to attend a periodic face mask fitment at the first aid room.[21]

With nine Shift members absent, instead of leaving the control room to conduct routine in-field checks for Unit C4, the **Unit C4 Control Room Operator** asked the **Unit C3 Control Room Operator** if they could undertake in-field checks for both Unit C3 and Unit C4. This left the **Unit C4 Control Room Operator** to control both Unit C3 and Unit C4, while eating their lunch in the control room.

13.4.4 Decision on Switching

At approximately 1300 hrs, the **Electrical Supervisor** and **Electrical Technician**, entered the control room. They told the **Unit C4 Control Room Operator** they were going to continue with the Unit C4 battery charger switching process of the previous day to bring it online.[22]

<u>Author's Note</u>: *Switching is a documented process in which technicians follow a prescribed switching sheet defining the sequence of steps to be executed. These steps can span several shifts. This was the switching sequence that would initiate the incident.*

13.4.5 Switching Commences[23]

The **Electrical Supervisor** and **Electrical Technician** went to the Unit 4 DC switch room to continue switching on the Unit C4 DC system. They referred to the switching sheet to discuss what steps had been carried out in the previous shift, and the steps they now had to take.[24]

<u>Author's Note</u>: *The steps completed the previous day had been to connect the Unit C4 battery charger to the Unit C4 battery. This was to ensure the battery was fully charged before it was brought back into service, see figure.*

---

[19] Transcripts from (Unit C4 Control Room Operator, p7) (Unit B1 Outside Operator, p17) (REF 2021 2022 - Operations Shift Roster Callide).

[20] Transcript from (Unit B2 Outside Operator, p10), (Unit C4 Control Room Operator, p6), (B Shift Step Up Supervisor, p4).

[21] Transcript from (C Station Operator, p7).

[22] Transcript from (Unit C4 Control Room Operator, pp8-9) (Electrical Technician, p13).

[23] A detailed discussion on switching is contained in Chapter 12.3.

[24] Transcript from (Electrical Technician, p17).

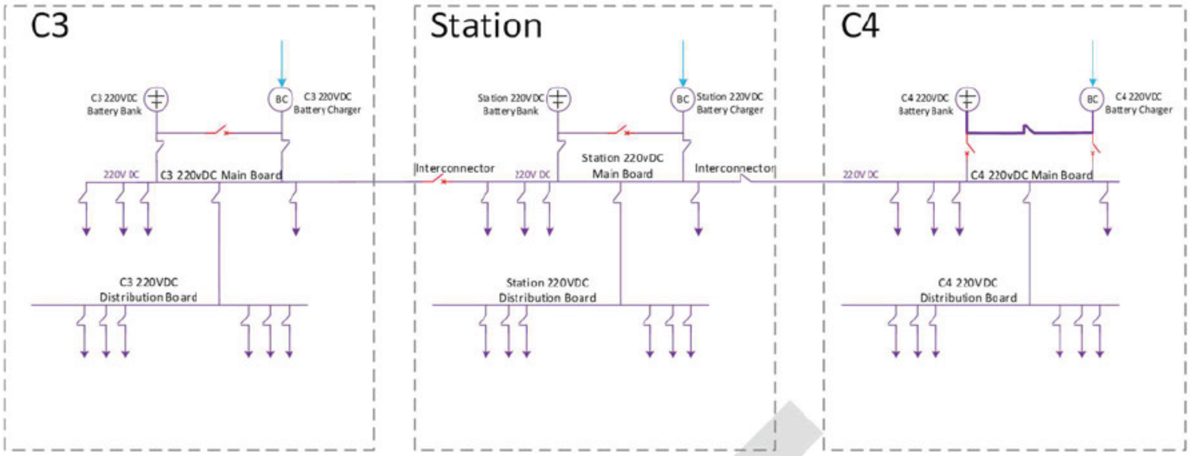


Figure 13 Configuration on the day before and morning of the incident

The **Electrical Supervisor** and **Electrical Technician** then successfully followed Steps 180 to 200 using the sequence prescribed on the switching sheet.

13.5 Initiation of the Incident

13.5.1 Opening the Interconnector

At 1333 hrs, the **Electrical Supervisor** and **Electrical Technician** reached switching Step 210. This step involved inserting Castell key 220V/2 into the switchboard to open an interconnector. Power to the Unit C4 DC system was currently being supplied through this interconnector from Station. Opening this interconnector cuts off the supply from the Station DC supply, and it requires the Unit C4 battery charger to maintain the voltage in the DC System. The **Electrical Technician** completed this step according to the switching sheet.

Upon opening the interconnector, the lights in the switch room went dark.[25] Both workers, now in the dark, stepped back from the switchboard. The emergency lighting immediately operated, with only one or two lights in the switch room providing minimal illumination. The two workers wondered what had just happened, and within an estimated 15 seconds they heard a loud bang from the turbine hall.[26] They looked at one another and wondered if the loud bang was related to the switching activity. Then, an estimated further 15 seconds later, they heard a second, even louder, bang.

Author's Note: *By this stage, the opening of the interconnector had led to the collapse of voltage in the DC System. This resulted in the loss of AC power to Unit C4 (following the arc flap protection erroneously operating). The loss of AC then led to the complete loss of DC power. The time elapsed between the loss of both systems was in the order of two seconds. Both workers were unaware that this had taken place. The loud bang was heard by several others and described as 'something large dropping', 'loud building rattling', and 'explosions'.*

---

[25] Transcript from (Electrical Technician, p21).

[26] Transcript from (Electrical Technician, p21).

13.6 Initial Response

13.6.1 Switching Team Evacuate

Upon hearing the second bang, the **Electrical Supervisor** and **Electrical Technician** left the switch room (in possession of their permit to work and switching sheets) back into the turbine hall. As they did so, the **Electrical Supervisor** used their mobile phone to telephone the **Unit C4 Control Room Operator** at the control room desk. There was no answer.

They mounted their purpose-built transportation cart and drove to exit the turbine hall.[27] As they did so, the evacuation alarm sounded.

The **Electrical Supervisor** and **Electrical Technician** proceeded to drive to the evacuation point, located adjacent to the station gatehouse.[28] Upon reaching the evacuation point, the **Electrical Supervisor** made another call, this time to the control room Shift Supervisor's phone. The **B Shift Step Up Supervisor** answered, and the **Electrical Supervisor** informed them that the **Electrical Supervisor** and **Electrical Technician** had opened the interconnector between Station and Unit 4, and that they were now out of the switch room and at the evacuation point.[29] The **Electrical Supervisor** and **Electrical Technician** remained at the evacuation point for the rest of the incident.

13.6.2 Loss of Unit C4 Operator Screens in the Control Room (12 Screens go Gark)

In the control room at 1333 hours, approximately half an hour after the **Electrical Supervisor** and **Electrical Technician** had left to do the switching operation, the **Unit C4 Control Room Operator** heard a loud bang.[30] All of the 12 screens used to monitor Unit C4 went dark. The **Unit C4 Control Room Operator** then had no visibility on what was happening with Unit C4 at this point.

<u>Author's Note</u>: *The Unit C4 screens have two power sources for redundancy. Power is provided by both the AC System and the DC system (which is converted to DC via the Unit C4 Inverter). Because both AC and DC have been lost, the screens have also been lost.*

Several seconds later, the **Unit C4 Control Room Operator** heard a second, louder bang. At that moment, the **B Shift Step Up Supervisor** entered the control room. The **Unit C4 Control Room Operator** told the **B Shift Step Up Supervisor** that the Unit C4 screens had gone dark. By this time, the control room fire panel alarms had automatically activated, with the screen on the fire panel displaying the ten most current alarms, which were overridden as new alarms sounded.

13.6.3 Confirmation of Physical Incident

The **B Shift Step Up Supervisor** immediately left the control room to investigate when their Shift Supervisor mobile phone rang. The Control System Technician, **Relief Chem Plant Operator** (working as the relief Chemical Plant Operator) had phoned them to advise that they had heard and felt 'loud booms', and that they could see smoke above the turbine hall. By this time, the **B Shift Step Up Supervisor** could see into the distance of the turbine hall and could see very bright, ten-foot-high

[27] Transcript from (Electrical Technician, p21 and Electrical Supervisor, p58).

[28] Transcript from (Electrical Technician, p22 and Electrical Supervisor, p60).

[29] Transcript from (Electrical Supervisor, p62). They refer to the interconnector as the 'Bus coupler'.

[30] Transcript from (Unit C4 Control Room Operator, p11).

flames on the bearing gear end of the Unit C4 turbine. They also noted that the fire-fighting water deluge system was operational. [31]

Author's Note: *This fire is likely to be a result of a mix of hydrogen gas escaping from the generator (due to the seal oil pumps being without power) and oil from the bearings.*

13.6.4 The Evacuation Signal Sounds

The **B Shift Step Up Supervisor** returned to the control room at a pace, and at 1336 hrs they activated the evacuation siren, informing the **Unit C4 Control Room Operator**, **Unit B2 Control Room Operator**, **Permit to Work Officer 1**, and **Unit B1 Control Room Operator** that they had seen very bright, ten-foot-high flames on the bearing gear end of the Unit 4 turbine.[32] Soon after the second bang, the **Production Manager** made their way to the control room, during which time the evacuation siren had been sounded.[33]

13.6.5 First Call from Callide Power Trading to the Control Room (1337 hrs -1339 hrs)

At 1337 hrs, approximately four minutes after the initiation of the event, the **Unit C3 Control Room Operator** answered a phone call from the **CS Energy Trading Manager** at Callide Power Trading (based in Brisbane). The **CS Energy Trading Manager** phoned as they were having issues viewing data from Unit C4. The **Unit C3 Control Room Operator** informed the **CS Energy Trading Manager** about a fire on the Unit C4 turbine, and that they had lost all of the Unit C4 screens in the control room.

During this call, the **Unit C3 Control Room Operator** informed the **CS Energy Trading Manager** that Unit C3 had also tripped, and that most of the Unit C3 screens were dark and that Unit C3 was on 'Turbine Follow' mode. 'Turbine Follow' is a mode of operation, (1 of 3 operational modes), where the boiler follows the turbine, adjusting its firing to constantly meet the turbine's requirements.[34]

The **Unit C3 Control Room Operator** confirmed to the **CS Energy Trading Manager** that there were four coal mills in service. Because so many screens had been lost, and there was a hive of activity in the control room trying to restore power to the Unit C4 screens, the **Unit C3 Control Room Operator** asked the **CS Energy Trading Manager** to follow the load remotely, in case the site is evacuated. The call ended at 1339 hrs.

13.6.6 Call to AEMO (1340 hrs -1341 hrs)

At 1340 hrs, the **CS Energy Trading Manager** called **AEMO**,[35] and informed **AEMO Operator 1** of the emerging situation with Callide Unit C4. Six minutes later, at 1346 hrs, **CS Energy Physical Trader 1** called AEMO and updated **AEMO Operator 1** on the situation, and suggested that Callide Power Trading were putting in a zero bid because Unit C4 was offline.

[31] Transcript from (B Shift Step Up Supervisor, p6).

[32] Transcript from (Unit C4 Control Room Operator, p12), (Unit B2 Control Room Operator, p8), (Permit to Work Officer 1, p8), (Unit B1 Control Room Operator, p22), (Relief Chem Plant Operator, p6).

[33] Transcript from (Unit C4 Control Room Operator, p12).

[34] Call 2847 CS Energy Trading Manager (1337-1339) Unit C3 Control Room Operator, CS Energy, Callide Power Station. CS Energy Trading Manager, CS Energy, Brisbane.

[35] The Australian Energy Market Operator.

13.6.7 A Hive of Activity in the Control Room

Soon after the initial loud bangs above, **Permit to Work Officer 1** and **Permit to Work Officer 2** entered the control room to see what was happening, and if they could help.[36]

Permit to Work Officer 1 noticed all the screens were dark on Unit C4 and Station, except for one Station screen on a start-up panel a little further from the main control panel.[37] **Permit to Work Officer 2** asked what had happened and was told that there was a switching incident and that Unit C4 had tripped.

Control Systems Technician 1 and **Control Systems Technician 2** were attempting to re-establish power supply to the screens by use of a power board and extension lead. None could be found in the control room and so **Control Systems Technician 2** ran upstairs to level 4, removed a lead and board from a desk, and returned to the control room. They untangled the cables running from each dark screen in an attempt to restore power to the 12 screens for Unit C4.

Between 1336 hrs and 1340 hrs, the **Unit C4 Control Room Operator** noticed one of the ash and dust plant screens, which is linked to the coal mills, turn on. The **Unit C4 Control Room Operator** selected the coal mills page and confirmed that the coal mills had tripped.

Author's Note: *The coal mills feed coal into the boiler, which in turn feeds steam to Unit C4. The operators made a deduction that if the coal mills had tripped, there would be no coal feeding the boiler and that if no coal was feeding the boiler, the boiler would also trip. By observing the ash and dust plant screens, the **Unit C4 Control Room Operator** could make these deductions.*

The **Unit C4 Control Room Operator** also determined that the emergency diesel generator and fire pump were online, based on information from the active ash and dust plant screens.[38]

Author's Note: *While the Emergency Diesel Generator did operate and did restore power to the Station AC system, it did not restore power to the Unit C4 DC system. This was because the equipment required to configure the Unit C4 AC system to receive this power is powered by the Unit C4 DC system, which has been lost.*

Having succeeded in connecting the Unit C4 screens to the power board and extension lead, **Control Systems Technician 2** waited for the screen system to power up.[39]

Permit to Work Officer 1 and **Control Systems Technician 2** decided to exit a control room door to the Annex to observe Unit C4. They did not see any fire at this time, but did observe a lot of white smoke and dust. Not wanting to get any closer and convinced something serious was happening, **Permit to Work Officer 1** and **Control Systems Technician 2** returned to the control room to help control the situation.

Permit to Work Officer 1 then contacted the **Relief Chem Plant Operator** in the Chemical Plant and asked them to shut off the hydrogen supply to the Station.

---

[36] Transcript of (Permit to Work Officer 1, p7), (Permit to Work Officer 2, p7).

[37] Transcript from (Permit to Work Officer 1, p8).

[38] Transcript from (Unit C4 Control Room Operator, p13).

[39] Transcript from (Control Systems Technician 2, pp11-12).

The control system designer (**SIEMENS Technician**) had been remote assessing the Callide control system earlier in the day for maintenance. As such, **Control Systems Technician 1** contacted the **SIEMENS Technician** to discuss their visibility of what was happening with the Unit and if they could confirm that the Unit 4 Master Fuel Trip had activated. Shift Operator and Unit 1 Outage Coordinator (**Unit B1 Outside Operator**) activated the Unit 4 Master Fuel Trip to attempt to trip the plant offline.

Author's Note: *The Master Fuel Trip is a manual way to trip and safely shutdown the system. The loss of DC power, however, meant that the Master Fuel Trip could not operate – there was no way, onsite, to disconnect Unit C4 from the grid.*

Permit to Work Officer 2 left the control room, and headed for the boiler basement on ground floor where the coal mills are located. Here they confirmed that the boiler had tripped.[40]

The **Unit C4 Control Room Operator** hesitantly sent Shift Operator **Unit B2 Outside Operator** from the control room to close the control and instrument air systems interconnection valve between B and C station units. By closing this valve, control and instrument air would be prevented from being drawn from B Station and would help Unit B2 remain online. The **Unit B2 Outside Operator** closed the valve located at the edge of Unit C3 and B2, and then immediately returned to the control room.[41]

Author's Note: *The coal mills and the boiler tripped instantaneously when Unit C4 lost AC and DC power at 1333 hrs. It took the control room personnel between 3 and 7 minutes to identify Unit C4 as the source of the incident, sound the evacuation siren, isolate Unit C4's hydrogen feed from the chemical plant, and confirm that the coal mills and boiler had tripped. All of this, with only a single plant screen.*

13.7 External Phone Calls (approximately 1340 hrs)

As the **Unit B2 Outside Operator** returned to the control room, the **Unit C4 Control Room Operator** answered a phone call from **Powerlink.** Powerlink advised that they could see Unit C3 coming offline. The **Unit C4 Control Room Operator** asked if Powerlink was sure that it was not Unit C4 that they could see coming offline. Powerlink confirmed they could see Unit U3 coming offline, and to them, Unit C4 was still exporting 280 Megawatts to the grid. The **Unit C4 Control Room Operator** informed Powerlink that Unit C4 was offline, but they had no screens to verify that and that they would phone them back.[42]

Author's Note: *Based on available evidence, the hypothesis is that Powerlink personnel were viewing data sent directly from the Unit C4 generator. Based on the way the DC power was lost, the power to sensors was lost, but the DC power was not lost to the ICMS data acquisition system (which receives a separate supply from Station). Under these circumstances the ICMS system retains the last measurement received, which in this case was exporting power. Unit C4, however, from the instant DC and AC power was lost, was not exporting power, but was in fact importing power.*

Powerlink confirmed that Unit C3 was going offline, which it was. The hypothesis is that this data was also coming directly from the generator and was a true reflection of its status because its sensors were unaffected in the incident.

[40] Transcript from (Permit to Work Officer 1, p10).

[41] Transcript from (Unit C4 Control Room Operator, p14).

[42] Transcript (Unit C4 Control Room Operator, p14).

13.7.2 Updating Traders Re: Status (1345 hrs)

At 1345 hrs, the **Unit C3 Control Room Operator** from the Callide control room called **CS Energy Physical Trader 1** in Brisbane, and informed them that Unit C3 had been lost. **CS Energy Physical Trader 1** asked the **Unit C3 Control Room Operator** if Unit C4 was still running, and the **Unit C3 Control Room Operator** responded that Unit 4 had tripped as well. In disbelief, **CS Energy Physical Trader 1** repeated what **Unit C3 Control Room Operator** has just told them, *"Unit 4 has tripped as well?"*. The **Unit C3 Control Room Operator** affirmed the statement.

13.7.3 Second Call to AEMO (1346 hrs - 1347 hrs)

At 1346 hrs **CS Energy Physical Trader 1** called **AEMO Operator 1**. They informed them that both Unit C3 and Unit C4 had tripped. Surprised, **AEMO Operator 1** responded *"C4 (Unit 4) has tripped?... we're still seeing Megawatts from C4"*. **CS Energy Physical Trader 1** confirmed to **AEMO Operator 1** that they had just spoken to the operator who said it had tripped. **CS Energy Physical Trader 1** asked **AEMO Operator 1** to advise Powerlink.[43]

Author's Note: *Based on available evidence, it appears that AEMO also receive the same data directly from the generator. They too appeared to be looking at the same hung data point, suggesting Unit C4 was exporting power, when it was importing power and motoring.*

13.7.4 Another Call from Callide Power Trading to the Control Room (1349 hrs - 1350 hrs)

At 1349 hrs Shift Operator **Unit B2 Outside Operator** answered a phone call from **CS Energy Physical Trader 1**. **CS Energy Physical Trader 1** asked if Unit C4 was still producing Megawatts, and again received the response, "*Unit 4 is offline*". **CS Energy Physical Trader 1** asked again, "*It's definitely zero?*". The **Unit B2 Outside Operator** responded "*Yes, mate - and Unit 3 is also offline*".

13.7.5 Third Call to AEMO (1350 hrs - 1352 hrs)

Shortly after 1350 hrs, **CS Energy Physical Trader 1** called AEMO again to confirm that Unit 4 was definitely offline. AEMO saw Unit C4 at zero Megawatts.

13.8 Twenty Minutes Later

13.8.1 Power Returned to Control Room Screens (1353 hrs)

At 1353 hrs, 20 minutes after they went dark, the Unit C4 screens returned to power and began to show data.

Control Systems Technician 1 noticed several discrepancies in the screen data. It wasn't clear if the turbine steam inlet valves, or the generator circuit breaker were open or closed. The turbine speed still indicated 3,000 rpm, and the generated Megawatt indications were also inconclusive.[44] This data suggested that the turbine generator was still being driven by steam and exporting power.

The **Unit C4 Control Room Operator** quickly assessed the data as bad feedback or a disturbed signal, causing the signal into the control system to not be 'live/current' but instead the data reading before

---

[43] Call 2850 CS Energy Physical Trader 1 (1346-1347) CS Energy Physical Trader 1, CS Energy, Brisbane. AEMO Operator 1, AEMO.

[44] Transcript from (Control Systems Technician 1, p15), (Unit B2 Outside Operator, p21).

the screen power was lost. At that moment in the control room, the screens did not provide the operators with a coherent understanding of the status of Unit C4.

<u>Author's Note</u>: *This suggests that the data is indeed the old data from immediately before the incident was initiated. The significance of the turbine inlet values being closed or not means that they cannot ascertain if steam is still entering and driving the turbine. The significance of the generator circuit breaker is important because they do not know if they are still connected to the grid or not.*

13.8.2 Motoring Concern (1353 hrs)

Just after 1353 hrs, **Control Systems Technician 2** requested the **Unit C4 Control Room Operator** to call Powerlink to confirm their reading at the Calvale substation, as it is from a different data source to that measured from within the Unit C4 control system. Powerlink stated that Callide was importing 50 Megawatts at 300 MegaVARs, but that it was also still exporting about 280 Megawatts. (It is not clear whether these readings refer to the Calvale substation.) This made for confusion, as Unit C4 could not be importing power as well as exporting power. In the control room, everyone was concerned that Unit C4 was in a state of motoring.[45]

<u>Author's Note</u>: *While there was concern there was motoring, the operators could not confirm that two of the key conditions necessary for it were present - i.e.: they were still connected to the grid (generator circuit breaker closed), and there was no steam driving the turbine (steam inlet valves closed).*

13.8.3 State of Play in the Control Room

In the control room, discussions focused on how to stop the machine from motoring. This is possible either by opening the generator circuit breaker (however, there was no power supply to do so since both AC and DC power was lost from 1333 hrs), or by having Powerlink open the generator circuit breaker 275 kV feeders located in the Calvale substation, which would disconnect Unit C4 from the grid.[46]

The primary concern with either option related to the steam inlet valves, which were showing up on the screens as 'open'. This was likely an error (disturbed signal) and represented the status of the steam inlet valves before the screens went dark.

There was a conversation about what could happen if the generator circuit breaker was opened while the steam inlet valves were open. The operators knew that the coal mills and the boiler had tripped. But they knew that there was enough potential steam energy inside the boiler that if the generator circuit breaker was opened with steam inlet valves still open, Unit C4 would likely experience an overspeed event, resulting in catastrophic failure of the turbine generator within an estimated 10-20 seconds. The operators considered it too dangerous to send operators out to check the status of the steam inlet valves, which are very near to the turbine.

<u>Author's Note</u>: *The conversation with Powerlink regarding the status of the Calvale Substation introduces conflicting information to what is being experienced in the control room at Callide C. The paradox of Calvale's readings showing Unit C4 producing 280 Megawatts and importing 50 Megawatts at 300 MegaVars introduces doubt in the minds of every operator inside the control room.*

---

[45] Transcript from (Unit C4 Control Room Operator, p15), (Unit B1 Outside Operator, p17), (Control Systems Technician 1, p15), (Control Systems Technician 2, pp13-14), (Permit to Work Officer 1, p11).

[46] Transcript from (Permit to Work Officer 1, p11).

13.8.4 Fourth Call to AEMO (1406 hrs)

At 1406 hrs **CS Energy Physical Trader 1** placed their fourth call to AEMO to update them on Unit C3 and C4 after they had just spoken to **Unit B2 Control Room Operator** in the Callide C control room. **CS Energy Physical Trader 1** advised **AEMO Operator 1** that Unit C4 screens were back on, and that Unit C3 had tripped. The call was interrupted by **AEMO Operator 1**, who apologised and told **CS Energy Physical Trader 1** that they would have to call them back as they thought something serious had just happened.

Author's Note: *The 'something serious had just happened' is likely to have been the cascading partial failure of the Queensland power grid. This timing corresponds to when the event concluded and the Calvale substation disconnected.*

13.9 Catastrophic Failure

13.9.1 The Final Explosion (1406 hrs)

At 1405hrs **Control Systems Technician 2** attempted to contact CS Energy Engineers based in Brisbane to discuss concerns of Unit C4 motoring. The first call to **CS Energy Engineer 1** rang out, but the second call was answered by **CS Energy Engineer 2**.[47] Simultaneously, the **Unit C4 Control Room Operator** reached for the phone to call Powerlink[48] to put them on standby to disconnect Unit C4 from the grid if that was the final decision made.[49] During this call, at 1406 hrs, a final explosion occurred.

In the control room, everything went dark, and then the emergency lights came on. Over the two-way radio, **Permit to Work Officer 1** heard **Permit to Work Officer 2** (who was no longer in the control room) confirm observations of shrapnel going through the roof of the turbine hall.

The **Production Manager** ordered everyone except the **B Shift Step Up Supervisor** and **Unit B1 Outside Operator** to evacuate the control room.[50]

13.9.2 Requesting the Opening of the Circuit Breakers at Calvale (1422 hrs)

At 1422 hrs **CS Energy Physical Trader 2** called the **Powerlink Operator** at Powerlink Operations. They told the **Powerlink Operator** that the people in the control room believe that Unit C4 was

[47]Transcript from (Control Systems Technician 2, p14).

[48]Transcript from (Unit C4 Control Room Operator, p16).

[49] Transcript from (Unit C4 Control Room Operator, p16). There is a discrepancy between Unit C4 Control Room Operator's NRF interview transcript and the B Shift Step Up Supervisor's witness statement. Unit C4 Control Room Operator states, regarding asking Powerlink to open the circuit breaker at Calvale, "I was reaching for the phone to give Powerlink a call back, to have them on standby for a final decision to be made, and then the final … at that stage the final explosion happened", whereas the B Shift Step Up Supervisor states "*I heard Unit C4 Control Room Operator ask the Powerlink operator to open the Calvale feeder. About 20 seconds to 30 seconds after Unit C4 Control Room Operator asked the operator, there was a third, massive boom. It was about 2.06pm*".

[50] Transcript from (Permit to Work Officer 1, p12), (Unit C4 Control Room Operator, p16), (Permit to Work Officer 1, p11), (Unit B1 Outside Operator, p17), (Unit B2 Outside Operator, pp21-22), (Control Systems Technician 1, pp15-16).

motoring, and that the generator circuit breaker had not opened. They appeared to have been unaware of the event at 1406 hrs. [51]

At 1426 hrs, **CS Energy Physical Trader 2** made a call to the **Network Operations Operator** at Network Operations to request that the circuit breakers at Calvale for Unit C3 and C4 be opened. The **Network Operations Operator** confirmed 853 and 854 circuit breakers at Calvale were open and that Unit C3 was de-energising.[52]

13.10 ERT response

13.10.1 Introduction

The following section examines the emergency response and evacuation of the Callide site.

13.10.2 Initial Response

On 25 May 2021, Scheduling Supervisor **ERT Member 1** was on shift in the Callide C planning office. In addition to their planning and scheduling duties, **ERT Member 1** was a trained site Emergency Response Team (ERT) member. At 1333 hrs, they felt vibrations through the floor and began preparing for a possible emergency.

Within moments of feeling the vibrations, **ERT Member 1** heard the site Evacuation Alarm. They immediately grabbed their helmet, looked at their colleague **ERT Member 6**, and called them to action.[53]

When the site evacuation siren sounds, CS Energy's ERT members are required to immediately assemble at the on-site fire station and receive a briefing from the ERT leader. When **ERT Member 1** arrived, they heard the **ERT Leader** say there was a fire in the turbine hall. **ERT Member 1** prepared, but there was no briefing before they, and fellow ERT members left the station in the fire truck. As they left, **ERT Member 1** remembered to swipe their site access card; ERT members did this to leave a record in the system, signifying they were responding to an event and therefore accounted for during an evacuation.[54]

As the fire truck made its way towards the turbine hall, **ERT Member 1** took note of the wind speed and direction (south-westerly breeze) by observing the condensation plume from the cooling tower. This is common practice for ERT members who may be dealing with a situation involving dangerous chemicals, fumes, or gases such as the hydrogen, used in the turbine cooling systems.[55]

When the fire truck arrived at Unit C4 turbine hall, **ERT Member 1** was listening to two-way radio communications on channel 3. The **ERT Leader** was relaying information regarding the fire within the turbine hall. **ERT Member 1** alighted from the vehicle along with the other ERT members, **ERT**

---

[51] Call 2862 CS Energy Physical Trader 2 (1422-1424) CS Energy Physical Trader 2, CS Energy, Brisbane. Powerlink Operator, Powerlink.

[52] Call 2863 CS Energy Physical Trader 2 (1426-1427) CS Energy Physical Trader 2, CS Energy, Brisbane. Network Operations Operator.

[53] Transcript from (ERT Member 1, p4).

[54] There is no evidence why a briefing was not done before ERT members mobilised or whether all ERT members swiped their access cards before leaving the on-site fire station.

[55] Transcript from (ERT Member 1, pp8-10).

Member 2, **ERT Member 3,** and **ERT Member 4,** the three of whom went inside the turbine hall, while **ERT Member 1** remained with the fire truck. They got back in and sat in the passenger seat across from the driver, **ERT Member 5**.[56]

ERT Member 2, **ERT Member 3**, and **ERT Member 4** returned to the fire truck reporting a fire on the generator level. **ERT Member 1** and **ERT Member 5** looked directly at each other and unanimously agreed it was hydrogen-related and decided to retreat to safety and report in.

Author's Note: *The hydrogen is escaping from the generator. ERT members utilise the Australian Emergency Response Guidebook known as the HB76 Manual that provides direction when responding to emergencies involving dangerous goods and hazardous materials. HB76 Guide 115 Gases – Flammable directs ERT members to isolate and consider an initial evacuation for 1600 metres in all directions when responding to a fire involving hydrogen.*

As they withdrew from the turbine hall and staged across the road from the cooling tower they heard a series of explosions coming from the turbine hall prompting them to retreat further to the southern workshop where the team discussed minimum safe distances for hydrogen. **ERT Member 1** consulted their HB76 Manual to confirm the requirements when responding to a hydrogen-related event, and relayed it via two-way radio to the **ERT Leader**, who decided to retreat to the site entrance gates.[57]

Once the fire truck reached the staging area just north of the front gate, **ERT Member 1** began setting up. An explosion was heard, and debris was observed to be raining down upon the turbine hall roof.[58] Eventually, the Queensland Fire & Emergency (**QFES**) ordered the ERT to retreat right out to the highway.[59]

Author's Note: *ERT members responding to the Unit C4 incident did not have important risk information prior to their arrival at the turbine hall. Only when entering and observing the flames did they recognise the presence of hydrogen gas.*

13.11 Crisis Centre

When the Callide **General Manager / Crisis Controller** heard the first explosion, they thought the blast sounded really close. Not long after the first, they heard the second explosion and immediately knew something was not right. Shortly after, the **General Manager / Crisis Controller** heard the evacuation siren. They left their Webex call, grabbed their emergency evacuation folder, and headed to the crisis centre at the end of the security building.

The **General Manager / Crisis Controller** was accompanied in the crisis centre by **Crisis Management Team Member 1** and **Crisis Management Team Member 2**. Early information was starting to come through to them via mobile phone calls: there had been an explosion and fire on Unit C4, people were responding at the evacuation points, and the **Production Manager** was in the control room interacting with the Operations team.[60]

---

[56] Transcript from (ERT Member 1, p13).

[57] Transcript (ERT Member 1, pp15-16).

[58] Transcript (ERT Member 1, p17).

[59] Transcript (ERT Member 1, p20).

[60] Transcript from (General Manager / Crisis Controller, p7).

Crisis Management Team Member 1 was scribing the incoming information about the event (how and when things were happening and points of activity) on the board in the crisis room.

The **General Manager / Crisis Controller** prioritised establishing a few people across key areas. This included asking **CS Energy Corporate Team Member 1** to work out what Human Resources needed to be doing, asking **Crisis Management Team Member 2** to get the evacuation report so they could see who was accounted for at the evacuation points, and directing **Crisis Management Team Member 3** to assist in making sure everyone was accounted for and safe.[61]

Amidst the phone calls the **General Manager / Crisis Controller** was informed that the Queensland Fire & Emergency Services Incident Coordinator (**QFES**) and Queensland Police Service (**QPS**) were on the way. Simultaneously, the **General Manager / Crisis Controller** was still trying to determine an initial headcount, as there were several people not accounted for. There had been no reports of any injuries or visible fire, however the **General Manager / Crisis Controller** observed the turbine hall from just outside the crisis centre where they heard bangs and observed intermittent smoke.[62]

The QPS **Queensland Police Sergeant** arrived and met the **General Manager / Crisis Controller**, who briefed them on the situation. QFES also arrived, and the **General Manager / Crisis Controller** handed over the scene. the **General Manager / Crisis Controller** was sharing the progressive headcount and location of the evacuation points when they, the **Queensland Police Sergeant**, and the QFES heard several explosions coming from the far end of Turbine 4. QFES directed everyone to leave Evacuation Point A and the gatehouse and to proceed towards the car park, then further to the top corner. Evacuation Point B and the control room was also directed to join the full evacuation from the site.[63]

At this point **General Manager / Crisis Controller** could not definitively say that all 236 people on site were accounted for. They were taking several calls from **CS Energy Corporate Team Member 2**, providing direction back to the corporate office, and coordinating the response with Emergency Services. QFES checked the weather, which was forecasting a potential storm, so the decision was made to move everyone to the Civic Centre in Biloela.[64]

[61] Transcript from (General Manager / Crisis Controller, p8).

[62] Transcript from (General Manager / Crisis Controller, p8).

[63] Transcript from (General Manager / Crisis Controller, p8).

[64] Transcript from (General Manager / Crisis Controller, pp9-10).

14 PROCESS SAFETY

14.1 Introduction

Process safety is a discipline within major hazard industries that manages the risk of loss-of-control events that, while rare, have catastrophic consequences. It emerged out of the chemical industry in the 1970s.[65] Following several incidents in the 2000s,[66] it was first adopted in the power industry by Scottish Power in 2010. Then in 2014, Scottish Power's process safety advisor, Lockheed Martin, worked with Contact Energy, one of New Zealand's largest electricity generators to introduce process safety to its operations.[67] Contact Energy became CS Energy's process safety advisor when it began its process safety journey in 2016.

This chapter introduces process safety and the core task played by bowties in both understanding critical risks and building organisational competency and systems.

14.2 Definition

It is generally accepted that 'process safety' is about preventing and mitigating major incidents. These incidents, while having a low likelihood of occurrence, are typically associated with significant consequences that impact workers, communities, plants, and the environment. [68]

Fundamental elements in the effective management of process safety are 'safe design', 'engineering expertise and principles' and 'disciplined operating practice'.

These elements are underpinned by organisational 'risk competence', which is a robust understanding of the major accident events that can occur on a site, the causes of these events (causal pathways), and the controls that effectively prevent and mitigate those causes. Effective control requires a clear description of the control's performance, the activities that keep it reliable, and how it can fail in practice.

[65] CCPS (2016). *Introduction to Process Safety for Undergraduates and Engineers*. Hoboken, N.J.: John Wiley & Sons

[66] Incidents commonly referenced from this time include 2005 Buncefield Oil Depo at Hertfordshire, 2005 Radioactive Leak at Sellafield and 2005 BP Texas City refinery explosion. See Martin Sedgewick, Alec Harley, 'Bottom-line benefits through innovation in process safety ', KPI Management, Hazards 25 Symposium Series no 160, 2015. IChemE (https://www.icheme.org/media/8679/paper-38-hazards-25.pdf); Marc McBride and Graeme Collins, 'Governance of Process Safety within a Global Energy Company', Symposium Series No 155, 2009 IChemE (https://www.icheme.org/media/9500/xxi-paper-002.pdf)

[67] Contact Energy, 'Our Process Safety Story' October 2016. (https://www.nzism.org/crm/file/user/2/uploads/Contact%20Energy%20-%20Our%20Process%20Safety%20Journey%20-%20Overview.pdf). This article identified Lockheed Martin as the process safety engineers, the same advisors identified in Martin Sedgewick, Alec Harley, 'Bottom-line benefits through innovation in process safety ', KPI Management, Hazards 25 Symposium Series no 160, 2015. IChemE (https://www.icheme.org/media/8679/paper-38-hazards-25.pdf);

[68] There are many definitions for process safety management, with the Australian Institute of Health and Safety's (AIHS) Body of Knowledge defining it as: *Process safety is about managing the integrity of operating systems by applying inherently safer design principles, engineering and disciplined operating practices. It deals with the prevention and mitigation of incidents that have the potential for a loss of control of a hazardous material or energy. Such loss of control may lead to severe consequences with fire, explosion and/or toxic effects, and may ultimately result in loss of life, serious injury, extensive property damage, environmental impact and lost production with associated financial and reputational impacts."* Managing Process Safety, Core Body of Knowledge for the Generalist OHS Professional, Australian Institute of Health and Safety (AIHS), Second Edition, 2019.

There are many practices that are important for the management of process safety. The ones relevant to the investigation are discussed in the following sections. Intro

14.3 Risk Management

Process safety management requires a fundamental understanding of each unique hazard at a business's operating facilities that have the potential to cause catastrophic harm.[69]

Major incidents are typically caused by loss of control of major hazards, for example, high voltage electricity, contained hydrogen, or dam wall integrity. Within CS Energy, these are called Major Accident Hazards (MAHs).

Each major hazard has very different causes and is hence controlled by a series of controls unique to that hazard. Each control either prevents or detects the source of the hazard becoming uncontrolled or mitigates the consequences or loss post-event.

Within high hazard industries, a 'bowtie' represents best practice for visualising a single major accident scenario and its controls. A typical bowtie representation is shown in Figure 14.

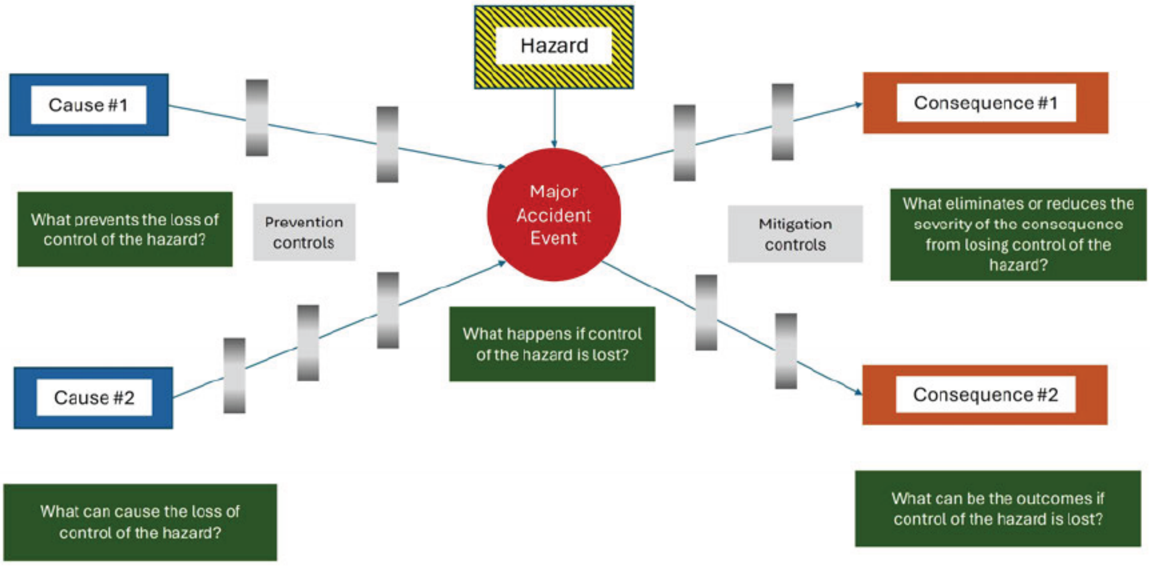


Figure 14 A typical bowtie representation

Each bowtie diagram visually represents a MAH, along with its causes and consequences. Then along each causal or consequence line it clearly identifies the controls that either prevent (on the left hand side) or mitigate (right hand side) the hazard.

---

[69] Within the context of Queensland regulations, Chapter 9 of the Work Health and Safety Regulations 2011 governs Major Hazard Facilities, which are defined as locations that store specified levels of specified chemicals at certain levels or above. These are usually oil refineries, chemical plants and large fuel and chemical storage sites. Operators of such sites are required to be licensed, which license can only be obtained with a detailed plan, called a safety case, for managing its major hazards. Work Health and Safety Regulation 2011. Note Chapter 9A imposes a similar licensing regime on major amusement parks. The safety case is required to demonstrate that the safety management system will control risks arising from major incidents and major incident hazards and that the control measures are adequate.

Bowties become the foundation for organisational knowledge of each major accident risk.

Organisations operating without this risk knowledge are unlikely to be aware of all of the possible casual pathways for an event, or of the controls that are meant to be in place to prevent it. Further, in the absence of this information, it is very difficult to recognise the warning signs of risks that are becoming uncontrolled.

Further, this is a live document, often informed by ongoing process hazard assessments, expertise and experience, and is updated as the organisation and industry learn more about the management of that particular risk.

The development of bowties at CS Energy is discussed further in the following chapter.

14.4 Learning from Incidents System

The purpose of a learning from incidents system is to gather information that assists an organisation identify where its systems, engineering of process safety, are not working effectively. The use of these learnings provides opportunities to address these deficiencies before an incident occurs.

It includes a structured and formal processes for any person to report issues, events, scenarios with uncontrolled hazards, process deviations, and potential control weaknesses – in short, anything that might be a warning sign of future failure.

A common misconception is that there needs to be a bad outcome for something to be reported. But, there are often lessons in situations where nothing bad has occurred but there was potential for it to do so given a slightly different set of circumstances.

Once issues are reported, there must be a robust system to classify events according to their potential severity. This allows the events of high potential to be escalated for management visibility, further analysis and sharing of lessons.

The right events can have their lessons extracted, shared to relevant areas, and embedded back into organisation to prevent systemic failures of a similar nature.

An effective reporting and investigation process for process safety is underpinned by the MAH control identifications discussed above. And include reporting of process deviations and potential control failures to be investigated using systematic root cause analysis methods.

14.5 Management of Change

Management of Change (MoC) has been identified as a causal factor in a large number of major industrial accidents worldwide, including the Flixborough disaster in the UK in 1974, the Bhopal disaster in India in 1984, Piper Alpha disaster in the North Sea in 1988, Esso Gas Plant in Longford, Australia in 1998, Texas City refinery explosion in the USA in 2005, and Deepwater Horizon explosion in the Gulf of Mexico in 2010.

Engineering changes often occur for good reason, however, without a rigorous application of a change process it can be easy for management, maintainers, operators, or engineers to lose sight of the original design intent of the facility and the plant status can become unknown.

For changes to be implemented effectively and safely, the potential impacts of the change on all aspects of the facility (or business) should be evaluated, understood, and communicated. Where required, risks should then be mitigated.

Additional requisites for the change process include involvement of appropriate competent personnel (experience and expertise specific to both the plant and the change), and ensuring the change is authorised by appropriate experts and the right level of management (who may have a different visibility of the change within the broader organisational system).[70]

The communication of the change to the appropriate plant personnel and management is essential to ensuring the plant status, including any abnormal plant conditions, are known and understood by those who need to know.

14.6 Organisational Culture

Process safety culture is a key organisational factor in several major process safety incidents.[71] Themes include: a failure to have a proper safety culture, a lack of strong leadership to support the culture, and a failure to create consistent operational discipline.

The Center for Chemical Process Safety (CCPS) made process safety culture a key aspect (the first element) when it published its Risk Based Process Safety Guidelines:[72]

> *A positive environment in which employees at all levels are committed to process safety. This starts at the highest levels of the organization and is shared by all. Process safety leaders nurture this process.*

A key feature of poor process safety leadership and culture is the failure of companies to learn. Since process safety incidents are by their very nature rare, the opportunities to learn directly from actual events is low. There is a need to be constantly vigilant for warning signs and precursor events.[73]

14.7 Personal Safety and Process Safety

Personal and process safety management do share common themes, but they have very different requirements as discussed above. This means that they need to be managed and monitored in different ways. The AIHS Book of Knowledge identifies three key factors which distinguish process safety from person safety (OHS):[74]

(a) The mechanisms of causation – while both process safety and OHS are concerned with a potential loss of control of hazardous energy, process risks have causes that are significantly different.

(b) The scale of potential consequences – while process safety incidents are less common than OHS incidents, their consequences are more likely to be severe due to higher levels of energy.

---

[70] A requisite input for a sound MoC process is access to consistent, up-to-date documentation. Without this, the change process has no frame of reference to previous changes and the current state of the plant.

[71] Understanding Process Safety Culture Disease Pathologies - How to Prevent, Mitigate and Recover from Safety Culture Accidents; Arend and Manton – IChemE Symposium Series #160; 2015.

[72] Center for Chemical Process Safety; Guidelines for Risk Based Process Safety 2007.

[73] The following are some characteristics of poor leadership and process safety learning, which lead to a poor process safety culture and operational discipline: People hide things and 'kill messengers', Procedures not followed without accountability, Mixed/improper safety/production messages, Complacency, low trust, silo mentality, Superficial causal analysis of problems. Things don't get fixed – or things don't stay fixed, No company memory.

[74] Managing Process Safety, Core Body of Knowledge for the Generalist OHS Professional, Australian Institute of Health and Safety (AIHS), Second Edition, 2019.

(c) The focus on engineering and design – process safety focuses on the safety of the system while OHS is about the safety of those who interact with the system.

Failure to identify these differences and develop appropriate management practices has been a significant factor in many process safety disasters where good personal safety indicators, such as a low lost time injury frequency has led to the belief that all safety is being managed well.

15 CS ENERGY ORGANISATION AND CULTURE

15.1 Introduction

This chapter provides an organisational overview of CS Energy, specifically focusing on the years leading up to the incident. Its purpose is to provide the organisational context in which the incident occurred.

15.2 Summary of Key Findings

The organisational findings relating to CS Energy's Organisations and Culture are as follows:

(a) CS Energy operates in the context of significant constraints, including its status as a government owned corporation, the joint venture ownership of Callide C power station, a highly regulated energy market and the impacts of climate change. These constraints influence investment and cost cutting, organisational focus, and decision making.

(b) The Shareholder Mandate drove focus on cost savings, whilst at the same time placing constraints on CS Energy's investment strategies, including into its existing assets.

(c) The metrics focused on by the CS Energy board did not include a focus on the management of process safety. Instead, they were focussed on personal injury, plant availability and financial performance.

(d) Between 2017 and the incident in 2021, Callide experienced significant turnover of key roles. This turnover would make it difficult to maintain a process safety focus.

(e) CS Energy implemented a swirl of at least 6 major initiatives across the organisation which impacted sites in a short period of time prior to the incident. This would also make it difficult to focus on process safety.

(f) In this type of environment, it is arguably very difficult to foster a focus on process safety, especially when the metrics at a corporate and organisational level have no such focus. There were likely competing tensions between cost reduction and process safety, and while process safety was discussed in the organisation, it did not result in any meaningful improvement in how major accident risks were managed within operations.

15.3 A Brief History of CS Energy

15.3.1 The organisation

The Queensland Government restructured the Queensland energy market in the 1990s to both increase competition and in readiness for the introduction of the national energy market (NEM). This restructure involved the establishment of several government owned corporations under the Government Owned Corporations Act 1993 (Qld). The State's power generating assets were transferred to these corporations.

CS Energy was registered as a public corporation in 1997, and Callide and Swanbank power stations were transferred to it. Mica Creek power station was also later transferred to its ownership, and in the early 2000s, CS Energy built further power stations at Callide (Callide C) and Kogan Creek.

The Queensland Government further restructured the state's energy assets in 2011, which led to CS Energy losing Mica Creek and Swanbank power stations and gaining Wivenhoe power station.

In October 2019, Wivenhoe power station was transferred to CleanCo, the Queensland Government's new, and third electricity generator (in addition to Stanwell Corporation). CleanCo was created to bring all the State's renewable energy generation capability under the one company. All non-renewable energy plants would remain with CS Energy and Stanwell Corporation.

15.3.2 Callide

The coal fired Callide power stations (A, B, and C) have provided a significant portion of Queensland's energy needs over the decades. Power generation started with the Callide A power station, which operated from 1965 till 2001, at which point it was put into indefinite storage.

The Callide B and C power stations each consist of two generating units: Unit B1 and Unit B2 for Callide B, and Unit C3 and Unit C4 for Callide C.

The Callide B power station was commissioned in 1988, was designed to have a 40-year technical life, and its planned closure date is 2028.[75] Callide C unit was commissioned in 2001, with a forecasted operating life running to 2050. This has since been revised to a planned closure date of 2038. Both Callide B and C can be considered 'aging' assets.[76]

15.3.3 CS Energy as a Government Owned Corporation (GOC)

CS Energy is a Government Owned Corporation (GOC) established in 1997 under the Government Owned Corporations Act 1993 (Qld). Like other companies, it is registered under the Corporations Act 2001 (Cth), and its shareholders are Queensland Government ministers (the shareholding ministers), who hold the shares in CS Energy on behalf of the people of Queensland. CS Energy's board is answerable to the Shareholding Ministers. The Shareholding Ministers expectations for CS Energy are contained in a Shareholder Mandate, which is issued by the Shareholding Ministers to CS Energy approximately every 5 years.

Every year, the board of CS Energy agrees a formal performance agreement with the shareholding ministers. This agreement sets out yearly financial and non-financial performance targets. These agreements are called Statements of Corporate Intent (SCIs) and are tabled in Parliament each year.

The SCIs are informed by the requirements of the Shareholder Mandates. The SCI contains CS Energy's strategic targets, including annual targets across a range of measures. It also includes a range of other information, including key assumptions and risks, capital expenditure, capital structure, a statement of compliance, and financial statements.

[75] CS Energy, Statement on the Future of Callide B Power Station, 27 October 2019, https://www.csenergy.com.au/news/statement-on-the-future-of-callide-b-power-station#:~:text=2028%20has%20always%20been%20the,design%20life%20of%2040%20years.

[76] See AEMO, Draft 2024, Integrated System Plan for the National Electricity Plan at p7 'Coal-fired generators, the ageing workhorses of Australia's electricity supply, are now retiring', https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/draft-2024-isp-consultation/draft-2024-isp.pdf?la=en

15.3.4 The Callide Board

At the time of the incident, the board of CS Energy consisted of five non-executive directors that were appointed by the Queensland Government.[77] The chair of the Board had been appointed in 2015, and did not have a technical engineering or process safety background. Of the other four directors, one had a power industry operational background, one had a legal and governance background, one had a legal background, and one had a financial background.

The Board Charter states that the board's role is to be *'responsible to the Shareholding Ministers for governance of CS Energy.'*[78] This includes *'setting the Risk appetite of CS Energy and ensures appropriate oversight of risk, primarily by setting risk policies and through the activity of the Board's Enterprise Risk Committee'*.

At the time of the incident the board operated with the support of four subcommittees:

(a) Audit and Finance Committee: financial risk management, corporate and financial reporting, management of external and internal audit functions.

(b) Culture and Remuneration Committee: people policies and remuneration strategy, policy and structure having regards to CSE's desire for a safe, construction and high-performance culture.

(c) Safety And Performance Committee: establishing and monitoring CSE's health, safety and environment frameworks, plant reliability and associated operational risks.

(d) Enterprise Risk Committee: establishing and monitoring CSE's effective governance risk, compliance frameworks.

CS Energy's board meet every month except December, usually on the last Friday or Thursday of the month. In the 12 months preceding the incident, the meeting durations varied between 72 minutes to the longest at 220 minutes (just over 3.5 hours). There were usually 8 or 9 full time attendees, and between 8 and 17 part time attendees.

The full-time attendees were the Chair, the Non-executive Directors (which varied between 3 and 4 across the year), the CEO, the EGM Corporate Services, the CFO and Company Secretary. The part time attendees were a range of CSE executives and staff, and external guests.

No Callide based site personnel attended a board meeting in the 12 months leading up to the incident. Of these 11 board meetings, five were held by teleconference (an impact of COVID-19), five were held in Brisbane, and one was held at Kogan Creek power station.

In the 5 years before the incident, board meetings had been held at Callide on 27 September 2019 and 23 February 2017.[79]

15.3.5 CS Energy's Operating Locations

CS Energy's executive team is based in Brisbane, together with the finance, IT, HR, Asset Management, Legal, Assurance, Learning and Development, Health and Safety, and Energy Trading teams.

---

[77] Non-executive directors do not have operational roles within CSE.

[78] Board Charter, July 2018, CSE.001.082.5729.

[79] The board met at Wivenhoe in September 2016, and at Kogan Creek on 27 October 2017 and 23 May 2019.

There are two operational sites: Kogan Creek Power Station, located in Chinchilla (approximately 260km west of Brisbane), and Callide Power Station located in Biloela (approximately 570km north of Brisbane).

This structure separates operations from management.[80]

15.3.6 Joint Venture ownership of Unit C

The Callide C power station is a 50/50 unincorporated joint venture between Callide Energy Pty Ltd and an international power generation company called Genuity Group (formerly known as InterGen Australia). The governance structure is shown in Figure 15.[81]

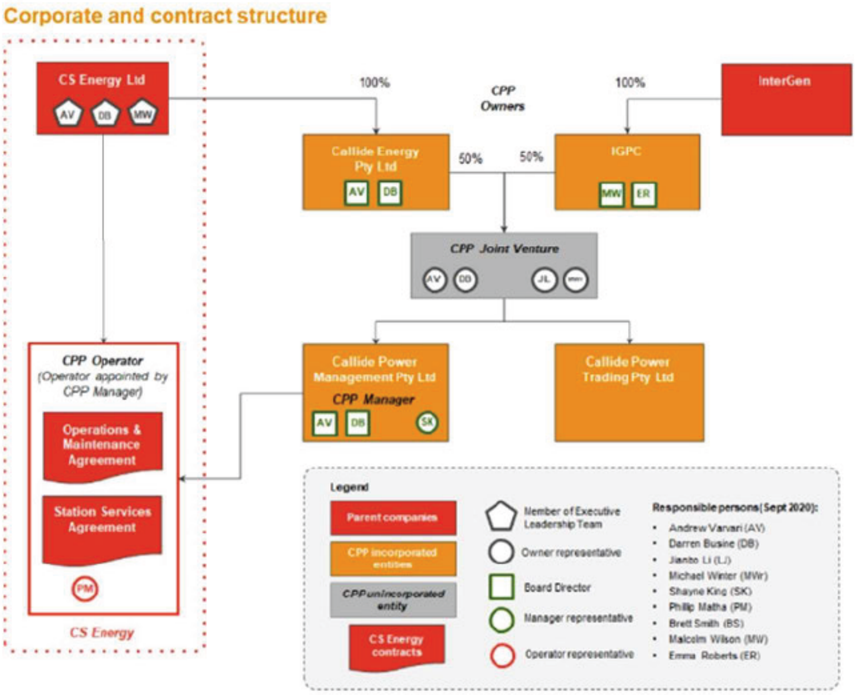


Figure 15 Callide JV governance structure

The joint venture was established in 1998 to design, construct, and operate the Callide C power station. The joint venture appointed Callide Power Management Pty Ltd as their management company to develop and manage Callide C Power Station on their behalf.[82]

Callide Power Management Pty Ltd entered into two agreements with CS Energy Ltd to run the station. These were the Operations and Maintenance Agreement, and the Station Services Agreement.[83]

These two agreements govern the fees payable by Callide Power Management Pty Ltd for the running of Callide C. The agreements also govern who can make what decisions about the running of Callide C

[80] NOTE: An examination of the separation of operations and engineering/management is ongoing for this investigation.

[81] PWC, 'Joint Venture Governance Reviews CS Energy October 2020' at 20, CSE.001.082.0391.

[82] Callide C Power Station Asset Management Plan Part 2: Reference Information, CSE.900.001.1196.

[83] Callide Power Project Operation and Maintenance Agreement, dated 11 May 1998 (as amended and restated on 17 June 2017) CSE.001.021.0266 and Callide Power Project Station Services Agreement, dated 11 May 1998 (as amended and restated on 5 June 2017), CSE.001.021.0394.

- notably, that Callide Project Management Pty Ltd has discretion over major works and overhaul projects.

From time to time, the joint venture ownership structure has had implications for the management of Callide C. In a governance review of the joint venture undertaken as part of CS Energy's assurance program in 2020,[84] a key finding was:

> *"There is a misalignment of strategy and objectives between the owners of the Callide C JV, which is manifesting as delayed decisions, budget disputes, a short-term focus and inefficiencies in governance and operations.'*

The review goes on to state:

> *'These are historical and reflect the varying commercial and strategic imperatives for each party and will be difficult to address in the short term particularly in the context of a 50/50 unincorporated joint venture. However, the current 5-year review process for the Operations and Maintenance Agreement (OMA) and Station Services Agreement represents an opportunity for CSE as both operator and owner to further define its strategy, objectives and risks and to develop a negotiation strategy to define and align (as much as possible) the strategic intent for the JV (2020.07.01)."*

Other findings in this report included:

(a) The joint venture does not clearly or formally identify, manage, or track risks.

(b) Issues arising out of CS Energy holding both owner and operator roles leading to duplication and ambiguity.

(c) The different financial years used in InterGen and CS Energy accounting together with lack of strategic alignment causes rework, delays in operational budgets and approvals.

The joint venture was further impacted when InterGen entered receivership on 14 June 2016. Receivers took control, which impacted InterGen's financial position and decision making.[85] The insolvency was triggered by InterGen's banks because InterGen was unable to refinance its debt.[86] InterGen shifted into voluntary administration on 22 December 2016, with control shifting to external administrators, Ferrier Hodgson and PPB Advisory. InterGen emerged from insolvency in early 2018.

Resolution of the administration included resolving a dispute over the Base Fee payable under the Operation and Maintenance Agreement for its extension (the 2016 Five Year Review) applying from 1 July 2016. This dispute was settled in mid-2017. The settlement agreement locked in fees payable under the O&M agreement, including for operator training fees.[87]

15.3.7 Financial Performance

Figure 16 tracks the profit and loss history of CS Energy and the energy price between 2010 and 2021. The red boxes indicate loss making years, while the green boxes represent profitable ones.

---

[84] PWC, 'Joint Venture Governance Reviews CS Energy October 2020', CSE.001.082.0391.

[85] Deed of Appointment Receivers and Managers, CSE.001.023.2702.

[86] Ben Potter and Mark Ludlow, '*Callide C power receivership blamed on banks, poor col supply*' 8 July 2016, AFR. https://www.afr.com/companies/banks-appoint-receivers-to-us-partner-of-callide-c-power-plant-20160708-gq1a07

[87] Callide Power Project - Deed of Amendment, settlement, and release, CSE.001.021.2986.

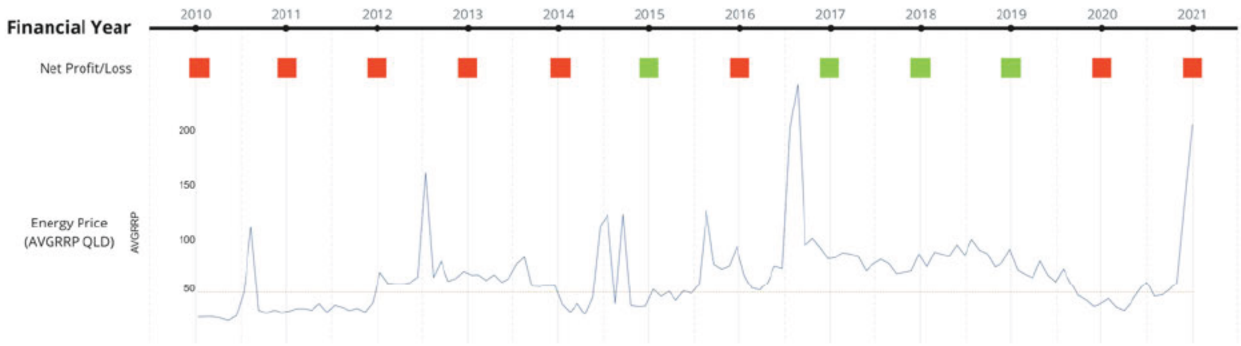


Figure 16 Historical profit and loss of CS Energy, 2010 to 2021

CS Energy experienced an extended period of loss making from 2008 to 2015, before then returning to profitability. This profitability correlates with the return of the average energy price to above $44/MWh. This period of profitability then came to an end again in 2020, coinciding with the fall in energy prices. Prior to 2015, CS Energy last previously recorded profit in the 2008/09 financial year.

During this 7-year loss making period between 2008 and 2015, a major cost cutting initiative was launched in 2012/2013. This took the form of a strategic objective to reduce operational expenditure in line with the shareholding ministers' expectations, as set out in CS Energy's response to shareholders expectations letter, see Figure 17:[88]

1.2 Response to shareholders' expectations letter

Consistent with the shareholders' expectations letter, CS Energy is focussed on achieving cost and performance efficiencies from the existing asset base. Overhead costs are a significant focus, with a planned reduction of corporate office staff from 180 to 120 already well progressed and expected to be completed by 31 December 2012. Other non-labour operational costs at corporate office and sites are also being reduced; capital expenditure has been reduced to focus only on essential and committed work and projects.

Figure 17 Extract from SCI describing CSE's response to the shareholder's expectations letter

CS Energy's 2013/2014 annual report states that $35.3 Million in cash flow savings was achieved in the year ending June 2013, with a further $46.1 Million saved in the year ending June 2014.[89] The savings, which exceeded shareholder targets, were reportedly realised through:

(a) 'increased discipline over costs, the implementation of value based decision making processes, leading to the elimination of non-essential operating and capital expenditures. Ensuring staffing levels are in line with, but do not exceed requirements, is consistent with establishing appropriate cost discipline and eliminating non-essential costs'.[90]

---

[88] Amended Statement of Corporate Intent 2012/2013, 28 September 2012.

[89] CS Energy, Annual Report 2013/2014.

[90] CS Energy, Annual Report 2013/2014.

15.4 External Context

15.4.1 Climate change

Climate change has posed multiple challenges for CS Energy and the ongoing viability of its coal powered power stations. This has included:

(a) Regulatory and financial uncertainty created by the potential carbon price by the Federal Government introduced between 2010 and 2014.

(b) Investment in technology projects.[91]

(c) The establishment of CleanCo in 2017, which removed access to renewable energy as a source of revenue for CS Energy, and transferred Wivenhoe dam out of CS Energy's portfolio.

CS Energy subsequently developed it Future Energy Strategy to secure future revenue streams.

15.4.2 Industry – AEMO, AER, Powerlink

AEMO (Australian Energy Market Operator), formed in 2009, oversees the operation and security of the National Energy Market (NEM) and is responsible for restoring energy systems in the event of an emergency. AEMO is also responsible for providing the framework for the regulation of wholesale electricity and gas markets, which is then regulated by the AER (Australian Energy Regulator).

The AER was founded in 2005 as a merger between 13 bodies previously in charge of energy regulation across Australia. As well as monitoring the wholesale electricity and gas markets, the AER also monitors compliance with electrical law.

The AER also regulates Powerlink, who owns, develops, operates, and maintains the high voltage electricity transmission network in Queensland. Powerlink is also a government owned corporation, and it was founded in 1995 as part of the restructuring of the Queensland power industry. Powerlink's network covers the majority of Queensland, extending from 1,700 km north of Cairns to the NSW border.

15.4.3 Industry - Energy Prices

The market price for energy started to diminish in late 2019 and throughout 2020. CS Energy's internal management response to these lower market prices was a program titled *Project Adams*. The program's objectives included changing the power stations from fixed to flexible generators and reducing the cost of production.[92]

CS Energy's quarterly report to the shareholding ministers on 31 July 2020 outlined how this impacted the business.[93] The letter highlighted that Queensland continued to record the lowest mainland spot price in the national electricity market. It also stated that, as a result of low gas prices and increases in large scale renewable generation, contract prices had decreased by up to 10% over the three-year forward market.

---

[91] These projects included the Oxyfuel Project at the Callide power plant between 2003 and 2012 and the Kogan Creek A Power Station Solar Boost Project which began in 2011.

[92] Board Paper Business Transformation - Project Adams, 21 February 2021, CSE.001.023.5583 and Board Paper Business Transformation - Project Adams 21 May 2021, CSE.001.023.6024.

[93] Letter, Jim Soorley to Treasurer and Minister for Natural Resources, Mines and Energy, 31 July 2020, CSE.001.082.7094.

The impact of these low prices was a $300 Million reduction in the value of CS Energy's generation assets (as a result of the lower-than-expected future revenue). The letter also states that: *'These financial results demonstrates the importance and urgency of CS Energy's strategy to transform the business form a traditional generator to a diverse energy business'*.

15.4.4 Impact of COVID-19

CS Energy was also affected by the COVID-19 pandemic that emerged in 2020. In 2020 CS Energy ran a 'COVID-safe' major overhaul of Unit B1 and a minor overhaul of Unit C4. These overhauls involved the introduction of around 200 contractors to the site, working under strict hygiene measures. These overhauls took longer than usual to accommodate for the differing working conditions.[94]

As per the 2021 annual report, CS Energy stated '*Our financial performance and cashflow was not materially impacted by COVID-19 during the year ended 30 June 2021*". And additionally, "*Forecast cash flows have been updated in the short term to reflect observable and publicly available information on the expected impact COVID-19 will have on economic factors impacting the market outlook, including demand projections and fuel price assumptions. Forecast fuel and water pricing and supply contracts have not been materially impacted by COVID-19.*'

These statements were repeated in the 2022 annual report and indicate the effect of COVID-19 on the business from a financial standpoint was immaterial.[95]

15.5 Strategy and Metrics

15.5.1 2016 Shareholder Mandate

CS Energy's 2016 Shareholder Mandate,[96] which was to be in place to around June 2019, required CS Energy to, in respect of operations:

(a) Not develop, invest, or own new generation capacity.

(b) Give priority to the effective management of existing assets.

(c) Focus on the specific area for improvement of 'exceeding efficient targets'. These targets were set at $500,000 per year, over each of the coming 5 years, thus giving an expectation of $2.5 Million savings over the period FY15/16 to FY19/20.

(d) Consider opportunities around asset management (including opportunities to reduce expenditure associated with scheduled outages and overhauls), O&M costs (noting that benchmarking showed CS Energy was in the mid-range of industry) and flexibility (consider opportunity to improve flexibility in its existing fleet of assets in a transitioning market).

15.5.2 2020 Shareholder Mandate

The 2020 Shareholder Mandate was subject to negotiation between CS Energy and Treasury from mid-2018 to late-2020 (the 2016 Mandate being due to expire in June 2019).

---

[94] CS Energy Annual Report 2022 at 9.

[95] CS Energy Annual Report 2022 at 62.

[96] Shareholder Mandate for CS Energy, Queensland Treasury Corporation, May 2016, CSE.001.082.3776.

In an assessment of the 2020 draft mandate,[97] CS Energy made the following observation:

(a) CS Energy did not obtain support for policies that supported more flexible labour and workforce restructures.

(b) CS Energy sought to use surplus cash reserves for investment in its existing and new assets, but received a more limited agreement that debt management must be considered equally with portfolio revenue.

(c) Limitations were being imposed on the type of investments and renewable contracts it could enter.

15.5.3 Statement of Corporate Intent (SCIs)

Pursuant to section 102 of the Government Owned Corporations Act 1993 (Qld), a Government Owned Corporation must have a Statement of Corporate Intent for each financial year. That SCI must:[98]

(a) Be consistent with the GOC's corporate plan.

(b) Specify the GOC's financial and non-financial performance targets for the relevant financial year.

(c) Include matters relating to its community service obligations, as well as employment and industrial relations plan.

The SCI is negotiated and agreed by the GOC and the shareholding ministers each year.[99] The Board of CS Energy then undertakes to achieve those targets each financial year.[100]

The FY2020/21 SCIs at the time of the incident are shown in Figure 18:[101]

[97] Board Paper, Shareholder Mandate Update, 28 August 2023, CSE.001.082.7213 and attached PowerPoint, Shareholder Mandate update, August 2020, CSE.001.082.7216.

[98] Section 104 and 105 of GOC Act.

[99] Section 107 of the GOC Act.

[100] This undertaking is set out in the SCI published each year by CSE.

[101] CS Energy Statement of Corporate Intent 2020/21, CSE.001.082.8111.

Strategic Priority		Full year target	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Strengthen our Foundations	All injury frequency rate (AIFR)[1]	≤28	≤27	≤26	≤26	≤28
	Constructive culture[2]	28	NA	NA	NA	NA
Optimise our Assets	Equivalent unplanned outage rate (%)[3]	7.4	6.9	7.1	7.8	7.8
	Commercial availability (%)[4]	87.0	83.2	85.4	85.8	87.0
Maximise our Returns	All in unit cost ($MWh)	43.39	51.89	50.96	35.94	37.44
	Underlying EBITDA ($M)[5]	282.4	59.3	68.2	90.9	64.0
Deliver Future Energy	C&I market share (%)[6*]	9	NA	NA	NA	NA
	Product solutions[7*]	69	NA	NA	NA	NA

Figure 18 SCIs for FY2020/21

Of note:

(a) There is no target that relates to process safety. The selection of suitable process safety metrics is challenging, but its absence is likely to message that process safety is not a focus.

(b) The All Injury Frequency Rate (AIFR) is a lagging indicator, meaning it provides information on the incidents that have happened. Despite its widespread use, it is a poor measure that provides no information on the effectiveness of an organisation's ability to manage their fatality risks. The causes of incidents that result in fatality risks are largely different to those that cause the incidents that are recorded in the AIFR.

(c) The AIFR is also not a measure of the effectiveness of an organisation's management of catastrophic process safety risks. In other words, a decreasing AIFR should not be considered indicative of the effective management of process safety risk. As in the case of fatal risks above, the causes of incidents that contribute to the AIFR metric are different to the causes of process safety incidents. Further, the reliance on AIFR as the only safety metric can give the impression that process safety risk is well managed in the organisation.

(d) The use of AIFR as a metric can, in and of itself, lead to a reduction in incident reports (not just in personal safety, but in all forms of reporting). This is typically due to organisational pressure to 'drive down the metric'. This typically inhibits an organisation's ability to collect and analyse the warning signs of potential future failures, including process safety failures.

(e) AIFR also puts the leadership focus on the prevention of higher frequency, but lower severity risks, which can take focus away from the events that are rare, but catastrophic, which is the nature of process safety events.

(f) Constructive culture measures the outcome of a culture and engagement survey undertaken every two years within CS Energy.

(g) The remainder of the metrics focus on optimising assets, maximising return on investment and delivering future energy. None of these metrics reward a meaningful focus on the management of process safety risks. It is important to note that Equivalent Unplanned Outage Rates (%) and commercial availability (%) are not proxies for the measurement of the effectiveness of the management of catastrophic process safety risks. They too, like the AIFR, are lag indicators.

(h) The effectiveness of how an organisation manages process safety risk is underpinned by clearly defining what the major process safety risks are, how they are caused, as well as a deep understanding of the controls that manage those risks. It also involves the continuous checking and confirmation that these controls are in place and effective. In the absence of completed and implemented bowties, it would have been very difficult for CS Energy to develop the necessary competency and metrics to manage these risks at corporate and board level.

15.5.4 Incentives (Non-Union Staff)

An incentive structure applies to staff who are on alternative individual agreements (AIAs). This structure applies to most corporate staff, as well as the senior leadership team at Callide.[102]

Historically the scorecard was based around the SCIs, but 2020 saw the introduction of a broader set of measures linked to new business initiatives and strategic outcomes. These measures are contained in an Enterprise Scorecard.[103] The proposed Enterprise Scorecard for 2020 is presented in Figure 19.[104]

[102] This incentive structure is in addition to fixed salaries, and it provides for payment of up to 15% of base salary. The incentive structure is governed by CSE's Salary and Performance Review process. The incentive is based on a combination of group (Enterprise Scorecard) and individual (individual Achievement Plans) outcomes. The Executive General Managers and their direct reports have a higher weighting to Enterprise outcomes. From a base of 25%, ELT Direct reports carry a 40% weighting, EGMs 50% and the CEO, 100%. The only precondition to payment of the bonus is base profit (referred to as the Operating Profit Gateway). The incentive is decided in August of each year, firstly by the Culture and Remuneration Committee and then it goes to the board for approval.

[103] It is noteworthy that from 2020 onwards, with this revised approach, the financial weightings reduced from 45% of the incentive scheme to 25%.

[104] Enterprise Scorecard 2020, CSE.001.082.6373. Note, no bonus was ultimately paid in 2020 because of COVID-19.

Strategic Priority	Measure	Threshold	Target	Stretch	Weighting
Awarded Incentive		50%	75%	100%	
Award for performance between tiers			Linear		
Strengthen our Foundations (30%)	All Injury Frequency Rate (**AIFR**)	<32	<30	<28	15%
	Significant Environmental Incidents (**SEI**)	0	0	0	5%
	Pulse Cultural Survey score (**OCI**)	Casual factor percentile based on FY19 OCI	10% improvement on FY19 OCI	13% improvement on FY19 OCI	10%
Optimise our Assets (25%)	Equivalent Unplanned Outage Rate (**EUOR**)	11%	9%	7%	10%
	Key Time Availability	91% at wholesale market prices > $20/MWh	Threshold ***and*** 91% at wholesale market prices > $50.50/MWh	Target ***and*** 91% at wholesale market prices > $100/MWh	15%
Maximise our Returns (25%)	All-in Unit Cost ($/MWh)	$55.50/MWh	$50.50/MWh	$45.50/MWh	10%
	Underlying Earnings before Interest, Tax, Depreciation and Amortisation (**Underlying EBITDA**)	$288.5 million	$320.5 million	$352.5 million	15%
Deliver Future Energy (20%)	Number of retail customers	3 retail customers signed	5 retail customers signed	7 retail customers signed	10%
	Renewable generation under contract	150MW	175MW	200MW	10%

Figure 19 2020 enterprise scorecard

As with the SCIs, which it is closely aligned with, the scorecard does not contain a process safety metric. These metrics present the same issues, discussed above, with the use of the AIFR, availability and unplanned outage metrics.

15.5.5 Summary

The Shareholder Mandate drove focus on cost savings, whilst at the same time placing constraints on CS Energy's investment strategies, including into its existing assets.

Combined with this, the SCIs were dominated by financial metrics and failed to include any meaningful focus on process safety.

Further, the focus on personal safety using the All Injury Frequency Rate (AIFR) is a poor measure that provides no information on the effectiveness of an organisation's ability to manage their fatality risks or catastrophic process safety risks. The causes of incidents that result in fatality risks are largely different to those that cause the incidents that are recorded in the AIFR. Reliance on AIFR as the only safety metric can give the impression that process safety risk is well managed in the organisation.

15.6 Management Turnover

Between 2017 and the incident in 2021, Callide had had four different general managers, three maintenance managers, and five production managers.[105] We have mapped the timing and nature of these changes in the figure below.

[105] Based on an analysis of roles referred to across CS Energy records.

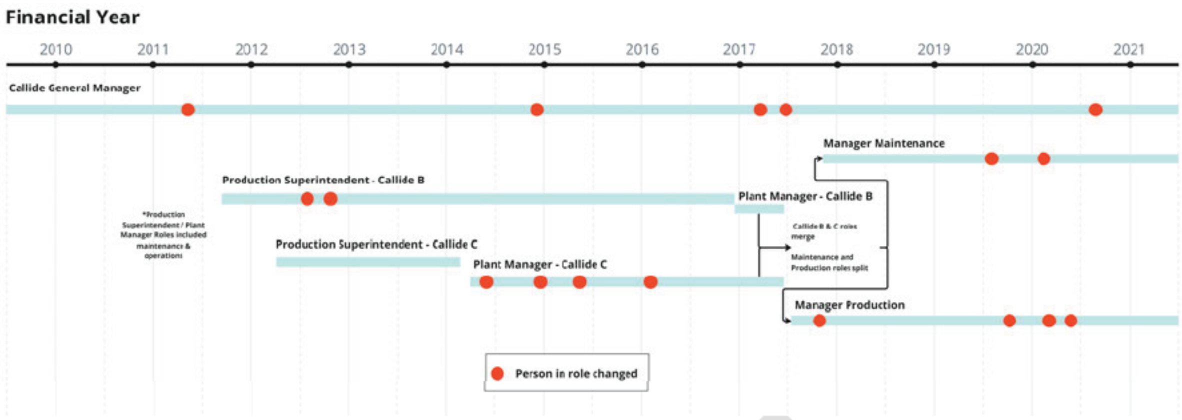


Figure 20 Site Management Turnover

Maintaining continuity of approach to process safety would have been difficult given these management changes.

15.7 Initiatives

In the years leading up to the incident, there had been a range of initiatives launched within CS Energy that impacted the Callide operations. The changing management team at Callide would have had to balance the multiple cost pressures within the organisation based on the multiple initiatives discussed below. [106]

15.7.2 PIP, Project Drive and the Transition to the Asset Owner/Operator Module

After the 2017 Callide Unit C4 Overhaul, Partners in Performance (colloquially known as PIP) were engaged to undertake an independent post project completion report.[107] That report's findings, which were presented to CS Energy's board in January 2018, included a '*significant shortfall in the expected overhaul. Issues were identified with inconsistent safety performance, Permit to Work breaches, and poor project planning and management*'.[108]

In the third quarter of 2017, PIP was in addition carrying out a review of operations at Callide.[109] This operations review involved significant changes to how work was done at site and staff coaching.

[106] In addition, in 2020, Biloela was selected as the case study for the Queensland Government's Just Transition initiative, supporting workers and communities through the transition of the energy sector. Full Pack Culture and Remuneration Committee 18 February 2021 at 53, CSE.001.023.8686.

[107] CS Energy Callide C4 Overhaul Close-Out Review, December 2017, CSE.001.082.3672.

[108] Board Paper, 29 January 2018, Callide C4 Overhaul - Post Completion Review CSE.001.082.3537 and Power Point presentation 'CS Energy Callide C4 Overhaul Close Out Review', December 2017, CSE.001.082.3672.

[109] Board Paper, 28 August 2017, CEO Report CSE.001.082.2504 and Board paper, CEO Report, 29 September 2017, CSE.001.082.2635.

15.7.3 Project Drive

The operations review informed, and in part led to, *Project Drive*, which was the project to separate 'plant operations' from 'asset management'. This reorganisation was formulated in late 2017 and implemented in the first half of 2018.[110]

Under this model, the site retained the role of operator and maintainer. A new Brisbane asset management team was the asset owner, taking responsibility for asset management and capital delivery functions. This asset owner team were also responsible for asset management plans and equipment strategies, as well as the planning, scoping, and delivery of major projects, outages, and overhauls.[111]

The new model was forecast to lead to savings in operating costs at Callide over the longer term, including reductions in overtime, contract labour, workforce planning, and joint venture recovery.[112]

The operations review also led to changes to workflows and processes used at site, including the introduction of a 'war room' with large visual boards.[113]

15.7.4 Accelerate Program and Project Wham

Following the restructure, the EGM Asset Management directed the new asset management team to the key issues affecting plant availability. This initiative was initially called the *Accelerate Program*. This program was '*aimed at focusing staff on a goal for improving asset performance and is supported by key improvement projects, plant area 'kaizens',*[114] *and regular communication*'.[115]

A subset of the *Accelerate Program* was *Project Wham* ('whacking the moles that are slowing us down'). This initiative was introduced in July 2018 to the Plant Performance Committee.[116] Twelve projects were initially identified as part of *Project Wham*, including Alarm Management Optimisation, Management of Change, and Process Safety (discussed above).

15.7.5 Inventory Management Review and Project

An inventory management review was performed in September 2018 by PwC.[117] This review led to the Inventory Improvement Project, which was completed in 2020.[118]

---

[110] See: [redacted] and [redacted] Asset Management and Plant Operations, 23 March 2018, CSE.001.082.4862; Board Paper, CEO Report, 23 February 2018, CSE.001.082.4765; Callide Performance Improvement Programme, Close out document, 27 July 2018, CSE.001.081.7111.

[111] DRIVE Consultation Phase 1, 15 November 2017, CSE.001.086.6280.

[112] Audit and Risk Committee Updated Five Year Forecast FY19-FY23, 9 April 2018, CSE.001.081.9804.

[113] Callide Performance Improvement Program Close Out Document, 27 July 2018, CSE.001.081.7111.

[114] A kaizen is a Japanese term for continuous improvement. It was even formally adopted as a management methodology by CSE in 2018. See meeting of the Innovation and Sustainability Committee, 28 September 2018, CSE.001.023.7215.

[115] Board Paper, CEO Report, 7 April 2018 at p2, 30 July 2018, CSE.001.082.3993.

[116] Reliability and Plant Performance Committee, 26 July 2018, CSE.001.081.7058 and WHAM Process, [redacted] and [redacted], 26 July 2018, CSE.001.081.7059.

[117] PwC, CS Energy Assurance Report Inventory Management Review Final Report, September 2018, CSE.001.081.1902.

[118] Final Report - Inventory Management Verification Review August 2020 CSE.001.081.1890.

In a presentation on this project given to the Audit Risk Committee in March 2019,[119] it was observed that past inventory projects had limited success. This project was designed to establish a robust inventory management process and system. An executive steering committee was established to oversee the project, consisting of four EGMs and two site GMs, as well as a working group. Four external and two internal resources were assigned to absorb the workload.

15.7.6 Project Adams

In late 2020, the business identified that falling market energy prices would, within a two-year horizon, challenge the economic viability of CS Energy's power stations, including Callide.[120]

In response, *Project Adams* was presented by management to CS Energy's board on 25 February 2021.[121] The project objective was to change the power stations from fixed to flexible power generators, with the ability to be able to support different running profiles depending on demand. A key objective of the project was to reduce the costs of production at Callide from $52/MWh to $42/MWh by a target date of 30 June 2022.

One way identified to achieve this objective was to move from a high and fixed costs base to a low variable one. This would be achieved by having a more flexible workforce, and by adopting different running profiles for the plant. In the first half of 2021, this initiative involved:[122]

(a) Rationalising capital investment.

(b) Improving planning and reducing inventory and spares holdings.

(c) Streamlining and simplifying services.

(d) Minimising contracted services.

15.7.7 Safety Programs

In addition to the initiatives above, there were long term safety programs operating at site.

In 2014, CS Energy embarked on a cultural change program that aimed to build a high performance, constructive culture. This program followed a 12-month long investigation by DuPont into CS Energy's incident investigation capability.[123] In December 2014 CS Energy adopted the DuPont Felt Leadership Strategy and a Safety Reset exercise.[124]

In May 2017, CS Energy launched a Cultural Improvement Program (CODE) 'to shift our workforce to a more constructive culture'.[125] And in 2018 a new Health and Safety Handbook and a Mobile App to capture hazards, safety interactions, and inspections was launched. A specific CODE Resilience program was launched in 2020 to support staff with tools and online training to support their personal mental health and wellbeing.

[119] Inventory Improvement Project Audit Risk Committee, 29 March 2019, CSE.001.081.7870.

[120] [redacted] Asset Management 15 December Update, December 2020, CSE.001.058.5281. [121] Board Paper Business Transformation - Project Adams, 21 February 2021, CSE.001.023.5583. [122] Board Paper Business Transformation - Project Adams 28 May 2021, CSE.001.023.6024.

[123] CS Energy Incident Investigation Report Version 1.2, December 2015, CSE.001.081.4897. [124] CSE Annual Report 2014/15

[125] CSE Annual Report 2016/17

In 2020, senior leadership were also engaged in a series of Inclusive Leadership Workshops to support CS Energy's inclusion and diversity goals.[126]

15.8 Summary

Since its inception in 1998, CS Energy has been subject to many changes and pressures. It has had long loss-making periods, gone through multiple asset changes, and has had to adapt to external influences brought on by climate change and the changing electricity market.

The years from 2017 onwards were characterised by significant internal reforms and pressures. Shareholder mandates have pushed to extract more from aging assets, and multiple cost cutting initiatives have been undertaken. At Callide C, CS Energy’s JV partner went through administration. The Callide site went through multiple management changes at the same time as they had to juggle the roll-out of multiple initiatives in a very short time.

In this type of environment, it is arguably very difficult to foster a focus on process safety, especially when the metrics at a corporate and organisational level have no such focus. There were likely competing tensions between cost reduction and process safety, and while process safety was discussed in the organisation, it did not result in any meaningful improvement in how major accident risks were managed within operations.

[126] Inclusion and Diversity Operational Plan, Culture and Remuneration Committee, 28 August 2020, CSE.001.082.0807.

16 THE CRITICAL RISK PROGRAM

16.1 Introduction

This chapter sets out the Critical Risk Program developed by CS Energy. This included improving both process safety and personal safety (with respect to fatality risks). While the program got off to a promising start, its scope was minimised, and it became less effective.

16.2 Summary of Key Findings

The organisational findings relating to the Critical Risk Program are:

(a) By the time of the incident in 2021, process safety had been introduced as a concept within the business since 2016. It was launched as a formal process safety program (called the Critical Risk Program) in 2017.

(b) The Critical Risk Program, however, changed strategic approach in 2018 and ended the work needed to develop the appropriate foundation in risk competence related to the understanding of Major Accident Hazards risks, and the controls required to manage them.

(c) The process safety program was under resourced and starved of funding. There was effectively no process safety team from April 2019 to July 2020.

(d) In mid-2020 CS Energy shifted away from its initial detailed suite of bowties to a high level approach to bowties that would fail to provide CS Energy with detailed insight into the health of its controls.

(e) CS Energy also adopted at this time a single Process Safety Frequency Rate (PSFR) metric, a lag indicator that had the tendency to support a confident, but unfounded, view of the health of CS Energy process safety systems.

(f) Internal messaging to the board provided a false sense of confidence that its approach to process safety, whilst in need of improvement, could deliver effective process safety outcomes.

(g) Corporate and board don't have competency to assess the risk. In the absence of completed bowties across its sites, it was simply not possible for CS Energy to develop the necessary understanding and competency of process safety risks at a corporate and board level.

16.3 The Critical Risk Program

By the time of the incident in 2021, process safety had been introduced as a concept within the business since 2016. It was launched as a formal process safety program (called the Critical Risk

Program) in 2017. Multiple factors led to its introduction back in 2016,[127] including external pressure from Workplace Health and Safety Queensland,[128] as well as several process safety related incidents.[129]

In the first half of 2017, the Critical Risk Program, which comprised the management of both personal fatality risk and Major Accident Hazards (MAHs)[130], was developed and a pilot program began at CS Energy's Wivenhoe site.[131] This Critical Risk Program was formally documented in an Operations Review, which was presented to, and accepted by, the CS Energy board in June 2017.[132]

Two years later, in its 2018 Annual Report, CS Energy stated it had '*established a process safety management system that integrates process safety into our business-as-usual activities. Beginning in FY2019, CS Energy will monitor and measure our process safety performance in line with industry and international standards.*'[133] Similarly positive statements are also made regarding process safety in its 2019 and 2020 Annual Reports.[134]

Despite these statements, as well as a formal process safety management procedure being in place since September 2018,[135] process safety thinking had not been established at CS Energy, and no meaningful change had occurred with respect to how process safety risk was managed within operations.

16.4 Commencement and Pilot

16.4.1 Introduction

The Critical Risk Program was led by two teams: the Health and Safety, and the Governance, Risk and Compliance team.[136] Described as a key initiative, the program was endorsed by the CS Energy board

[127] The concept was introduced at a workshop held by CS Energy's Health and Safety, Governance and Risk teams in August 2016. See 'Building on Risk and Safety Maturity: The Process Safety Journey: Procurement Business Planning Day, PowerPoint Presentation, 31 August 2016, CSE.001.232.0071.

[128] WHSQ Audit Recommendations - 2016.XLS (CSE.001.088.1848).

[129] See for example, Significant Incident investigation C4 Boiler Low O2 Event, 5 April 2016, CSE.001.014.8766; Incident Report Chlorine Leak, 14 August 2016, CSE.001.088.3371; and refer to p9 of 'Building on Risk and Safety Maturity: The Process Safety Journey: Procurement Business Planning Day, PowerPoint Presentation, 31 August 2016, CSE.001.232.0071.

[130] Note, the term Major Accident Hazard or MAHs is also called by some a Major Accident Event or MAE.

[131] See for example, CSE Enterprise Strategy, 23 February 2017, CSE.001.082.3020; Technical Services Plan FY 2017/018 Performance Plan CSE.001.084.4373; CEO Report, Board Paper, 28 August 2017, CSE.001.082.2504, Audit and Risk Committee Paper, 23 March 2018, CSE.001.081.8716.

[132] Operations Review Board Paper, 26 June 2017 and Minutes of Board Meeting, 26 June 2017, CSE.001.082.2127 and Meeting of the Board of Directors, 26 June 2017, CSE.001.023.3921.

[133] 208 Annual Report.

[134] The 2019 the Annual Report states that '*CS Energy integrated process safety into our business-as-usual activities in FY2019, following the introduction of a process safety management system the year before.*' In 2020 the Annual Report states '*We also continued to embed process safety into our business, consolidating process safety risks with our broader health and safety risks and establishing a Process Safety Frequency Rate metric to effectively measure our performance.*'

[135] CS Energy Procedure, Process Safety Management CS-Risk-08, January 2019, CSE.001.113.0001.

[136] Based on background to program in Contact Energy's contract, 16 March 2017, CSE.001.019.0800.

in June 2017,[137] and was embedded in CS Energy's Technical Services Plan for 2017/2018 [138] and risk register.[139]

The program was delivered by an internal project manager, the Senior Governance Risk and Compliance Officer, who had joined CS Energy in 2016. The project manager was supported by external consulting resources.[140]

The project manager reported to a steering group made up of three senior executives within CS Energy. The program engaged with the wider organisation though several channels, including a project working group, site sponsors, site project leads, and expert leads.[141]

16.4.2 The Wivenhoe Pilot

The Critical Risk Program began with a pilot program at CS Energy's Wivenhoe site. Phase 1 of this pilot program focused on:

- awareness raising of critical risks within the teams,
- identifying critical risk scenarios for the Wivenhoe site,
- developing bowties, and
- conducting a gap analysis of the critical control elements.[142]

The pilot program at Wivenhoe occurred between March and August 2017.

For Wivenhoe, a total of 32 critical risks were identified (15 personal fatality risks and 17 major accident hazard (MAHs) risks). Bowties were completed for each of these. In addition, 13 high priority actions flowed from the pilot to improve controls on the site.[143]

At its conclusion, the pilot program was reported internally as '*very valuable, with some immediate actions being implemented.*'[144] The 'intangible benefits' of the pilot program, primarily the increased capability of CS Energy's people, was described in a subsequent report, see Figure 21.[145]

[137] Minutes of Board meeting 26 June 2017.

[138] Technical Services Performance Plan FY 2017/018 Performance Plan CSE.001.084.4373.

[139] Risk Register 18 July 2017, CSE001.081.9186. In the risk register, the risk identified was described as '*lack of, or ineffective, critical risk systems leading to a fatality*'. This risk does not encompass major accident risks, but instead is skewed toward personal fatality risk.

[140] Contact Energy's contract, dated 16 March 2017, CSE.001.019.0800.

[141] Presentation, Critical Risk Project, Steering Committee update, 9 October 2017, CSE.001.240.5246.

[142] Contact Energy Services Conditions – Executed, 15 June 2017, at 11, CSE.001.019.0800.

[143] Appendix 4 to Critical Risk Business Case October 2017, Findings of Wivenhoe Pilot, CSE.001.240.3514.

[144] Board Paper, CEO Report, 28 August 2017, CSE.001.082.2504.

[145] Appendix 4 to Critical Risk Business Case October 2017, Findings of Wivenhoe Pilot, CSE.001.240.3514.

Intangible benefits

The project has already significantly raised the level of Critical Risk understanding within CS Energy leadership and workforce. Our people can now more clearly articulate what are critical controls are for both Personal Fatality Risk and Major Accident Hazards. The additional benefit of the Critical Risk Programme methodology has been our people more detailed and expanded (ie understanding of the interlinkage and interplay of critical risk scenarios and controls) of our critical risks.

Figure 21 Extract from findings of Wivenhoe Pilot Project

The approach taken in the pilot played a key role in raising CS Energy's competency, presumably limited to Wivenhoe, in both the recognition and identification of hazards, as well as the controls required to manage them. This was a good first step for CS Energy, the focus now turned to undertaking the same steps at Kogan and Callide.

16.5 Transition from Pilot to the Full Program

After the successful pilot, by October 2017 CS Energy had developed a 47-page detailed business case for the complete Critical Risk Program.[146] This document detailed the intended approach, delivery options, governance structure, and costs to roll out the entire program.

The objectives of the Critical Risk Program, as set out in the business case, were consistent with the principles of process safety discussed in the previous chapter, namely, to develop:[147]

2. *A common understanding of our critical safety risks providing sufficient knowledge of our major hazards and fatality risks.*
2. *Controls and the quality of controls in place to manage critical risks are well understood.*
3. *That gaps in controls are identified and rectified to manage critical risks at an acceptable level.*
4. *Critical controls are monitored to ensure they are operating effectively.*
5. *The suitability of and compliance with our systems and processes is adequate to provide a reliable framework for the effective management of critical risks.*
6. *Critical Risk management becomes an integrated and embedded part of normal business and our performance discussed and reported at all levels (frontline to Board).*

The program was to be rolled out in three phases.

(a) **Phase 1**: This phase focused on identifying the MAHs (and personal fatality risks) relevant to each site, developing their bowties, and understanding the critical controls for each MAH (and personal safety risk). Because Wivenhoe had completed its bowties, the focus was on Kogan Creek and Callide completing their bowties. Kogan Creek planned to begin their bowties in November 2017, with Callide commencing in March 2018.[148] This approach is in line with good process safety thinking.

[146] Critical Risk Business Case, October 2017, CSE.001.240.3514.

[147] Ibid at 6-7.

[148] The business case recognised that two types of actions could emerge out of the bowties: specific actions that impact only one or two bowties and systemic actions that effect a number of bowties. An example of a systematic action arising out of the Wivenhoe pilot was the need to focus on maintenance management and management of change. (Ibid 19.)

(b) **Phase 2**: This phase focused on control improvements, with the critical controls being identified through Phase 1's bowtie process.

(c) **Phase 3**: This phase was to develop the framework for an effective critical risk program effective, through the development of the structures, systems, and people capability to support the program.

The bowtie development in Phase 1 was to follow a 5 step process, see Figure 22.

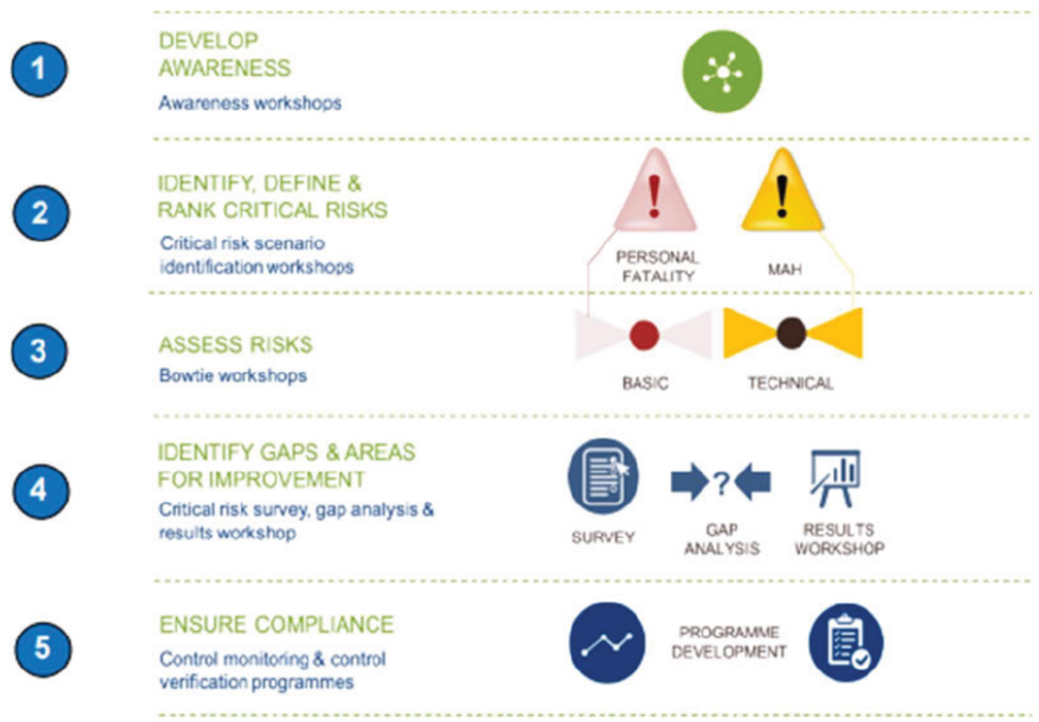


Figure 22 Extract Critical Risk identification

The process is consistent with good safety practice. The costs of completing Phase 1 - across all of CS Energy's sites - was estimated at just under $2 Million. However, this business case, with this specific scope, was not approved by the CEO, and before such approval did occur, the scope of the program would be changed significantly.

16.6 A Change of Owner and Direction

16.6.1 A New Owner

Across the first half of 2018, a change in organisational structure separated Asset Management from Operations, under a project named Project Drive, which is discussed further in section 15.7.3.

Responsibility for MAHs and the Critical Risk Program (as opposed to personal fatality risk) moved from Health and Safety to this newly formed Asset Management team.[149] In addition, the steering group members were replaced, which likely created a continuity issue.[150]

16.6.2 Resourcing

The role of Process Safety Manager[151] was created in this new division, and the project manager that had led the Critical Risk Program for the previous year, the Senior Governance Risk and Compliance Officer, was appointed to the new role.[152]

There was one other dedicated process safety resource, a process safety specialist, appointed to complete the roll out of the Critical Risk Program. They had been appointed under a 6-month contract in late 2017.[153]

16.6.3 A New Strategy

A new strategy for the Critical Risk Program was developed, with the approach to delivering the Critical Risk Program changed from that of October 2017. This new strategy, as presented to the Audit and Risk Committee in March of 2018,[154] focused on two areas:

(a) Control improvement on the top 3 systemic priority elements.[155] These elements had emerged out of the preceding bowtie work and included management of change.[156]

(b) Piloting three process safety systems[157] – incident reporting for critical risks, dashboard reporting, and the critical risk framework.

Excluded from the scope was other control improvements that had been identified by the work to date. But, critically, the new strategy removed the remaining bowtie work from the scope. Figure 23 below is how this new strategy was presented.

[149] See Presentation, Critical Risk Program – Working Group Phase 2 Workshop, February 2018 CSE.001.240.6714, Minutes of Meeting, Steering Committee 22 February 2018, CSE.001.241.4838 and Audit and Risk Committee Paper: Governance Risk and Compliance Report, 23 March 2018, CSE.001.081.8716.

[150] Email, 8 February 2018, CSE.001.240.9122.

[151] PSEC Committee paper, Process Safety Project Update, 29 June 2018, CSE.001.081.6154.

[152] It appears the appointment was on an acting basis only, based on the signature block.

[153] Signed letter of offer, 21 December 2017, CSE.001.241.2047.

[154] Audit and Risk Committee Paper: Governance Risk and Compliance Report, 23 March 2018, CSE.001.081.8716.

[155] These were identified as Management of Change, Operational Procedures and Staff Competency (system to measure). See Presentation – Critical Risk project – Working Group Phase 2 Workshop for Ops, 28 February 2018, p16, CSE.001.241.8221.

[156] Presentation – Critical Risk project – Working Group Phase 2 Workshop for Ops, 28 February 2018, p16, CSE.001.241.8221 and see for eg the discussion of the outcomes of the Wivenhoe pilot at p44 of the Critical Risk Business Case, October 2017, CSE.001.240.3514 and see p8 Critical Risk Process Safety CDC Funding March 2018, CSE.001.234.0041. There is evidence that work was done in connection with this management of change program, including a reference to the plant modification procedure being updated in the handover notes of the process safety specialist, May 2019 CSE.001.234.0428. .

[157] Audit and Risk Committee Paper: Governance Risk and Compliance Report, 23 March 2018, CSE.001.081.8716.

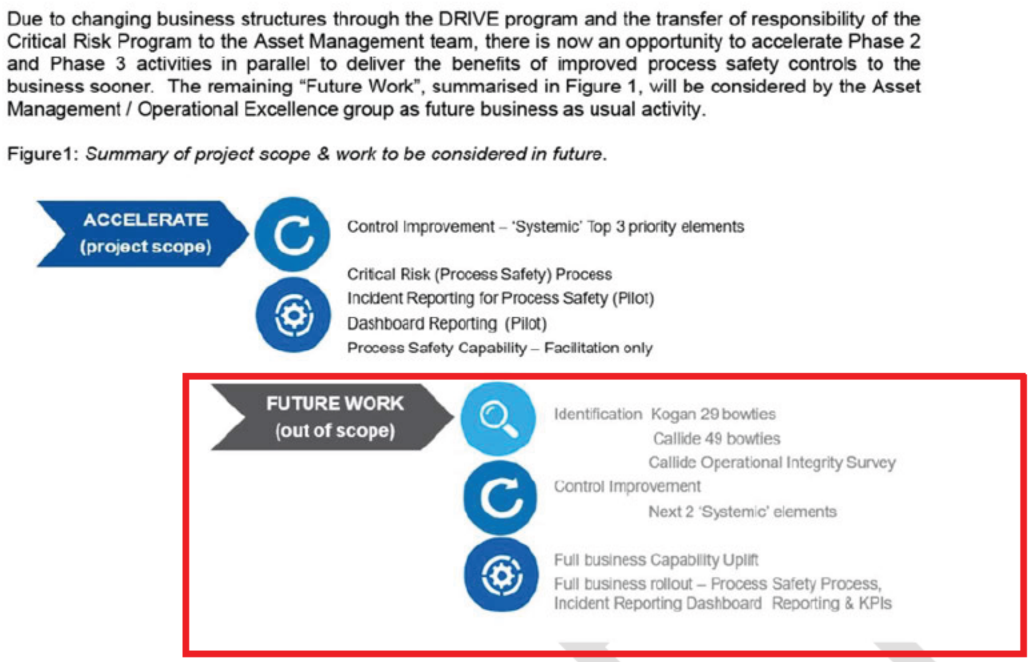

Due to changing business structures through the DRIVE program and the transfer of responsibility of the Critical Risk Program to the Asset Management team, there is now an opportunity to accelerate Phase 2 and Phase 3 activities in parallel to deliver the benefits of improved process safety controls to the business sooner. The remaining "Future Work", summarised in Figure 1, will be considered by the Asset Management / Operational Excellence group as future business as usual activity.

Figure1: *Summary of project scope & work to be considered in future.*

Figure 23 Extract ARC Committee paper, Governance Risk and Compliance Report 23 March 2018

This amended business case was approved by the CEO in April 2018.[158] Whilst a presentation from this time to the CEO included notes that state that the program's delivery had now been '*honed to deliver the key foundational pieces for process safety to transition to business as usual*',[159] this is an incorrect statement. While there was a move towards implementation and establishment, this was doing so without developing the appropriate foundation in risk competence related to the understanding of MAH risks, and the controls required to manage them.

16.7 Callide Bowtie Development Status

16.7.1 Introduction

When the new strategy emerged, the status of the first tranche of bowtie was:

(a) Wivenhoe bowties were completed during the pilot program.

(b) Kogan Creek had completed its first tranche of bowties, reviewed its process safety controls, and developed a plan to prioritise control improvements.

(c) Callide was yet to commence work on its first tranche of bowtie development.

Callide was scheduled to begin its first tranche of bowtie work in April 2018 and complete it by 21 May 2018.[160] It was planned that the first tranche would consist of 6 personal injury and 27 MAH bowties.

[158] Email [redacted] to [redacted], 26 April 2018, CSE.001.243.5645. There is evidence the business case was initially knocked back by the CEO in April 2018. Email [redacted] to [redacted] 10 April 2018, CSE.001.241.4425.

[159] Notes to PowerPoint presentation – Critical Risk Presentation – [redacted], 4 April 2018, CSE.001.245.7708.

[160] Critical Risk Business Case, October 2017, CSE.001.240.3514.

But the roll out of Project Drive (the organisational restructure discussed further in Section 15.7.3) was proving a demanding workload at site, and the Callide Site Manger negotiated and had agreed a revised program for this first tranche phase with the Group Manager Governance, Risk & Compliance. The revised program would reduce the number of bowties prepared down to 5-8 bowties, which would be delivered in a similar time period. The request was also made to focus on personal injury risks over process safety.[161]

16.7.2 Bowties Completed at Callide?

The evidence suggests that of 38 bowties planned for Callide, two are crossed out, and 15 are recorded as done. This information comes from a master bowtie list titled 'Post Stage 1 Completion May 2018.'[162]

The MAH's for the completed bowties are:

Human Factors - Loss of Control.

ST - Generator/H2 system - Hydrogen – LOC.

Electrical Systems - HV Tx tower - Structural failure.

ST - Generator - Rotating Parts - Overspeed – LOC.

Control & Instrumentation - Fire Protection/Detect/Suppress Systems – failure.

Conveying, Storage, Pulverising, Drying and PF Transport Systems - Blockage, LOC.

Boiler - Stack, FG Ducting - Structural Failure.

Boiler - Firing Systems – LOC.

Boiler - Firing Systems – Unburnt Fuel.

Civil Engineering - Cooling Towers/Air Cooled Condensers – Collapse.

Cooling water system, Chemicals - Chlorine – LOC.

Boiler Dosing System, Chemicals - Ammonia – LOC.

Waste Containment Facility - Ash – LOC.

Chemicals - Sulfuric Acid – LOC.

Chemicals - Caustic Soda – LOC.

The MAH's for bowties which were not done were:

BOP - Backup electrical systems (site or DC) – Failure.

---

[161] Emails between General Manager Callide Power Station and Group Manager Governance, Risk & Compliance, 22 January 2018, CSE.001.242.4481. In this email exchange the request was stated to be made to accommodate the 'workload associated with DRIVE implementation 1st half of 2018'.

[162] CS Energy Master Bowtie list_rev 8, Callide MAH Bowtie list – Post Stage 1 Completion May 2018, CSE.001.234.0117. In relation to Kogan, CS Energy Master Bowtie list_rev 12, Kogan MAH Bowtie list – Post Stage 1 Completion February 2018, lists 45 potential bowties, marking 15 as complete.

BOP - Compressed Air System - air – LOC.

BOP - Rotating Equipment Mechanical.

Dropped objects (damage to plant) – LOC.

Electrical Systems - AC Electrical and Battery Systems - Transformer, IPB, Cable Systems, Switchgear, Reactors, Earth System - Electrical Fault.

Electrical Systems - DC Systems DC.

Electrical Systems - Oil Filled HV Transformers - Oil – LOC.

Natural hazards.

Road Traffic Accident - Loss of control leading to accident and loss of containment.

BOP - Raw Water Pond - Water - LOC B.

ST - Generator - Protection Systems - Loss of Protection Systems - Major electrical fault.

ST - Generator - Mechanical/Electrical Failure.

BOP - Storage - Hydrogen - LOC H.

Civil Engineering - ST Generator, Cooling Towers/Air Cooled Condensers, Boiler, Coal Bunkers - Supporting Structures & Foundations – Failure.

Collection, Conveying, Storage and Disposal of Wet and Dry Ash Systems – LOC.

BOP - Aux Boiler inc. tubes, headers - Gas, HP steam – LOC.

ST – Generator - Lube/Hydraulic Oil Systems – LOC.

Feed System - Feedwater/condensate systems - Hot water, steam – LOC.

Boiler - Boiler Tubes and Headers and drums - steam/hot water – LOC.

BOP - Auxiliary Systems – LOC.

BOP - Chemicals including storage (excluding fuels)- LOC.

Amongst the incomplete bowties, the MAHs included elements of the electrical systems and auxiliary systems involved in the incident.

16.7.3 Summary

The completion of bowties at Callide were reduced by both the change in strategy to the Critical Risk Program and the push back form the Callide site management to do this work when planned. As a consequence, Callide based staff did not get as much opportunity to build risk competency through the bowtie development process.

16.8 Actual Deliverables

The revised approach to process safety also refocused the process safety team's work towards the systems paperwork. Across 2018, the two-member process safety team delivered against this new plan. They delivered the:

- process safety procedure,
- a pilot dashboard,
- pilot process safety incident report,

- a process safety awareness e-module for all staff,[163] and
- a process safety campaign was rolled out.[164]

Around this time, the program of work begins to be called the Process Safety Program.[165]

Despite the bowtie work never being competed, a December 2018 Executive Briefing Paper delivered to CS Energy's executive and management team, prior to the launch of the roll out of the process safety campaign to all staff in January 2019, effectively says that the Critical Risk Program had delivered the bowties and control improvements phases for the process safety program.[166] This paper was delivered across CS Energy's executive and management team, prior to the launch of the roll out of the process safety campaign to all staff in January 2019, see Figure 24.

In 2017/18, the Critical Risk Program was one of CS Energy's 'Big 4' Business Change Initiatives. The Critical Risk Program had two phases:

- **Phase 1 – Identification** – We conducted facilitated sessions with multi-disciplinary teams to identify and assess our critical risks using the Bowtie Methodology and analyse the critical controls required to manage these risks.
- **Phase 2 – Control improvement and action management** – We prioritised and categorised control improvement actions identified in Phase 1.

Figure 24 Extract Executive Briefing Paper

16.9 Funding Challenges

16.9.1 Funding

By the end of 2018 and into 2019, forward budgeting for the process safety staff became uncertain,[167] especially as the cost of the program was being shifted from strategic funding to operational budgets.

To continue to deliver process safety, on 2 January 2019, the Process Safety Manager sought confirmation from the Head of Business Improvement that the forward budget would be for a team of three people.[168]

This was followed on 18 January 2019 by the Process Safety Manager writing a formal memo to EGM Asset management (acting) seeking appropriate resourcing to continue with the process safety program within CS Energy.[169] The original business case had recommended using external support to

---

[163] Details from Funding Variation approval request from November 2018, CSE.001.247.0581 and PSEC – Process Safety Project Update power point, CSE.001.246.4107.

[164] The communication plan was developed in August 2018 and the launch of the process safety campaign was in early 2019. See Communication Plan, August 2018, CSE.001.247.5163. The campaign was titled 'PS Always on my mind', see eg PowerPoint presentation, Process Safety Town Hal, Callide January 2019 CSE.001.247.3910.

[165] This term is used in the August 2018 Communication Plan, CSE.001.247.5163. The Critical Risk Program is described in this document as one of the 2017/18 Big 4 Business Change Initiatives.

[166] Executive Briefing Paper, Process Safety 3 December 2018 CSE.001.248.1853 and as evidence of its presentation to management see various emails arranging this presentation CSE.001.247.0876, CSE.001.246.4258, CSE.001.246.3229, CSE.001.247.2316.

[167] Email Process Safety Manager (acting) to Head of Business Improvement and EGM Asset Management, 2 January 2019, CSE.001.247.3582.

[168] Planning referenced in email [redacted] to [redacted] 2 January 2019, CSE.001.247.3582.

[169] Memo Process Safety manager to EGM Asset Management, 18 January 2019, CSE.001.248.2129.

complete phase 1 and envisaged the ongoing need for two process safety staff to get to the end of Phases 2 and 3.[170] In this memo, the Process Safety Manager sets out the risk of not having approved funding for the existing two process safety staff, plus strategic funding for a third person for 12 months. Without funding, the process safety manager would be returning to the team they had been seconded from, and the assistant's contract would end, see Figure 25.

> **KEY RISKS**
>
> In the event that the recommended future resourcing of Process Safety at CS Energy does not proceed, the Process Safety team would be dissolved. At 1 July 2019, this would result in the:
>
> - seconded FTE (Process Safety Manager) returning to a substantive position in the Risk and Compliance team, and
> - the second (contracted Process Safety Specialist) FTE equivalent would leave the business at 30 June 2019.
>
> The Process Safety team's knowledge, drive and commitment have them positioned as highly respected experts in this priority work. They engage 'hearts and minds' of our people across our sites in their personal commitment to Process Safety and enhancing our overall capability.
>
> Our people across our sites now consider that Process Safety is what we do. The loss of CS Energy's support for dedicated resources to this function is likely to threaten the sustainability of the benefits achieved as well as having a negative cultural impact.

Figure 25 Risks of not doing as outlined

Key points this memo is trying to make include that:

- the business has made a substantive financial investment in the process safety initiative.
- the work postponed by the March 2018 strategy still needed resources to deliver it.
- there was no funding currently allocated for process safety resources post 30 June 2019.

The resourcing request was approved by the Acting EGM Asset Management around 22 January 2019,[171] but was however closely followed on 1 February 2019 by the EGM Asset management launching a significant budget review across the entire Asset Management division.[172]

Some evidence suggests that approval going forward was only given for two staff, and there was no further budget allocation for the process safety program.[173]

[170] Critical Risk Business Case, October 2017 at 29, CSE.001.240.3514.

[171] Email Process Safety Manager to EGM Asset Manager attaching signed and endorsed memo for additional resourcing, 22 January 2019, CSE.001.247.5185.

[172] Email EGM Asset management to Asset Management Leadership Team, 1 February 2019, CSE.001.247.8827.

[173] Exit Survey of Process Safety Manager, dated 6 March 2019.

16.9.2 Process Safety Team Resign and Aren't Replaced

The Process Safety Manager resigned on 22 February 2019, with their last day being 8 March 2019.[174] The reasons cited included unmanageable workloads, and a lack of funding for process safety (notably by comparison to Health, Safety and Environment). They also go on to outline how process safety was *'drowned out by Titan, overhauls, SAP upgrade, etc'*.[175]

The contracted process safety specialist resigned a month later, on around 3 May 2019.[176]

Whilst the Asset Management team looked to backfill these roles, there was effectively no process safety team from April 2019 to July 2020. A new head of process safety was slated to begin in May 2019,[177] and there is evidence that the individual commenced in that role. However, the records also indicate that they were also acting as the of Head of Health and Safety (variously described as Acting or Part) from as early as October 2019.[178] There is no evidence of progress on process safety during this time.

Evidence then indicates that responsibility for process safety moved back into the Health and Safety team. A single process safety specialist is appointed in July 2020. This process safety specialist came from within CS Energy's asset management team, with prior roles as an asset management specialist and specialist risk advisor.

Figure 26 summarises the resourcing provided to the Critical Risk Program from 2017 to the time of the incident.

Figure 26 Timeline of process safety ownership and resourcing

In all, the Critical Risk Program had three different owners within CS Energy, never exceeded two dedicated staff, and for just shy of twelve months – between May 2019 and July 2020 - had no dedicated process safety specialist in role.

[174] Email Acting Process Safety Manager to EGM Asset Management, CSE.001.248.4283, CSE.001.248.4284. There is correspondence to suggest they initially resigned in December 201, CSE.001.247.0620.

[175] Acting Process Safety Manager's Exit Survey (Staff Exit Interview) and follow up meeting notes dated 6 March 2019.

[176] Based on date of handover report for process safety specialist, CSE.001.234.0428.

[177] See Powerpoint Presentation PS Next Steps, April 2019, CSE.001.250.0034.

[178] See e.g., Record of meeting Agenda CSE.001.083.4141 and Meeting of the Performance Committee, 29 November 2019, CSE.001.023.7490.

16.9.3 Loss of Funding

Based on the Process Safety Manager's handover notes from when they resigned in March 2019,[179] funding cuts were impacting the following components of the process safety work:

(a) process safety dashboard, reduced to '*meet the bucket of money available*'.

(b) Bowtie XP software, '*scope will need to be reduced*'.

(c) Completion of bowties and priority actions, '*only a portion of the entire portfolios [sic] bowties have been completed, of those completed a priority list of #16 actions were agreed. These are being tracked…*'

Extracts from those notes are presented in Figure 27 below.

PROCESS SAFETY DASHBOARD

The Process Safety Dashboard (Pilot) as approved under the Process Safety project was completed in October 2018.

TRIM LINK B/D/19/5696

The current piece of work known as PROCESS SAFETY DASHBOARD MVP2 includes developing the pillow dashboard further with 6 additional KPIs and incremental enhancements including safety critical equipment categorisation (Kogan data pilot) This was additional scope approved in November variation and has been reduced to meet bucket of money available".

BOWTIE XP

With the amendment to the dashboard scope and increased costs from Bowtie XP, this scope will need to be reduced.

Project cost to Capex 2302645

My latest estimate from the provider is $25k for HTML 5 Webviewer plus $6k for each additional Advanced users licence.

In principle, [redacted] would like the Webview only at this stage – no additional licences.

I have also discussed this reduction in scope with [redacted] and he is comfortable to just have the Webviewer.

BOWTIE SPECIFIC IMPROVEMENT ACTIONS

Only a portion of the entire portfolios bowties have been completed, of those completed a priority list of #16 actions were agreed. These are being tracked in various forums (8:30 meeting, Mon arvo AM meeting, CHSE)

Figure 27 Extracts from process safety manager's handover notes

The process safety specialist's handover notes make the same observations about the funding cuts to the project dashboard and bowtie XP software.[180] These observations also confirm the relationship between the bowtie process and process safety confidence reporting, the implication being that any

[179] Process Safety Manager Handover Notes, 8 March 2019, CSE.001.248.5449.

[180] Handover Notes of Process Safety Specialist, 3 May 2019, CSE.001.234.0428.

confidence rating given is inherently qualified by the limited bowties that have been completed, see Figure 28.

BOWTIE SPECIFIC IMPROVEMENT ACTIONS Only a portion of the entire portfolios (45 out of 84) bowties have been completed, of those completed a priority list of #16 actions were agreed. As discussed with [redacted] this list need to be updated and discussed during the Asset Management Weekly Toolbox meeting to ensure actions are tracked to closures. Reporting - these actions are also forming the basis of the calculation for Process Safety confidence interval (board risk committee meeting) [redacted] or [redacted] from the Risk & Compliance team will contact Process Safety team at each board reporting cycle. TRIM LINK B/D/18/10250	Focus and visibility to achieve completion. Follow up with action owners each month (or week if any of these actions are progressing that fast) and update the calculation as progress is made.

BOWTIES As part of the "Critical Risk" Stratex project some (not all) bowties for Process Safety were developed. This was a business decision at the time which has consequently caused some anxiety as we some people have (rightly) felt that we aren't addressing the true top issue w.r.t Process Safety. Bowtie Folders TRIM F/17/6671 As per the Process Safety Management	Pending resources, I would strongly support the re-establishment of the Plan on a page workshops and Bowtie workshops. We need to identify where capital needs to be spent to address process safety and get it into the "stack". It was still on my "to-do" list to see how the Process Safety jobs were "stacking" in the Capital Stack revised tool.

Figure 28 Extracts from process safety specialist handover notes, May 2019

16.10 The Return and Redesign of Process Safety in 2020

16.10.1 Introduction

In mid 2020, the process safety team is restaffed, and a new strategy is designed as part of the broader health and safety team's 5-year strategy.

A Process Safety Leadership Group is later established to help the process safety specialist engage with the business. This group met for the first time in April 2021.

In addition, two major changes emerge from this new strategy:

(a) A shift to using 6 company-wide MAHs for the basis of future bowtie work.

(b) The adoption of the Process Safety Frequency Rate (PSFR) as the process safety performance indicator.

These two changes fundamentally and negatively impact the way the process safety program would be managed going forward.

16.10.2 The 6 Major Hazard Bowties

Under the new strategy, there was no longer a focus on developing site specific bowties, and instead there was to be a focus on the development of 6 high level Major Accident Hazard (MAH) bowties.

For example, the MAH shifted from a site-specific risk loss of containment from a site's ash dam[181] to the risk of any civil structure failing.

There are obvious benefits to conducting such high-level bowties, namely the financial and time savings due to less risk content needing to be developed. However, this high-level approach is only useful when there is a very thorough set of process hazard assessments that underpin the high-level bowtie. There are fundamental dangers with creating such high-level process safety bowties without the detailed underpinning risk assessments.

Bowties are at their most value when they demonstrate the unique causal pathways of how the risk eventuates. This cannot be underestimated in its importance. If these causes are not understood, then it is unlikely that each causal pathway will be controlled effectively. Further it is also unlikely that the intricacies of the control performance requirements will be understood, which in turn affects implementation and verification work intended to ensure the control works effectively in all range of scenarios.

Because of this change, when the verification on the effectiveness of the controls is undertaken, the analysis shifts from site specific control performance measures in the context of a specific failure to fewer higher-level controls, with lack of clarity about those controls.

Not only had CS Energy shifted away from its initial detailed suite of bowties, but it had also shifted to a form of bowties that would fail to provide CS Energy with detailed insight into the health of its controls.

As highlighted in Section 14.3, this can result in a loss of the fundamental knowledge for a well-designed and effective process safety management system.

16.10.3 Reporting Against PSFR

The other significant change was the adoption of a metric to report on process safety performance selected in 2020, called the PSFR (Process Safety Frequency Rate). It was calculated as the number of process safety incidents reported against operating hours.[182]

The issues with the adoption and reliance on this single PSFR metric in 2020 include:

- It is a lag indicator, only reporting on events after they have already happened. It also provides no information on whether or not the controls to manage process safety are working effectively.
- The metric is dependent on the underlying quality of incident reporting and the reporting system itself. This in turn is heavily dependent upon the risk competence, or risk imagination, of leaders to be able to link the event's circumstances to a potential consequence, which (most of the time) did not eventuate. Risk imagination is even more difficult to achieve for leaders who have no bowties as a frame of reference for what 'could happen'.
- A KPI was established for this metric of not greater than 3. As a result, internal discussion of process safety becomes focused on whether the KPI is being achieved and why it may be trending up or down. As an example, minutes form the Process Safety Leadership Forum in April 2021

[181] 'Loss of containment of Fuel, Loss of control of Boiler Firing'.

[182] Prior to this metric, a range of lead and lag indicators were being measured and communicated, and in 2018 a process safety dashboard had been built and piloted.[182] There is no evidence that this dashboard progressed beyond the pilot phase.

record '*Process safety frequency is trending up. This is due to reduction in plant operating hours and an increased number of reported PS related incidents compared to the same period last year.*'[183] The KPI became the goal as opposed to the effectiveness of the process safety program.

This metric on its own has the tendency to support a confident, but unfounded, view of the health of CS Energy process safety systems. This metric uses the absence of events, rather than a measure of the presence of effective process safety systems.

16.11 CS Energy's Self-Assessment in Progress in Process Safety

In April of 2021, the Health and Safety Team, as part of its presentation for the process Safety Leadership Group, included its assessment of the organisation's process safety maturity. This was presented to the senior leadership group in April 2021, see Figure 29.[184]

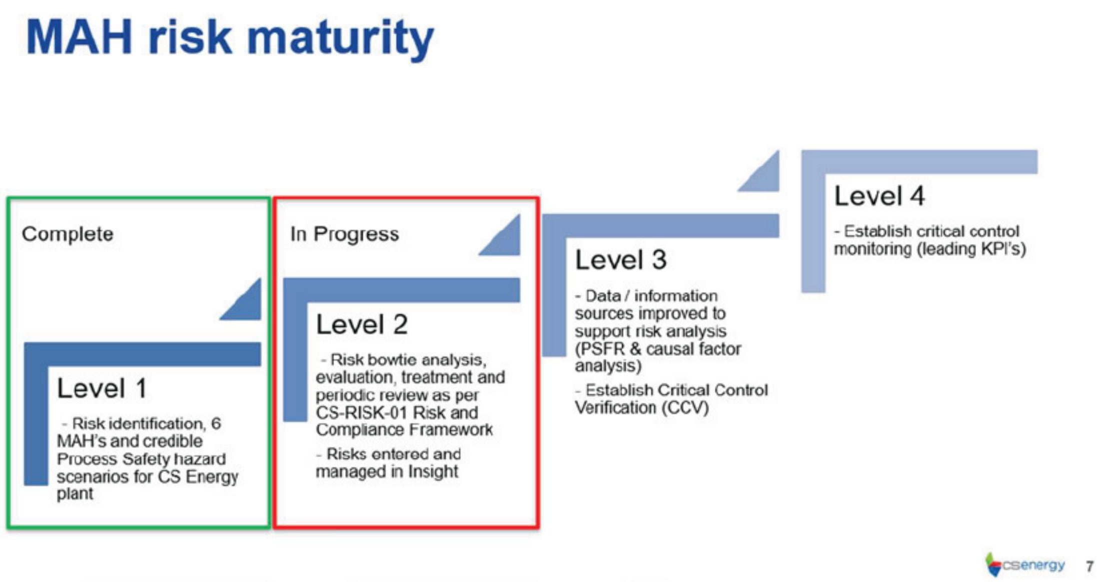


Figure 29 CS Energy MAH risk maturity

The self-assessment shows that after 4 years of 'focus' on process safety, very little had been achieved. CS Energy had only just completed its first step, risk identification of its 6 new MAHs, and it was yet to complete the bowties for them.[185]

16.12 Internal and External Messaging on Process Safety

16.12.1 Annual Reports & External Parties

Process Safety had been reported on in its annual reports since 2018. These reports say:

---

[183] Minutes of Meeting, Process safety Leadership Forum, 13 April 2021, CSE.001.003.2656.

[184] PowerPoint, Process Safety Leadership Workshop, 12 April 2021, CSE.001.003.2676.

[185] Progress reported at the Process Safety Leader Workshop in April was that progress was slow, two bowties were active, five were in drafting, and one was planned. PowerPoint, Process Safety Leadership Workshop, 12 April 2021, CSE.001.003.2676.

- 2017 Annual Report – 'we continue to invest prudently in the safety of our people, with major program being undertaken in 2017/18 for the behavioural and process safety'.
- 2018 Annual Report – 'integrated process safety into our business as usual activities'.
- 2019 Annual Report – 'CS Energy integrated process safety into business as usual activities in FY2019, following the introduction of a process safety management system the year before.'
- 2020 Annual Report – 'We also continue to embed process safety into our business consolidating process safety risks with our broader health and safety risks and establishing a Process Safety Frequency Rate metric to effectively measure our performance.'

In February 2019, CS Energy also advised its insurers, as captured in an Engineering Survey Report prepared for the insurer, that 'CS Energy also indicated that over the next couple of years they will continue to undertake a significant amount of work in developing Process Safety protocols across their power station operations. The objective of the Process Safety program is to ensure that there is significant clarity in the identification of the potential major accident hazards across each site, and also the confirmation and validation of controls that are in place to manage the potential associated risks'.[186]

16.12.2 Messaging to the Board

In the year prior to the incident, process safety was specifically reported to the board within the quarterly Health, Safety end Environment Report. Those reports dedicate 3 – 4 paragraphs, updating the board on resourcing, the 6 new MAHs and their bowties, the PSFR and significant incident investigations.[187] No concerns were raised in these reports.

The most in depth presentation at board level involving process safety was in a presentation to CS Energy's board in July 2020, when the management team reviewed CS Energy's systems against the coroner's finding regarding Dreamworld after its 2016 fatal incident.[188] The process safety system is called out as an area for improvement, see Figure 30.

[186] Operational ISR Engineering Survey Report, AIG Global Property, February 2019 [reference required].

[187] Refer Health, Safet and Environment Report papers, 24 April 2020, CSE.001.082.1380, 31 July 2020, CSE.001.082.1467, 30 October 2020, CSE.001.082.1480, 29 January 2021, CSE.001.082.1473 and 28 April 2021, CSE.001.082.1570.

[188] Board Paper, Dreamworld Learnings, 31 July 2020, CSE.001.082.8324.

Dreamworld Finding	**Failure to effectively manage process safety**
CSE Controls	• Process safety awareness training has been completed. • Process safety framework developed but not yet fully implemented. • Principal Process Safety Specialist currently being recruited.
Action in Progress	**Process safety improvement program is being prioritised, including completion of the remainder of bowtie risk workshops on Major Accident Hazards and subsequent assurance activities on critical controls.**
Accountable Area	Health & Safety
Accountable EGM	[redacted]

Figure 30 CS Energy presentation on Dreamworld finding

Against the overarching confident observation that '*CSE has a comprehensive and well-documented safety management system in place which is monitored regularly*',[189] the only existing controls referred to in relation to process safety are described as completion of awareness training, a framework which had been developed, but not yet implemented, and the appointment of a process safety specialist.

Both of these assessments reflect knowledge that CS Energy's process safety goals had not been achieved, but provided a false sense of confidence that its approach to process safety, whilst in need of improvement, could deliver effective process safety outcomes.

16.13 Conclusion

After a promising start CS Energy never achieved its original process safety goals. When the decision was made to cease the development of the site-specific bowtie risk assessments, it was unlikely to achieve them.

From 2019 onwards, process safety was under resourced, and the critical foundational work needed to establish process safety was never delivered.

From its beginnings where the program was highly visible and supported by leadership as a priority program, by the time of the incident process safety had become just one part of a much larger health and safety team with limited resources and engagement from senior leadership.

The implications of the change in approach to process safety do not appear to have been identified or critically examined. The introduction of the PSFR as the key indicator of process safety and the change in bowtie methodology further weakened CS Energy's process safety efforts, whilst providing a false sense of confidence in the system. The process safety program had minimal impact on process safety risk at Callide.

[189] Ibid.

17 ASSURANCE: THE HEALTH OF CS ENERGY'S SYSTEMS

17.1 Introduction

Part of CS Energy's approach to process safety includes a governance and assurance requirement that independently checks processes and procedures against good industry standards.[190] This Chapter explores some of the findings from these independent checks, primarily for the purpose of ascertaining the health of key process safety systems.

The following sections examine four assurance reviews that were conducted in the years leading up to the incident. These systems are plant modifications, maintenance work, learning from incidents and permit to work.

17.2 Summary of Key Findings

The organisational findings relating to Assurance are:

(a) In the years leading up the incident, CS Energy's assurance program had identified systemic issues with multiple systems, including plant modifications.

(b) The actions that were taken in response to the issues raised by the assurance reviews were predominantly focused on addressing the symptoms and not their root cause.

(c) It was assumed that the actions taken in response to these audits would manage those systemic risks to acceptable levels, despite in some cases these issues reoccurring across multiple audits.

17.3 Independent Assurance Program

Independent Assurance is established under CS Energy's Enterprise Risk and Compliance Management Framework.[191] Its purpose is to provide the CEO, the Executive Leadership Team, and the Board with assurance that the company's internal processes are operating in an efficient, effective, and ethical manner.[192]

It does this via an independent team, which, either with its own resources or using external parties, undertakes reviews of parts of the business. The team's findings are reported to the Audit and Risk Committee. In response to their findings – as part of the review process – a set of actions is agreed with CS Energy's management. The assurance team then, at some point in the future, conducts audits to verify whether these are completed.[193]

[190] Refer to Section 6.2.8 of Process Safety Management CS-Risk-08 01/19.

[191] CS Energy Standard, Enterprise Risk and Compliance Management Framework, CS-Risk-01 CSE.001.049.0094.

[192] Assurance CS-AUD-01 CSE.001.081.1386.

[193] The procedure governing the work of the Assurance team is CS Energy Procedure Assurance CS-AUD-1, CSE.001.081.1386.

17.4 Plant Modification Reviews

17.4.1 The 2016 Review

A Plant Modification Review was carried out in 2016. Its objective was to determine whether or not CS Energy employs a '*consistent and controlled approach to the management of plant modifications*'.[194]

The key findings from the 2016 review identified:

(a) Shortcomings still existed in document control, routine monitoring of registers, and training. These shortcomings had been previously identified in a 2011/12 audit.

(b) Although the basic elements of the corporate procedure have been implemented at Kogan Creek and Callide Power Stations, the systems were not fully compliant with that corporate procedure.

(c) There were 2,202 open modification proposals (across Callide, Kogan Creek, and Wivenhoe) in SAP. The review identified that these open modification proposals were of potentially unknown priority, and that they may be masking potential high-risk issues across Callide, Kogan and Wivenhoe. The management action in response to this finding was a review of the modification backlog and register, and an external resource was engaged to assist. This action was due to be completed by 1 August 2016.[195]

(d) There was uncertainty about the nature of the risk being assessed with respect to '*any new risks being introduced as a result of the proposed modification*'.[196] It was recommended to Callide that it should confirm that the risk assessment should consider such risks and that there be awareness training. The management response was to review the Plant Modification procedure (CS-AMS-010) to remove the uncertainty with regard to risk assessment.[197]

(e) Knowledge of the process was not well understood. The management response was to review the modification system training package and complete training at site.

The actions from the 2016 audit were checked by the assurance team in March 2017. Six actions were verified as completed, including updating the plant modification procedure. Four actions were partially verified. The new plant modification training had not yet been delivered to operators at Callide, and Callide was still working through their modification backlog.[198] In a spreadsheet used by the verification team, the notes on this specific action say '*nothing has fundamentally changed (yet) at*

[194] Plant Modifications Review – 2016.03, 24 February 2016, CSE.001.081.5540. Note, the review's scope explicitly exclude whether plant modifications are safe and free from defects, or if risk assessments were completed and reasonable.

[195] When this action was checked the following year, 2017, the action was only partially verified and it was noted that Callide was '*still working though their mods and prioritising them*'. The due date for the action was extended to 20 June 2017. Audit Actions Implementation Progress Report – Plant Modifications, 21 March 2017, CSE.001.081.5556.

[196] Plant Modifications Review – 2016.03, 24 February 2016, at 11, CSE.001.081.5540.

[197] When checked the following year, it was confirmed that the procedure had been updated. The action to provide modifications systems training was yet to be performed for operators. Engineers and maintenance had received training. Audit Actions Implementation Progress Report – Plant Modifications, 21 March 2017, CSE.001.081.5556.

[198] Audit Actions Implementation Progress Report – Plant Modifications, 21 March 2017, CSE.001.081.5556.

Kogan and Callide. Callide is still working through prioritising and them cutting mod notifications and hopes to be complete by end of June 2017'.[199]

There is no evidence the assurance team revisited this action until the next review in 2020.

17.4.2 The 2020 Review

The next Plant Modification Review occurred in late 2020 and was completed in January 2021. The review recognised that '*Management of Change is a critical and essential element of a robust and comprehensive risk based asset management and safety management system*'.[200]

The scope of the review examined:

(a) Whether CS Energy's processes were aligned to current industry best practice.

(b) If plant modifications followed the modification process, including in the context of their initiation and risk assessments.

This review's scope excluded an assessment of whether completed plant modifications were free from defects. It also excluded auditing if assessments were complete and reasonable.

This review identified the plant modification process was appropriate for the industry, and that its framework and process was mature. This statement is made in the summary of findings, but it is not given any specific explanation, nor is it one of the report's express findings. It is written to frame the detailed findings that follow, i.e., that the procedures aren't followed in practice.

Three findings were:

(a) 'Risk assessments were not always adequately completed'.

(b) 'Modifications were carried out with partial or non-compliance to the process'.

(c) '*Project commissions were completed that had not followed the plant modification process'*.

These three findings were risk assessed as moderate, and coloured yellow under CS Energy's risk matrix.[201] Each of these findings is now examined in turn.

17.4.2.2 Finding 2021.01.01 – Risk assessments not always adequately completed

The detailed findings discuss underlying causes that relate to why risk assessments were not always completed. Quoting from those findings:

(a) '*there is varying clarity on the scope of the risk assessments and that there were varying skill levels observed*'. (This is a repeat concern from the 2016 plant modifications review).

---

[199] Plant Modifications Review – Verification of Completed Actions Spreadsheet, CSE.001.081.5555.

[200] Plant Modifications Review 2020.01, December 2020, undertaken by GHD, CSE.001.226.0134.

[201] The use of CS Energy's risk matrix for the assessment of process safety risks is flawed. The assessment relies on calculating the risk based on likelihood and consequence. Process safety related risks, however, should be assessed based on potential consequence alone. This is because process safety risks are rare, and combining a rare likelihood with a severe or catastrophic outcome will produce a low or moderate risk on the CS Energy risk matrix. By contrast, for example, personal safety risks, which have a possible likelihood and a Major consequence will get a Significant rating.

(b) The plant modifications procedure requires a hazard and operability (HAZOP) study – an advanced methodology to identify risks – be initiated on all proposed high and significant risk modifications. *'This requirement is not well understood by some outside of Engineering'*.[202]

CS Energy identified three actions in response:

(a) 'Develop a risk assessment template specifically for modifications based on 'Safety in Design' principles'.

(b) 'Update the procedure (CS-AM-010) to reference the new template'.

(c) 'Communicate the updated risk assessment process to all Engineering Teams'.

These actions were closed after the incident in November 2022, with the last status comment from June 2022 noting '*changes to CS-AM-010 have been submitted for tech check. This action is very close to completion. Procedure and risk assessment template updated and registered*'.[203]

17.4.2.3 Finding 2021.01.02 – Modifications partially compliant or non-compliant or process

The detailed findings discuss underlying causes that relate to why the plant modification process was not always complied with. Quoting from those findings:

(a) '*the level of understanding and awareness of the Plant Modifications requirements outside of the Engineering department is limited*'.

(b) '*Adherence to the process often relies on the drive of people in the Engineering teams and it does not appear to be a cultural norm yet*'.

(c) '*There is a perception from some in the site Maintenance teams that the plant modification process is too hard to follow and that it is too difficult to locate the forms and engage with the right people in the Engineering teams. This is concerning given CSE's aging plant and its large occurrence of obsolete components'.*

Root Causes given for this were:

(a) *'Lack of understanding of the risks associated with not following the process*'.

(b) *'Perception that the process is too hard to follow*'.

(c) *'There are no 'consequences' associated with not following the process*'.

CS Energy identified five actions in response:

(a) *'Finalise development of the plant modification system in J5*'.

(b) *'Develop training materials and register in the LMS*'.

(c) *'Test and implement J5 at all sites*'.

(d) *'Ensure training matrix in the LMS includes the plant modifications training for relevant roles: - General Awareness to Maintenance & Operations - Modification Officer to all Engineering & project management staff*'.

[202] This comment was based on the outcome of interviews and a review of 6 sample risk assessments conducted by GHD.

[203] Extract Assurance (Internal Audit) tracking systems, Plant Modifications. CSE.001.268.0003.

(e) *'Ensure appropriate training has been completed – method of delivery (classroom-based or online) to be determined by Site Leadership Teams'.*

The J5 electronic MOC system was developed and the action closed in June 2022, after the incident. Also after the incident, the updated training package was developed and went live in September 2022.[204]

17.4.2.4 Finding 2021.01.03 Projects commissioned that have not followed the plant modification process

The reviewers state that, during interviews, it was mentioned that some projects had been commissioned and are in operation, despite the sign off steps in the plant modification procedure not being followed.

Root causes given for this were listed as:

(a) *'Pressure to deliver capital works and upgrades in a timely/under budget manner'.*

(b) *'Plant modifications process adherence not part of project delivery performance measures'.*

(c) *'There are no 'consequences' associated with not following the process'.*

CS Energy identified three actions in response:

(a) *'Project management staff to receive Modification Officer training'.*

(b) *'Ensure all project management staff have plant modification system compliance as a measure in their IAPs'.*

(c) *'Failure to follow the processes will be managed under fair and just processes'.*

The action was closed after the incident upon confirmation that all staff received the training by June 2022.[205]

17.4.3 Messaging of Review Findings Within CS Energy

The 2020 Plant Modification Assurance Review was presented to the Audit and Finance Committee on 26 March 2021.[206] The report paints a positive review of the findings, highlighting the overarching statement made that CS Energy's procedures are consistent with good industry practice. Only limited attention is made to the negative findings, except for the fact that they are moderate, see Figure 31.

---

[204] Extract Assurance (Internal Audit) tracking systems, Plant Modifications, CSE.001.268.003.

[205] Extract Assurance (Internal Audit) tracking systems, Plant Modifications, CSE.001.268.003.

[206] AFC Committee Paper, Executive Summary Assurance, 26 March 2021, CSE.001.082.0714.

Plant Modifications Review (2021.01)

A review of CSE's plant modification process was performed by GHD.

The review observed that several initiatives in 2020 created a renewed focus on the management of plant modifications, including an update of the Plant Modifications Procedure (CS-AM-010), the introduction of a self-assurance check process and a focus on closing out historical issues.

Overall, it was found that the intent of the plant modifications process is completely appropriate for this industry and when compared to other power generation companies, the framework and process is quite mature and represents sound engineering practice.

Notwithstanding this, three Moderate-rated findings were identified. An Executive Summary can be found in **Attachment 2** with the full report including managements response included in **Attachment 3**.

Assurance has completed the summary report for the **Continuous Assurance Program for Health and Safety and Environment** (2021.07). These reports can be found in **Attachment 4** and **Attachment 5**.

Figure 31 Extract from Assurance Report

The report merely notes that '*three moderate-rated findings were identified*' but does not identify them.

The Committee minutes are also positive, focusing on the maturity of the systems and processes, as well as noting that a third of Callide's outstanding modifications (the issue identified back in 2016) have been closed out (without noting that this still left in the order of 1,300 still open), see Figure 32.[207]

[redacted] noted that GHD performed the Plant Modification Review which resulted in three moderate findings and confirmed that CS Energy's processes are in line with good industry practice.

[redacted] detailed to the Committee:

- That the review found that CS Energy's framework and process is quite mature and represents sound engineering practice.
- That improvements are being actioned and noted that one third of Callide Power Station modifications have now been closed out.
- That CS Energy now has one process for plant modifications across the company (reduced from 3 procedures).

The Committee queried the process for updating plant drawings. Management confirmed that each site has a contract resource to assist with the drawing process including any backlog.

Figure 32 Extract from minutes

17.4.4 Discussion

The Plant Modification Reviews reveal issues with the effectiveness of the plant modification process going back a decade.

Actions being undertaken (or completed) by CS Energy in response to those findings were largely focussed on treating the symptoms (as opposed to the cause of the issue), such as focusing on catch-up work, training, and updating procedures.

[207] Meeting of the Audit and Finance Committee, 26 March 2021, CSE.001.023.8892.

The actions did not have a focus on addressing the underlying reasons and root causes of the findings. Instead, a high degree of confidence appears to have been held in the systems and procedures. This is reflected in the risk rating given for the risks associated with plant modifications.

17.4.5 A Relevant Incident

It is noteworthy that at around the same time but seemingly unconnected, on 21 January 2021 a Category 4 incident Review from May 2020 is presented to the Safety and Performance Committee in relation to the Callide C3 A Expansion Joint Failure.[208] A corrective action from the incident included the delivery of the MOC improvement plan that emerged from the December 2020 review, in response to a key learning that '*Adherence to the management of change process for plant modifications continues to be a high focus for the management team*'.[209] A specific action included the creation and communication of a risk assessment guide specific to technical change management (plant modification).

17.4.6 Summary

The assurance process did identify a substantive and long-term issue of non-compliance with the plant modification process. The upward reporting of this issue to the board was minimised. The substantive question of whether the plant modification procedure was effective remained unresolved.

17.4.7 A Note on How Plant Modifications Are Managed in Insight.

Insight is CS Energy's enterprise risk management system. One of the risks tracked in Insight is the risk of plant modifications that do not follow procedures.

Prior to the 2020 plant modification review, this risk was rated as significant (orange). This is shown in the Residual Risk Level (Pre-review) column in Figure 33 below.

[208] Cat 4 Incident Review – Callide C 3A Expansion Joint Failure, 12 May 2020, CSE.001.082.1396.

[209] Ibid at 9.

1.4 Key Risks

The following risk event and controls have been identified as part of this review:

Risk	Controls	Inherent Risk Level	Residual Risk Level (Pre-Review)	Residual Risk Level (Post-Review)
Plant Modification undertaken that has the potential to cause harm or equipment damage	• Plant Modifications training module in the LMS • CS-AM-010 Plant Modifications Procedure being followed • Self-assurance checklist • Site modification registers/ database • All technical requirements implemented into the various CSE systems • Adequate and relevant plant modification impact risk assessment carried out	High	Significant	Moderate

MoC is a key control in the Technical Risk Management area of CSE's Process Safety Framework.

Figure 33 Extract Plant Modification Review

As part of the review this rating was reconsidered and was changed from 'significant' to 'moderate', based on the risk event and controls identified in the review. This is shown in the Residual Risk Level (Post-review) column in Figure 33 above.

The controls relied upon are listed in the second column in Figure 33 above. These controls include – '*CS-AM-010 - Plant Modifications Procedure being followed*' and '*Adequate and relevant plant modification impact risk assessments carried out*'.

This rating is applied even though the review itself raised issues regarding compliance with the plant modification procedure, and that risk assessments were not always adequate and relevant. The residual risk rating of moderate, therefore, assumes that the actions emerging from the review were both completed and effective to overcome the findings.

17.5 Maintenance Work Management Review 2019

The Maintenance Work Management Review was completed in 2019.[210] The focus of the review was to provide assurance that non-outage related maintenance work was performed in a timely, safe, and efficient manner.[211]

The key review findings stated that:

[210] Maintenance Work Management Review 2019.05, July 2019, CSE.001.081.2478.

[211] Assurance CS Energy Maintenance Work Management Review Scope of Work, 15 April 2019, CSE.001.081.2249.

(a) Backlog maintenance exceeds approved limits across all sites. A specific warning was made that '*continuously operating at the current backlog levels increases the risk to the business that sites will experience increased asset failures leading to CSE being unable to achieve its plant availability targets*'.

(b) Statutory Maintenance also suffered backlogs. In the detailed findings on this issue, the observation was made that '*limited use of formal risk assessment processes was also observed for statutory PM changes or overdue statutory PMs resulting in Plant Engineering not being aware of the lack of compliance of safety critical assets*'.

(c) '*CS Energy's Work management Manual was inconsistent with industry best practice*' and '*there had been no formal training of work management staff or competency assessment, no work packs being used to undertake maintenance, and little of no quality assurance of maintenance execution*'.

The management actions agreed upon in response to these findings were to:

(a) *'Reduce the statutory maintenance backlog'*.

(b) *'Take a prioritised approach to reducing maintenance backlog'*.

(c) *'Update the work management manual'* and '*communicate the updated work management manual*'.

The work backlog issue was the subject of a separate presentation to the CS Energy Board, dated 31 January 2019,[212] which discussed a substantive project to address the backlog, '*Callide Work Management Improvement and Maintenance Risk Reduction*'.

The 2019 Maintenance Work Management Review was verified after the incident in 2022.[213] The outcomes achieved at the time of verification were as follows:[214]

- The maintenance backlog '*had not been brought back within KPI Limits*' and was being addressed by prioritising the maintenance actions on a risk basis, critical work getting a P1-4 range. '*The majority of the back log work is now a P-5*'.
- There were '*many overdue*' statutory inspections found at Callide at the verification. This led to management deciding that addressing this backlog work '*as a key priority*', and to '*reinforce the requirement that there be no overdue statutory requirements, unless a risk assessment has been signed off by the management and engineer*'. The action was re-opened so it could continue to be tracked by the Assurance team.
- The updated work maintenance procedure was finalised and rolled out after the incident in April 2022.

[212] Board Presentation, Update: Callide Work Management Improvement and Maintenance Risk Reduction, PowerPoint Presentation, 31 December 2019, CSE.001.089.6581.

[213] CS Energy, Maintenace Work Management Verification Review, #2019.05, July 2022.

[214] This summary is based on the Maintenace Work Management Verification Review, #2019.05, July 2022 and Extract Assurance (Internal Audit) tracking systems, Maintenace Work Management Review CSE.001.268.0001.

17.6 Incident Management and Resolution Review 2019

An audit into the effectiveness of CS Energy's incident investigation processes, undertaken by DuPont first occurred in 2014/2015. This 18-month review culminated in a report dated 15 May 2015.[215] This audit incorporated the 'Safety Reset' program which had the goal of addressing unsafe practices and near misses.

DuPont assessed CS Energy's safety maturity against the DuPont Bradley Curve. The curve has four stages, which range from poor to more effective: Reactive, Dependant, Independent, and Interdependent. DuPont assessed CS Energy as '*Reactive and Dependent*', which they describe employees as achieving safety by natural instinct, where compliance is the goal, and where they will do the right thing when there is supervision and consequences.

The management response to the DuPont Investigation was reported on 21 March 2016 to the Audit and Risk Committee, which included a range of training, procedural and process changes.[216]

The DuPont Assessment also went to the People, Safety and Environment Committee on 25 November 2016, where the committee accepted the criticisms made of CS Energy as valid. The committee also recognised that the recommendations to change the culture need to be taken seriously.[217]

There was a subsequent Assurance Review of H&S Incident Management and Resolution in 2019. The scope of this review was to provide '*assurance whether the health and safety process safety incident investigations are performed in accordance with the CSE Learning from Incidents Procedure*'.[218]

In a July 2019 Working Paper, a range of non-compliances were identified, including:[219]

(a) '*Health and safety risks in the enterprise risk system are not reviewed following incidents*'.

(b) '*Bowties/risks … are not reviewed post incident to see which controls were absent or failed*''.

(c) '*some confusion around how SAP IMD workflows are intended to work'.*

(d) '*Procedure refers to SAP IMD training in section 5.6, however this is no longer used'.*

(e) '*Action verification is limited and ad hoc*'.

(f) '*only limited lead measures have been defined and these have not been consistently reported on'.*

The Review in September 2019 found:[220]

(a) *'Following the DuPont Review, a number of improvements to the management of health and safety incidents at CSE were made'.*

[215] DuPont, CS Energy Incident Investigation Report Version 1.2, December 2015, CSE.001.081.4897.

[216] Attachment 5 – Management Response – Effectiveness of Investigations for Serious Health and Safety Incidents CSE.001.081.4886.

[217] PSEC Minutes, 25 November 2016, CSE.001.081.4886.

[218] Health and Safety Incident Management and Resolution Review Scope of Work, 2019.06, CSE.001.081.1550.

[219] Work Paper, Incident Management and Resolution Review, CSE.001.081.1590.

[220] Health and Safety Incident Management and Resolution Review 2019.06, September 2019, CSE.001.081.1672.

(b) *'This review did however note further improvements are required, especially in several areas that are key to preventing a recurrence of a health and safety incident at CSE'.*

The areas for improvement included:

(a) that CS Energy needed to improve its ability to learn from incidents;

(b) to perform quality assurance over its incident management processes; and

(c) close out of actions post incidents.

Specifically, in relation to Process Safety Incident investigation, they found *'a lack of clarity around management of process safety incidents, including investigation methodology and incident closeout'*.

The action from the review directed specifically at process safety was to provide further training. This action was recorded as completed in 2022, after the incident.[221]

This review was included in the 29 November 2019 Audit and Finance Committee Meeting, the minutes of which were included in the January 2020 Board papers.[222]

The scope of this review included the questions: whether lessons learnt are being effectively communicated across the business, and if the system is effective at preventing reoccurrence of lessons.

In the context of process safety, the review found that process safety incidents were being treated in the same way as operations incidents, with the risk being of repeat incidents, see Figure 34.

2019.06.04 Lack of clarity around managing process safety incidents	Risk Level	Moderate
Finding	**Root Cause & Risk**	**Recommendation #**
CS-IM-01 was updated on 30 October 2018 to include process safety incidents. Since then there have been three Category 3 and 4 incidents classified as Process Safety Events (PSEs): 1. IMD 8946 (SO3 plant fire at Callide) – interim investigation report available only. No final report available or green banner issued. This was reportedly due to the scene not being preserved so there was inadequate evidence to perform a root cause analysis. 2. IMD 8996 (Multiple plant modification non-compliances at Callide) – no investigation report available or green banner issued. 3. IMD 9046 (Windbox fire at Callide) – RCA methodology used, final report is available but no green banner was issued. Currently, process safety investigations appear to be treated in the same way as Operations incidents. The Process Safety Improvement Manager is aware of the lack of clarity regarding PSEs and has started assisting Plant Operations to increase the level of understanding.	Root Cause • No training or awareness has been provided on process safety incident management. • Lack of clarity and guidance regarding PSEs. Risk Repeat incidents of a similar nature occur at CSE sites.	5. Process safety 8. Update CS-IM-01
* *Moderate risk rating obtained using the following logic:* *Consequence:* ***Catastrophic** – Safety & Security* *Likelihood:* ***Rare** – Less than 1% probability*		

Figure 34 Extract from Incident Management and Resolution Review

17.6.2 Summary

The assurance review of the incident management systems revealed fundamental issues with the effectiveness of the learning from incident system as it related to process safety.

[221] Extract Assurance (Internal Audit) tracking systems, H&S incident Management and Resolution Review. CSE.001.268.0002.

[222] AFC Meeting, 29 November 2019, CSE.001.023.7664.

17.7 Permit to Work Reviews

As part of a review into investigation effectiveness in 2015, incidents in relation to isolation and permit to work were identified.[223] When this review was raised at the People Safety and Environment Committee in November 2016, the Committee Chair raised concerns that the PTW system was cumbersome and an area of concern.[224] Management response was that '*there is nothing particularly wrong with the system, however the way it is being applied could be improved. There is a lot of bureaucracy and paperwork that is designed to ensure compliance rather than keep people safe. In addition, there are instances where people have chosen to work outside the system. In which case there are no protections*'. The CEO at the time challenged management to review the system and its application, and stated that the recommendation should be taken seriously.

A Permit to Work Review was carried out and reported in June 2017.[225] The audit was carried out by O&M Consulting. The significant findings of the review included:

- The Work Clearance Documents contained known errors increasing the likelihood of an incident because of a low level of confidence that changes to the plant would be reflected in the templates.
- Management of PTWs during outages need to be better managed to prevent delays.
- There was a large backlog of plant labels changes to be made. The finding comments that '*accuracy of plant labels … is critical to safe isolation of plant*'.

The next review of the PTW system was brought forward following a Category 4 Incident: '*Check Weigh Bin 415v isolation restored while Permit to Work Issued*'. This incident was presented to the board in February 2018.[226]

A verification report of the actions from the 2017 PTW Assurance Review was issued in July 2018.[227] It found that actions were still to be completed, noting the absence of the PTW Administrator.

This verification report was included in the Assurance and Risk Committee Papers in July 2018, and the minutes record that there was discussion of the outstanding actions, including unavailability of key personnel.[228] The minutes say that *'now that the Head of Operations Services is back in [their] role and a PTW Systems manager has been appointed on a 2 year fixed terms contract the system will be simplified, improvements made (with an upgrade due by the end of June 2019) and training undertaken'*.

This report was also raised in the Reliability and Plant Performance Committee Meeting held on 26 July 2018. The minutes record that the Committee queried how the role could be sidelined for nine months, and noted that the PTW system is a focus area and required to be running on a new platform by the end of 2019.[229]

---

[223] DuPont, Incident Investigation Report, December 2015, CSE.001.081.4897.

[224] Meeting of the People, Safety and Environment Committee, 25 November 2016, CSE.001.023.6927.

[225] Permit to Work Review, 19 June 2017, CSE.001.081.4432.

[226] See minutes of the Meeting of the Board of Directors 23 February 2018 CSE.001.023.4043, and Health Safety and Environment Report, 23 March 2018 CSE.001.081.6103.

[227] Permit to Work Verification Report CSE.001.081.4499.

[228] Executive Summary Assurance, Audit and Risk Committee Paper, 30 July 2018,CSE.001.081.8180 and Minutes, Meeting of the Audit and Risk Committee, 30 July 2018, CSE.001.023.7151.

[229] Meeting of the Reliability and Plant Performance Committee, 26 July 2018. CSE.001.023.7306.

17.8 Effectiveness of Assurance Program Actions

The type of actions taken in response to the audit findings from eight reviews into process safety related systems was analysed as part of the Brady Heywood Investigation. These are the Plant Modifications Review, Maintenace Work Management Review, Plant Control Systems Review, Procurement and Contract Value Review, Training and Competency Assessment Review, Health and Safety Incident Management Review, Permit to Work Review, and Electrical Safety Review.

Each action was categorised according to the type of action taken (e.g., training, communication document update) and then categorised, as either:

(a) Symptom. These are actions which are cosmetic or which treat the outcomes of ineffective controls, such as undertaking catch up work.

(b) Cause. These are actions designed to identify and/or treat underlying root causes identified in the finding.

Of the 120 actions reviewed, 86, approximately 72%, treated symptoms, and 34% went to underlying root causes. See table below:

Review	***Number of actions***	***Actions - Symptom***	***Actions- cause***
Plant Modification Review 2021	12	9	3
Maintenance Work Management Review 2019	13	8	5
Plant Control Systems Review 2018	19	5	14
Electrical Safety Review 2017	15	15	0
Health and Safety Incident Management and Resolution Review 2019	9	7	2
Permit to Work Review 2018	30	29	1
Procurement and Contract Value Review 2018	14	13	1
Training and Competency Assessment Review	8	0	8
	120	86	34
		71.67%	28.33%

Actions that treat symptoms, as opposed to underlying causes dominate.

17.9 Assurance System Conclusions

Analysis reveals that, leading up to the incident, the assurance program was raising issues with system effectiveness, but was a weak tool for resolving those issues. Actions adopted through this process were more likely to be cosmetic, giving the appearance that action was being taken, but which did not address the underlying causes of why systems were not effective.

In addition, the assurance verification process only confirms if agreed actions have been taken and does not provide assurance of any subsequent improvement or effectiveness of the control.

A further consequence is that completion of the agreed assurance actions becomes a proxy for the view that controls would be effective and that risks were being managed within acceptable levels. This is seen most starkly in the Plant Modification Review.

18 LEARNING FROM INCIDENTS

18.1 Introduction

This section explores the effectiveness of CS Energy's processes to learn from incidents. Organisational learning is a key part of ensuring the robustness of engineering and process safety systems. CS Energy has a formal learning from incidents process known as the '*Learning from Incidents Procedure*'.

The purpose of a learning from incidents system is to gather information that helps identify where an organisation's systems and controls, both engineering and process safety, are not working effectively. Such learnings provide opportunities to address these deficiencies before a major incident occurs.[230]

Effective learning from incidents requires:

(a) An understanding of both the immediate technical causes and the systemic organisational causes[231] of the incident (and sharing these findings throughout the organisation).

(b) Implementing improvements which address both the immediate technical and systemic organisational causes.

18.2 Summary of Key Findings

The organisational findings relating to learning from incidents are:

(a) At Callide, effective learning was achieved for only a very limited number of process safety incidents.

(b) The lack of organisation risk competency meant that CS Energy did not have the basis to effectively identify warning signs of process safety risks.

(c) Learning opportunities were limited by several factors, including a narrow set of incidents that qualified for investigation and warning signs lost in other systems.

(d) CS Energy's system for learning from process safety incidents was not working effectively at Callide.

18.3 Learning Achieved at Callide

In the approximately 2 ½ year period from October 2018, when process safety reporting was introduced, to the incident,[232] there were 776 incidents entered in the incident reporting system at

[230] CS Energy has a documented procedure for learning from incidents. The version of this procedure which was in place for the majority of the time period prior to the C4 incident was CSE.001.246.0966 (in place between 23/10/2018 and 4/2/2021).

[231] If an organisation only focusses on understanding and addressing the technical causes of an incident, they may prevent that particular event (or very similar events) in the future. However, by understanding and addressing the systemic organisational issues related to the event (in addition to the immediate technical causes), the organisation can improve the key systems which prevent a range of potential events. This allows for faster and more effective improvement of process safety systems.

[232] Incidents with an event date between 23/10/2018 and 24/5/2021.

Callide.[233] Incidents are reported in SAP (a software system used by CS Energy for capturing incidents and assigning actions).

Table 3 shows the breakdown of reported incidents by their primary incident type.[234]

Table 3 All incidents reported at Callide (October 2018 to May 2021)

Incident Type	Number of Incidents Reported	% of Total Incident Reports
Process Safety (PSE)	30	4%
Health and Safety (H&S)	513	66%
Operations (OPS)	184	24%
Environmental (ENV)	47	6%
Security (SEC)	2	0.3%
TOTAL	776	

A total of 30, approximately 4%, of the incidents reported had a primary incident type of process safety (PSE).[235] By contrast, there were 17 times more Health and Safety incidents, and six times more Operations incidents. There were significantly less learning opportunities from process safety incidents when compared with other incident types.

18.3.1 Learning from Process Safety Events

Under CS Energy's Learning from Incidents process, when an incident is reported, it is assigned an incident category between 1 and 4. Category 1 incidents are the least significant, while Category 4 incidents are the most significant.[236]

Of the 30 process safety incidents reported, the following incident categories were assigned, see Table 4.

[233] SAP is the software used for incident reporting at CS Energy. Only incidents which are reported in SAP are subject to the learning from incidents procedure.

[234] Incident type refers to the 'Log entry type' recorded in SAP. Log entry type AUD (Audit) and HAZ (Hazard) have not been included as these do not differentiate between Process Safety and other incident types (e.g., Environmental or Operations). All incident data analysis was done using SAP data extracts CSE.001.260.0001 and CSE.001.260.0002.

[235] These are incidents where the Log Entry Type is 'PSE' in SAP and between 23/10/2018 and 24/5/2021.

[236] CS Energy Procedure, Learning from Incidents, CS-IM-01, October 2018, CSE.001.246.0966.

Table 4 Process safety incidents by incident category

Incident Category	Number of Incidents Reported	% of Total Incident Reports
Category 1	17	57%
Category 2	7	23%
Category 3	5	17%
Category 4	1	3%
TOTAL	30	

The CS Energy Learning from Incidents procedure states that Category 1 incidents only require a SAP record or a 5 Why investigation.[237] This investigation method is simplistic and is unlikely to result in systemic organisational learnings and improvements.[238] Category 2,[239] 3 and 4 process safety incidents require a more detailed method of investigation (Learning Teams[240] or ICAM[241]). These investigation methodologies include an assessment of the more complex underlying organisational causes of the incident, and are therefore more likely to result in organisational system improvements.

The level of learning achieved from process safety incidents (between October 2018 and May 2021) at Callide is shown in Figure 35.

[237] CS Energy Procedure, Learning from Incidents, CS-IM-01, October 2018, CSE.001.246.0966.

[238] The Learning from Incidents procedure defines 5 Why investigations as "a simple process to highlight probable causes of an incident" CSE.001.246.0966.

[239] Only category 2 incidents which were categorised as Tier 2 Process Safety Events (PSEs). Other Category 2 incidents required a 5 Why investigation (at minimum) CSE.001.246.0966.

[240] The primary investigation methodology for significant Process Safety Events (PSEs) was Learning Teams. A Learning Teams was required for PSEs which were Tier 1 or 2 loss of containment events, CSE.001.246.0966. This method involves a facilitated discussion with people who were involved in the event (or who have useful information about that type of work) to learn and improve from when the work has gone well and gone wrong. This can be an effective method to drive organisational system learnings and improvement. There is no evidence of the Learning Teams method being used for any process safety incident investigations. This is consistent with a CS Energy assurance review of the learning from incidents system done in 2019 which found that there was a lack of clarity around the incident investigation process for Process Safety Incidents, CSE.001.081.1681.

[241] There is evidence of the ICAM method being used for Process Safety incidents. The ICAM method involves assessing the Absent/Failed Defenses, Individual/Team Actions, Task/Environmental Conditions, and Organisational Factors relevant to the incident. When done effectively, ICAM can result in a detailed understanding of how organisational systems have failed and result in improvement of these.

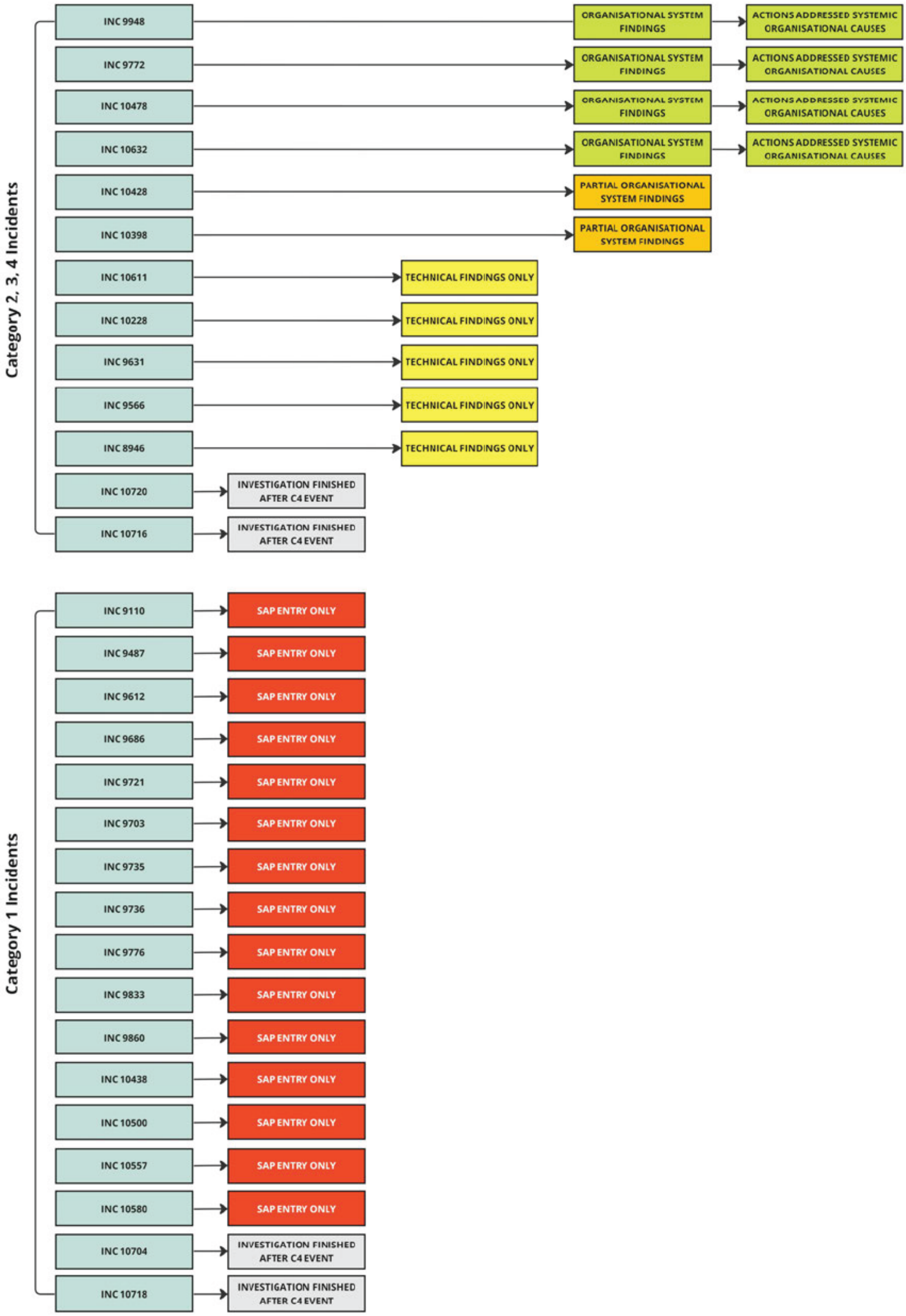


Figure 35 Effectiveness of learning achieved from process safety incidents at Callide[242]

As per the figure, the following learning was achieved from process safety incidents at Callide:[243]

- Four process safety incidents resulted in a thorough understanding of both the technical and organisational system causes, as well as improvements to organisational systems.
- Two process safety incidents resulted in a partial understanding of both the technical causes and systemic organisational causes of the incident. However, these investigations did not result in improvements to organisational systems.
- Five process safety incidents resulted in an understanding of only the immediate technical causes of the event, and they had no findings related to organisational system causes.
- 17 process safety incidents were categorised as Category 1 incidents. There was no evidence of any method of formal investigation (5 Whys, ICAM, Learning Teams, or RCA) conducted for these incidents.[244]

Therefore, across a 2 ½ year period, there was very limited learning and improvement related to systemic organisational issues as a result of process safety incidents.[245]

18.3.2 What were the Learnings?

When effective learning and improvement of organisational systems did occur, the following findings were made:

- Two incidents related to a need to improve the management of change process and increase adherence to the process.[246] These improvements included a need to implement hold points in the management of change process to ensure that modifications are not completed until the technical and support requirements have been met and relative authorisations are in place.
- One incident related to a need to improve organisational learning from incidents. Specifically, the finding highlighted the need to assess the risk of similar events occurring following an incident investigation (e.g., whether a similar event could occur on a different unit).[247] This would allow actions from an investigation to be implemented in a timely manner to manage this risk.
- One incident related to a need to increase operator capability to respond to emergency/abnormal scenarios, as well as the possible implementation of a training simulator.[248]

[242] These are incidents where the Log Entry Type is 'PSE' in SAP and between 23/10/2018 and 24/5/2021.

[243] A further 2 process safety incidents occurred during the period of analysis, however, the investigations were not completed until after the C4 incident. Therefore, the learning from these events were not assessed (INC 10720 and 10716).

[244] For 15 of these incidents, the investigation type was a SAP entry only. The other 2 incidents were still being investigated and actioned at the time of the C4 incident CSE.001.266.0001.

[245] There were other events which did not have a Log Entry Type of PSE. While not primarily process safety events, events with a different incident type (e.g., OPS or H&S) can have process safety as an additional impact. The learnings from these events which were classified as Category 2, 3 or 4 were also analysed. There was also very minimal learning about systemic organisational issues and improvements to organisational systems from these events.

[246] Incident 9948 and Incident 10632.

[247] Incident 10478.

[248] Incident 9772.

18.4 Reasons for Limited Effective Learning and Improvement

The limited level of effective learning and improvement, which resulted from process safety incidents at Callide, was likely the result of several factors. These are explained below.

18.4.1 A Poor Fundamental Basis for an Effective Learning from Incidents System

CS Energy did not have the fundamental basis for an effective learning from incidents system – a thorough understanding of their major risks and controls. This meant that the success of the learning from incidents system was likely limited from the outset. The prevention of major accidents relies on understanding the causes of each major risk, the controls that prevent or mitigate these causes, and the required level of performance of each control to ensure reliability.

This knowledge is essential to identify warning signs that controls (and the organisational systems which support them) are weakening. By not completing and implementing an effective bowtie program, as per the Critical Risk Program discussed in section 15, CS Energy did not have this foundational knowledge. With no formal way to clearly define what constituted warning signs for each risk, and no way create a systematic method to identify and escalate these within the organisation, CS Energy were highly dependent (and limited) by individual personnel's existing risk competency.

It is likely that important process safety-related warning signs were not recognised nor reported, and in the cases where they were reported, they may have not been categorised at a level that drove detailed investigation.

18.4.2 Limited Types of Incidents were Effectively Learnt From

The number of learning opportunities was also limited because of a narrow focus on the types of events that received detailed investigation.

18.4.2.2 Majority of effective learning occurred from events with an actual outcome

The nature of process safety events that resulted in effective learning (shown in Table 5), indicate a lack of learning from events where the consequences did not result in an actual negative outcome.

Table 5 Actual outcome of process safety events which resulted in organisational learning

Incident Number	Incident Category	Summary[249]	Was there an actual consequence?	What was the actual consequence?[250]
9948	4	3 A mill PA expansion	YES	Minimal plant damage
9772	3	Unit 1 'A' ID fan control damper failed and closed to 9%	YES	Unit output loss of approximately 700 MWH, damage < $5K
10478	3	CB2 Boiler Damper Failure	YES	Minor flame damage to wiring on the furnace ash conveyor
10398	2	Fire in 3A PF Mill Feeder	YES	Fire damage
10428	2	Ash reclaim water tanks were overflowing	YES	Visible loss of containment from ash reclaim tank onto road
10632	2	Callide B 'B' Compressor dryer not isolated under PTW	NO	No actual consequence

Of the six process safety events that resulted in effective or partially effective learning, five of these had an actual consequence (i.e., a visible and tangible result, such as plant damage or an outage).

This focus on learning from actual events, as opposed to a 'near miss' type event, is consistent with a lack of organisational risk competency: without a clear understanding of the risks and their causal pathways, the potential consequence of a near miss is difficult to recognise. This typically leads to a focus on learning from incidents which have a more visible consequence.

However, for every event where a bad consequence actually eventuated, it would be expected that there are many other near miss events. These events could include warning signs such as:

(a) The change management process, when required, has not been followed for a safety critical piece of equipment (regardless of whether a bad event occurs).

(b) A protection device, such as a pressure release valve, operating. While the device may have operated effectively, it is an indication that an 'off-normal' situation has occurred.

[249] The summary is the 'Event' field for the incident in SAP.

[250] Actual consequence of the event was determined by reading the investigation report.

(c) A critical process safety device being disabled or overridden without approval.

While no bad outcome has occurred in these above events, they still provide significant learning potential because they indicate weakness in critical process safety systems and controls.[251]

18.4.2.3 Majority of effective learning occurred from events which were mechanical in nature

The nature of the process safety events which were effectively investigated (shown in Table 5) also indicate a focus on learning from events that were mechanical, as opposed to electrical, in nature. There is little evidence of effective learning from events related to process safety electrical risks prior to the incident.

Of the six process safety events that resulted in effective, or partially effective learning, and improvement of organisational systems, five were mechanical in nature. The other incident was related to electrical risk. However, the event involved a failure to isolate live plant creating a personal exposure risk, rather than the risk of a major electrical system failure (as occurred during the C4 incident).

18.5 Warning Signs were Lost in Other Systems

There were other sources of warning signs which raised issues regarding the function of engineering systems that were not reported as incidents (e.g., J5 operator logs). Between October 2018 and the C4 incident there were over 5,000 log entries in the J5 operator log at Callide that resulted in a request for work.[252] It is highly likely that some of these log entries were opportunities to learn about organisational system weaknesses. However, there is no evidence that organisational learnings were achieved from these events.[253]

18.6 Pre-cursor Events

In addition to the assessment of learning which resulted from process safety incidents in the 2 ½ years prior to the C4 Event, pre-cursor events that had technical similarities to elements of the Unit C4 incident were also examined. These elements include:

(a) The loss of AC Supply to a unit.

(b) The switching process related to the DC system.

Pre-cursor events related to each element are discussed below.

[251] The focus of detailed investigations on events with an actual consequence is consistent with the Incident Category Matrix included in 'Learning from Incidents' CS-IM-01 CSE.001.246.0966. In the matrix, Category 1 Process Safety events are defined as near misses where the safety system has been challenged (including safe operating limit excursions, safety critical equipment failures/faults, activations of process safety protecting devices and errors/gaps in process safety management system requirements). Given that Category 1 events only required a SAP entry or 5 Whys investigation, the incident matrix was not driving detailed investigation into events with no actual consequence but which may have had a high potential consequence. Comparatively, Category 3 and 4 process safety events (which required more detailed investigation) were defined in the Incident Category Matrix as events with an unplanned or uncontrolled release of a material or energy which resulted in a consequence including LTI, hospital admission, impact to community, fire or explosion resulting in a direct cost to the company, pressure relief device discharge to the atmosphere. These are all events where a bad actual consequence has occurred. Therefore, the Incident Category Matrix likely contributed to a focus on learning from events with an actual bad outcome rather than 'near miss' type events.

[252] Log entries which referenced a WCA/WCD/WO/Notification, CSE.001.053.0001.

[253] CS Energy primarily analysed notification and work order data to understand loss of availability and maintenance costs.

18.6.2 The Loss of AC Supply to a Unit

During the incident in 2021, the loss of AC resulted in the loss of critical systems to Unit C4. The loss of AC was caused by a collapse in DC voltage.

In 2002, an event occurred which indicated that a momentary interruption in DC could result in the loss of the AC system. During this event, a fault in the Unit C3 battery charger led to the operation of the Unit C3 automatic changeover switch, which led to a loss of AC. This event resulted in an internal investigation[254] and a third-party report. While the mechanism of AC loss was significantly different to that of the incident in May 2021, this incident showed that it was possible to lose AC following a disruption in DC supply.

18.6.3 The Switching Process Related to the DC System

The switching process that initiated the 2021 incident involved the Unit C4 battery charger being the sole source of DC supply to Unit C4, when the interconnector to station was opened. The risks associated with this approach to switching were highlighted during an incident in 2010.

On the 12th of February 2010, a switching process on the DC system to perform routine maintenance led to a Unit C4 trip. Again, the incident category assigned to this event is not known, however, it did result in a Significant Incident Report being completed. From this investigation, several notifications were raised. These notifications included that a procedural change was needed regarding switching,[255] further training in the Callide C 220 V DC battery system was needed for Engineering, Maintenance and Operational staff,[256] and to investigate the behaviour of the battery charger which contributed to this incident.[257]

Further, a notification was raised to "*investigate current switching procedure and why two batteries cannot be connected*".[258] It was this inability to parallel batteries that resulted in a switching sheet that required the Unit C4 battery charger to be the sole source of DC supply to Unit C4 during the 2021 incident.

Between 2010 and 2017, all the notifications from the February 2010 incident were closed. However, while they were closed, there was no evidence of increased training, a change in procedure, or investigations into charger behaviour being completed.

Further, the notification to investigate the current switching procedure and the inability to connect two batteries was closed out with the comment, "*Procedures are deemed suitable to identify any faults. If there is an issue - stop switching. Reinstate if required*".[259] Hence, no practical risk competency, procedural or design improvements resulted from this incident.

[254] CS Energy, Trip Report – Preliminary 3 Unit, Internal Memorandum, 19 August 2002, CSE.001.044.0001.

[255] Notification 10284274, CSE.001.253.0045.

[256] Notifications 10284275, 10284276, and 10284277, CSE.001.253.0045.

[257] Notification 10284278, CSE.001.253.0045.

[258] Notification 10284279, CSE.001.253.0045.

[259] Notification 10284279, CSE.001.253.0045

18.7 Summary

CS Energy's system for learning from process safety incidents was not working effectively at Callide. In the lead up to the Unit C4 incident, there were very few process safety incidents which resulted in an understanding of both the organisational systems and technical failures which contributed to the incident. Therefore, incidents resulted in very few improvements of the organisational systems which support process safety. This reduced the ability to address deficiencies in these systems.

19 THE SWITCHING SEQUENCE

19.1 Introduction

This chapter presents the organisational findings related to the development and execution of the switching process that led to the interconnector between Station and Unit C4 being opened. As discussed in Part A of this report, this event initiated the incident.

19.2 Summary of Findings

The findings from this chapter include:

(a) There was no formal risk assessment (from a process safety perspective) for the preparation or execution of the switching process to bring the battery charger into service.

(b) The governing process used for switching[260] does not require any risk assessment in the development and execution of switching. Furthermore, the CS Energy Permit to Work process[261] used to manage the permitted work activity, including isolation of energy sources from the workers, requires only a job safety and environmental analysis (JSEA) for the work being performed. It does not require any consideration of the risks of removing isolations to bring equipment into service.

(c) A plant design protection mechanism to prevent overloading the DC system with two batteries being connected concurrently (i.e., in parallel) is the use of keyed interlocks. This results in predetermined steps for switching with the Unit C4 battery charger being the sole source of supply to Unit C4 following disconnection of Station and connection of the Unit C4 battery. This required the charger to deliver instantaneous DC supply to the unit upon removal of the Station supply.

(d) The original plan for the battery charger installation and commissioning was to complete the work during a Unit C4 outage. Project delays resulted in the unit being online and exporting at the time of bringing the new charger into service. While the keyed interlock design does allow for online switching, the Plant Manual does provide a warning that 'interruption to critical systems may occur'. There is no evidence that the potential consequences of undertaking the switching with the unit online was appreciated or considered.

(e) There appears to have been an implicit assumption in the switching process that the new Unit C4 battery charger would perform as required i.e., it would maintain the voltage in the Unit C4 DC system at a healthy level when the Station DC system disconnected. There is no evidence that this assumption was understood or communicated within CS Energy.

(f) There was a lack of awareness within the switching team regarding the status of the Unit C4 automatic changeover switch (ACS) which provides a level of DC power redundancy to the DC distribution board. The ACS is covered in detail in chapter 19. The DC distribution board

[260] Multiple Supply Electrical Equipment Isolation and Access (CS-OHS-53) 2016, CSE.001.103.0129.

[261] CS-PTW-01 - Permit to Work (PTW) Manual 2016, CSE.001.047.0015.

provides supply to some critical safety systems. The Unit C4 ACS was inoperable in automatic mode on the day of the incident and could not provide the designed redundancy.

(g) There were issues that had to be addressed during the commissioning which included the battery charger's circuit breaker tripping and shutting down the battery charger. While these issues were relayed to the supplier prior to the incident there is no evidence that the operators and switching team were made aware of the issues.

(h) All the personnel involved in the switching sheet writing and implementation were deemed competent as per the requirements within CS Energy which included all regulatory required training.

(i) When the 25 May 2021 incident started to unfold, the actions of the switching team were consistent with industry and CS Energy expectations as reinforced in their training.

19.3 The Planned Switching Sequence

As discussed in Part A, Section X, a switching activity was taking place on the day of the incident to restore the DC system on Unit C4 to its typical configuration.

19.3.2 Recap of the Planned Switching Sequence

This restoration switching began on 24 May 2021, the day before the incident. The Unit C4 battery had been dormant for many months and was no longer at full charge. The battery charger was connected directly to the battery to charge it overnight in a configuration referred to as 'offline charging', see Figure 36.

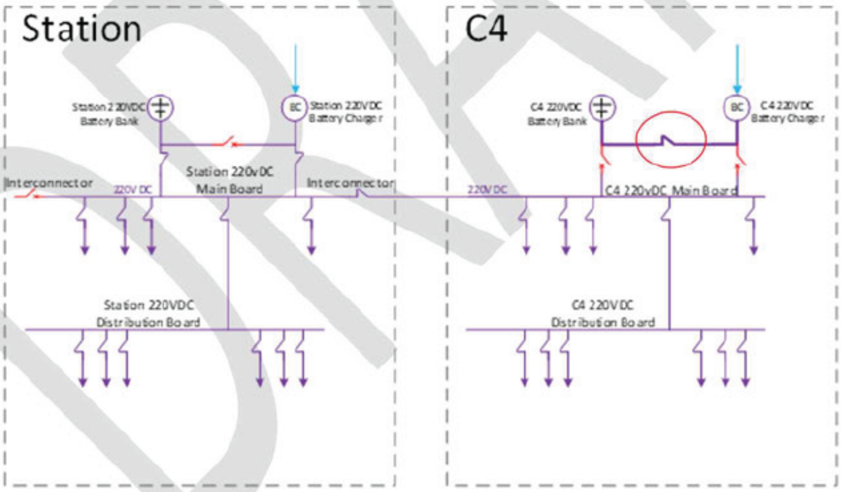


Figure 36 Unit C4 battery charger connected directly to battery

Just before 1:30 pm on 25 May 2021, with the battery restored to a full state of charge, the switching sequence continued. The next step was to disconnect the Unit C4 battery charger from the battery, and then to connect the Unit C4 battery charger to the Unit C4 DC main board.

At this point in the switching sequence, the Station and Unit C4 DC systems were still connected and had three independent sources of supply available; the Station battery, the Station battery charger, and the Unit C4 battery charger, see Figure 37.

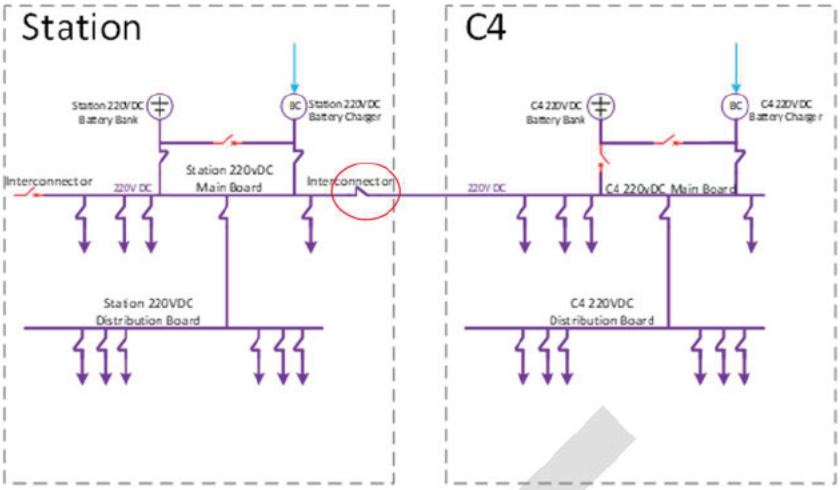


Figure 37 Unit C4 DC system supplied from Station and Unit C4 battery charger

The next step in the switching sequence was to open the interconnector between Station and Unit C4. This would remove supply to Unit C4 from the Station battery and Station battery charger. It was at this point that the collapse of the DC supply to Unit C4 was initiated. This occurred because the newly installed Unit C4 battery charger failed to maintain the DC voltage level as required by the, see Figure 38.

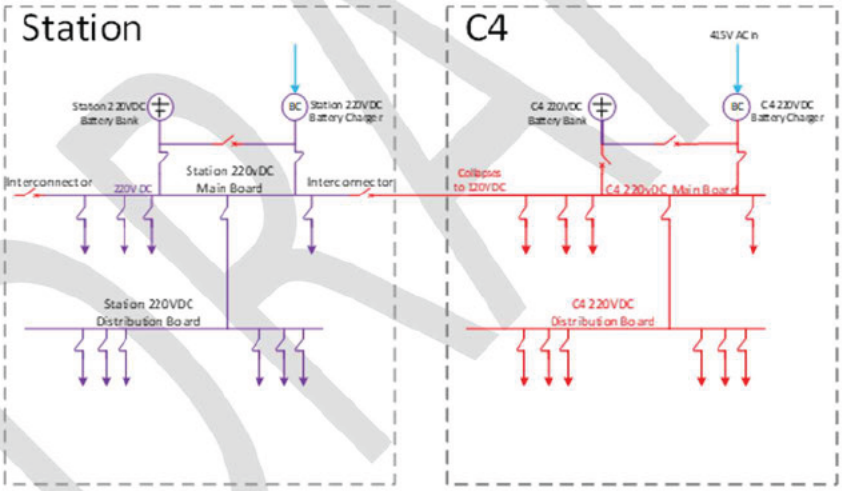


Figure 38 Unit C4 DC system disconnected from Station and supplied solely by the new Unit C4 battery charger

19.3.3 The Physical Switching Sequence

The design of Callide Unit C3 and Unit C4 plant[262] uses 'trapped key interlocks' to prevent connecting two 2000Ah batteries in parallel (one from the Station and the other in the unit)[263]. If this was possible,

[262] C D 14 10578 C L 11 253 - Manual (O&M) - Callide C (CC) - Electrical - DC Electrical Works Volume 1 of 7 (CSE.001.001.7169).

[263] Drawing C-747600_09.pdf (CSE.001.225.2076)

the instantaneous delivery of supply could exceed the fault rating of the switchgear if a fault were to occur.

These interlocks result in only one way to restore the Unit C4 battery and battery charger to their typical configuration, which was the basis of the switching sheet used on 25 May 2021. The restoration step when the interconnector between Station and Unit C4 is opened, results in the battery charger being the sole source of DC supply, see Figure 39.

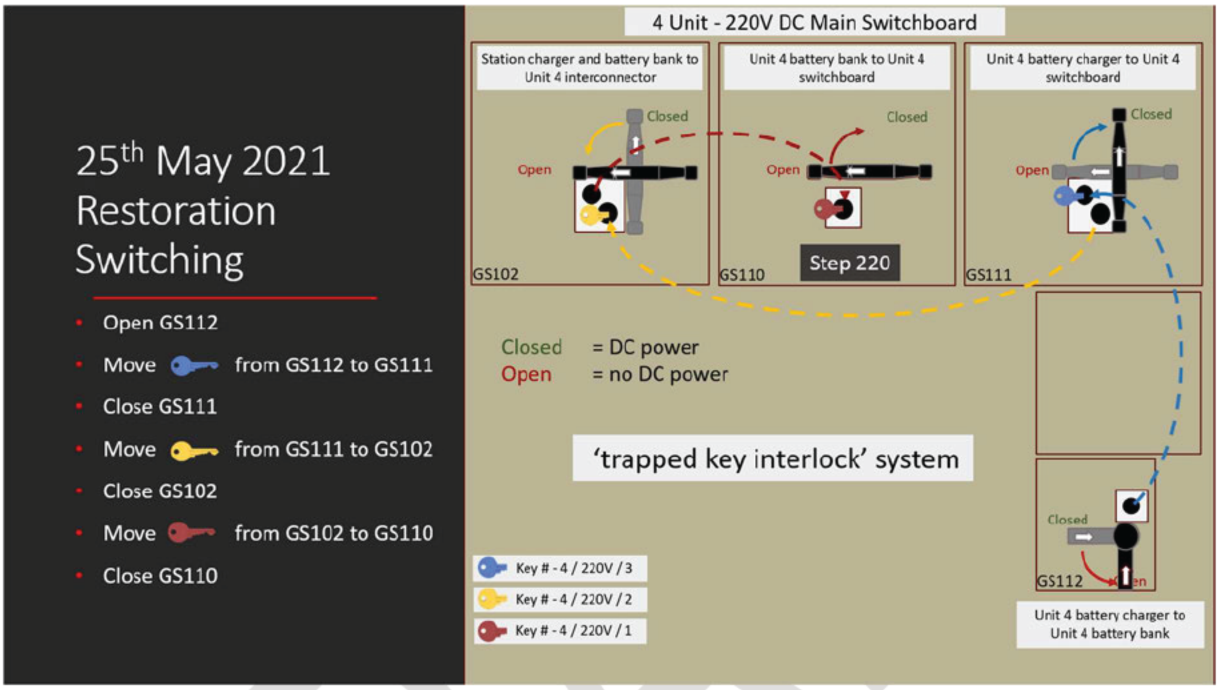


Figure 39 Restoration switching sequence using the keyed interlock system for the for the new battery charger

19.4 Overview of Switching

19.4.1 Background

CS Energy, as a business involved with electrical hazards, has a specific obligation to ensure that persons do not come into direct contact with live electrical equipment. A mechanism to isolate particular equipment to be worked upon is through electrical switching, which means any operation or action involved in de-energising, energising or earthing of a portion of electrical apparatus.

Electrical switching is considered a high-risk activity, specifically where equipment may involve high voltage or have more than one source of low voltage electrical power. It therefore must be pre-planned and executed according to the plan to ensure the correct isolations have been applied to render the equipment to be worked upon safe.[264] Switching includes both electrical isolations and restoration.

Persons involved with high voltage or multiple supply electrical switching must be a licensed electrician and competent under the national accreditation scheme which is provided by external

[264] Multiple Supply Electrical Equipment Isolation and Access (CS-OHS-53) 2016 (CSE.001.103.0129).

Registered Training Organisations. This is refreshed every 2 years in CS Energy. This is supported by requirements for individuals to have completed two years on site before being able to be nominated to be involved in switching. Following completion of the training, they must complete six different switching tasks, under supervision, within 3 months to be signed off by their line manager.

19.5 Switching and Permit to Work Requirements

Switching is undertaken as part of the Permit to Work system. The Permit to Work (PTW) system is used to provide all workers safe access to plant and equipment and is used at all CS Energy's sites. CS Energy considers 'the PTW system ensures a high level of control and minimisation of risk in areas that contain energy'.

An effective Permit to Work system should:

(a) Cover the isolation of the hazards from the work team.

(b) Manage risks to persons performing the work itself.

(c) Manage the process safety risks with the restoration of the plant.

The CS Energy PTW system does not include any steps to manage point (c) above.

Isolation of hazards to remove exposure of the work team is a key aspect of the PTW system. Mechanical isolation is carried out by the PTW officers directly within the system. The officers draft the isolation work clearance documents (WCD) and perform the isolations.

For electrical isolations, an additional step includes the development of switching sheets by the licensed electricians. These switching sheets are then used to develop the electrical WCDs which replicate the opening and closing steps from the switching sheets. The WCD then enables issuing of locks and tags by the PTW officer to be used in the isolations.

As indicated in section 17.2.3, the CSE PTW risk assessments are aimed at personal safety based on protecting workers carrying out the tasks on the permit. There are no requirements to consider the risk of switching (either isolation or restoration) on plant safety.

The procedural workflow for the PTW process include 6 steps as below.

Step 1 – Application for a Permit to Work - by the supervisor, planning personnel or officer in charge of the work

Step 2 – Plant isolation performed - electrical isolation by the switching team (switching); mechanical isolation by PTW officers

Step 3 – Permit to Work issued to the work party

Step 4 – Performing the Work by the work party

Step 5 – Surrender and complete the Permit to Work by the work party

Step 6 – Restoration of the plant - electrical isolation by the switching team (switching); mechanical isolation by PTW officers

At Step 2, the switching team receives the WCD, tags and locks from the PTW officer, who is not required to check the planned isolations, and then proceeds with the switching activity.

Restoration switching is not directly controlled by the PTW system in that Step 5 includes surrendering the permit prior to restoration switching. The PTW officers are not required to be involved with the decision on when electrical restoration switching can occur. This decision is made with the Operations team as stated on the switching sheet:

> Obtain clearance form shift supervisor or panel operator

Step 6 does not require any evidence to demonstrate that the plant can be restored safely with respect to the plant integrity as it is assumed that it will function as intended.

19.6 Training and Competency

The personnel involved in the switching sheet writing and implementation were all deemed competent as per the requirements within CS Energy, which included all regulatory required training.

19.7 Decision to Proceed with Switching

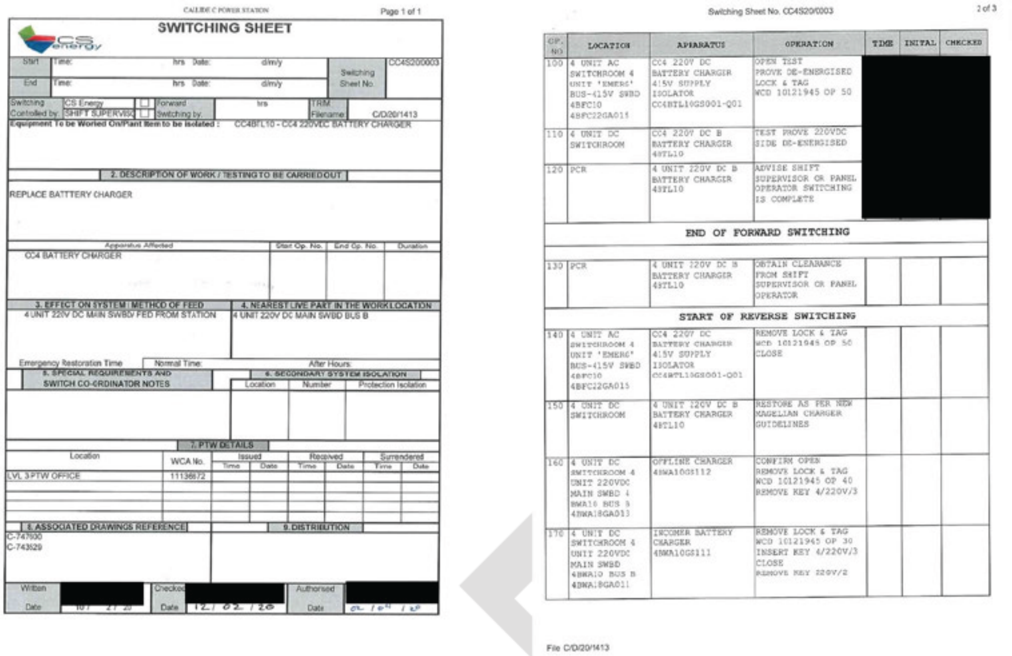
As per the requirement of the Permit to Work system, on the day of the incident the final decision on the switching proceeding was made in the control room by the shift supervisor. This person was a step-up supervisor on the day since the original supervisor left for personal reasons during the morning. The step-up supervisor did not report anything unusual in the handover briefing undertaken.

The decision to commence switching made by the step-up supervisor was done so purely from a general operational standpoint and there was no requirement to consider any risks of failure when restoring the battery charger.

19.7.2 Original Switching Sheet

The original switching sheet for the battery charger isolation and restoration was written in February 2020 for work planned in that year. [265] Due to COVID-19 and other reasons, the work was delayed until 2021. The original switching sheet is shown in Figure 40.

[265] Switching Sheet CC4S20/0003 – 10th Feb 2020 (CSE.001.103.0045).



CALLIDE C POWER STATION — Page 1 of 1

SWITCHING SHEET

Start	Time: hrs Date: d/m/y	Switching Sheet No.	CC4S20/0003
End	Time: hrs Date: d/m/y		
Switching Controlled by:	CS Energy / SHIFT SUPERVISOR	Forward Switching by: hrs	TRIM Filename: C/D/20/1413

Equipment To be Worked On/Plant Item to be isolated : CC4BTL10 - CC4 220VDC BATTERY CHARGER

2. DESCRIPTION OF WORK / TESTING TO BE CARRIED OUT

REPLACE BATTTERY CHARGER

Apparatus Affected	Start Op. No.	End Op. No.	Duration
CC4 BATTERY CHARGER			

3. EFFECT ON SYSTEM: METHOD OF FEED	4. NEAREST LIVE PART IN THE WORK LOCATION
4 UNIT 220V DC MAIN SWBD/ FED FROM STATION	4 UNIT 220V DC MAIN SWBD BUS B

Emergency Restoration Time — Normal Time: — After Hours:

5. SPECIAL REQUIREMENTS AND SWITCH CO-ORDINATOR NOTES

6. SECONDARY SYSTEM ISOLATION

Location	Number	Protection Isolation

7. PTW DETAILS

Location	WCA No.	Issued Time	Issued Date	Received Time	Received Date	Surrendered Time	Surrendered Date
LVL 3 PTW OFFICE	11136672						

8. ASSOCIATED DRAWINGS REFERENCE

C-747500
C-743529

9. DISTRIBUTION

Written	[redacted]	Checked	[redacted]	Authorised	[redacted]
Date	[redacted]	Date	12 / 02 / 20	Date	[illegible]

Switching Sheet No. CC4S20/0003 — 2 of 3

OP. NO	LOCATION	APPARATUS	OPERATION	TIME	INITAL	CHECKED
100	4 UNIT AC SWITCHROOM 4 UNIT 'EMERG' BUS-415V SWBD 4BFC10 4BFC22GA015	CC4 220V DC BATTERY CHARGER 415V SUPPLY ISOLATOR CC4BTL10GS001-Q01	OPEN TEST PROVE DE-ENERGISED LOCK & TAG WCD 10121945 OP 50	[redacted]		
110	4 UNIT DC SWITCHROOM	CC4 220V DC B BATTERY CHARGER 4BTL10	TEST PROVE 220VDC SIDE DE-ENERGISED			
120	PCR	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	ADVISE SHIFT SUPERVISOR OR PANEL OPERATOR SWITCHING IS COMPLETE			
			END OF FORWARD SWITCHING			
130	PCR	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	OBTAIN CLEARANCE FROM SHIFT SUPERVISOR OR PANEL OPERATOR			
			START OF REVERSE SWITCHING			
140	4 UNIT AC SWITCHROOM 4 UNIT 'EMERG' BUS-415V SWBD 4BFC10 4BFC22GA015	CC4 220V DC BATTERY CHARGER 415V SUPPLY ISOLATOR CC4BTL10GS001-Q01	REMOVE LOCK & TAG WCD 10121945 OP 50 CLOSE			
150	4 UNIT DC SWITCHROOM	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	RESTORE AS PER NEW MAGELLAN CHARGER GUIDELINES			
160	4 UNIT DC SWITCHROOM 4 UNIT 220VDC MAIN SWBD 4 BWA10 BUS B 4BWA18GA013	OFFLINE CHARGER 4BWA10GS112	CONFIRM OPEN REMOVE LOCK & TAG WCD 10121945 OP 40 REMOVE KEY 4/220V/3			
170	4 UNIT DC SWITCHROOM 4 UNIT 220VDC MAIN SWBD 4BWA10 BUS B 4BWA18GA011	INCOMER BATTERY CHARGER 4BWA10GS111	REMOVE LOCK & TAG WCD 10121945 OP 30 INSERT KEY 4/220V/3 CLOSE REMOVE KEY 220V/2			

File C/D/20/1413

Figure 40 Original switching sheet for the isolation and restoration for the new battery charger

19.7.3 Revised Switching Sheet

On 19 May 2021, an incident was logged involving several unauthorised changes to isolations of the new battery charger to allow commissioning testing.[266] These changes were not recorded on the switching sheet, and thus the status of the switching sheet did now not reflect the state of isolations.

A revised switching sheet was written to return to the original isolations and charge the batteries prior to restoration switching for the new battery charger. [267]

The restoration steps in the revised sheet are identical to the original switching sheet (other than the need to charge the battery). This confirms there was no change in approach from when the original sheet was prepared in February 2020 and 19 May 2021. The new switching sheet was written and checked in accordance with CS Energy switching requirements. Refer Figure 41.

[266] Incident Investigation Report 10720 – 19th May 2021 (CSE.001.054.0271).

[267] Switching Sheet CC4S21/0014 – 19th May 2021 (CSE.001.226.0027).

CALLIDE C POWER STATION

Page 1 of 1

SWITCHING SHEET

CS energy

Start	Time: hrs Date: d/m/y	Switching Sheet No.	CC4S21/0014
End	Time: hrs Date: d/m/y		

Switching Controlled by:	CS Energy SHIFT SUPERVISO	☐ ☐	Forward Switching by:	hrs	TRIM Filename:	C/D/21/7127

Equipment To be Worked On/Plant Item to be isolated : CC4BTL10 - CC4 220VDC BATTERY CHARGER

2. DESCRIPTION OF WORK / TESTING TO BE CARRIED OUT

ISOLATE BATTTERY CHARGER

ALLOW FOR OFFLINE CHARGING OF BATTERIES DURING RESTORATION

Apparatus Affected	Start Op. No.	End Op. No.	Duration
CC4 BATTERY CHARGER			

3. EFFECT ON SYSTEM / METHOD OF FEED	4. NEAREST LIVE PART IN THE WORK LOCATION
4 UNIT 220V DC MAIN SWBD/ FED FROM STATION	4 UNIT 220V DC MAIN SWBD BUS B

Emergency Restoration Time | Normal Time: | After Hours:

5. SPECIAL REQUIREMENTS AND SWITCH CO-ORDINATOR NOTES	6. SECONDARY SYSTEM ISOLATION		
	Location	Number	Protection Isolation

7. PTW DETAILS

Location	WCA No.	Issued		Received		Surrendered	
		Time	Date	Time	Date	Time	Date
LVL 3 PTW OFFICE	11145925						

8. ASSOCIATED DRAWINGS REFERENCE	9. DISTRIBUTION
C-747600 C-743529	

Written	[redacted]	Checked	[redacted]	Authorised	[redacted]
Date	19 / 5 / 21	Date	20 / 5 / 21	Date	20 / 5 / 21

Switching Sheet No. CC4S21/0014

2 of 3

OP. NO	LOCATION	APPARATUS	OPERATION	TIME	INITAL	CHECKED
90	4 UNIT AC SWITCHROOM 4 UNIT 'EMERG' BUS-415V SWBD 4BFC10 4BFC22GA015	CC4 220V DC BATTERY CHARGER 415V SUPPLY ISOLATOR CC4BTL10GS001-Q01	OPEN / CHECK OPEN TEST PROVE DE-ENERGISED LOCK & TAG WCD 10130621 OP 50	[redacted]		
100	4 UNIT DC SWITCHROOM	CC4 220V DC B BATTERY CHARGER 4BTL10	TEST PROVE 220VDC SIDE DE-ENERGISED			
110	PCR	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	ADVISE SHIFT SUPERVISOR OR PANEL OPERATOR SWITCHING IS COMPLETE			
			END OF FORWARD SWITCHING			
120	PCR	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	OBTAIN CLEARANCE FROM SHIFT SUPERVISOR OR PANEL OPERATOR			
			START OF REVERSE SWITCHING			
130	4 UNIT AC SWITCHROOM 4 UNIT 'EMERG' BUS-415V SWBD 4BFC10 4BFC22GA015	CC4 220V DC BATTERY CHARGER 415V SUPPLY ISOLATOR CC4BTL10GS001-Q01	REMOVE LOCK & TAG WCD 10130621 OP 50 CLOSE			
140	4 UNIT DC SWITCHROOM	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	TURN ON BATTERY CHARGER AS PER MAGELIAN CHARGER GUIDELINES			
150	4 UNIT DC SWITCHROOM 4BTE10	4 UNIT BATTERY FUSE SWITCH DISCONNECTOR 4BWA10GS113	REMOVE LOCK & TAG WCD 10130621 OP 20 CLOSE			
160	4 UNIT DC SWITCHROOM 4 UNIT 220VDC MAIN SWBD 4 BWA10 BUS B 4BWA18GA013	OFFLINE CHARGER 4BWA10GS112	CONFIRM OPEN REMOVE LOCK & TAG WCD 10130621 OP 40 CLOSE OFFLINE CHARGER			
170	4 UNIT DC SWITCHROOM	4 UNIT 220V DC B BATTERY CHARGER 4BTL10	CHARGE BATTRIES			

File C/D/21/7127

PAUSED SWITCHING SHEET TO CHARGE BATTERIES 25/5

Figure 41 Revised switching sheet for the isolation and restoration for the new battery charger

19.7.4 Knowledge of plant at the time

As noted above, the switching sheet for the Unit C4 battery charger installation was written more than a year before the switching was carried out.

The revised switching sheet writers and approvers also did not consider the possibility of the automatic changeover switch being inoperable in automatic mode - a risk factor since they did not consider the failure of the battery charger. The switching team on the day of the incident stated they had no knowledge of the status of the automatic changeover switch and thus followed the switching sheet up to the point of the incident.[268]

The lack of consideration of the plant being online and the ACS being inoperable in automatic mode are compounded by there being no requirements for risk assessments in the supporting processes.

19.7.5 Switching with Unit C4 Online

The initial installation of the replacement battery charger was commenced whilst Unit C4 was in an outage, but took it longer than anticipated and was then planned to be brought into service after Unit C4 was back online. The battery charger replacement project concept gate approval document identified that the new battery chargers could be installed and commissioned when units were online.

[268] Statement of Evidence of [redacted] - Norton Rose Fulbright, 30 March 2022 (CSE.001.09.0238)

When the revised switching sheet was developed in May 2021, Unit C4 was back online, but the revised sheet was essentially identical to the original sheet for the restoration steps due to the keyed interlock design. There is no evidence that the impact of Unit C4 being online, and the potential consequences should an interruption of DC or AC supply occur, was considered in drafting the revised switching sheet.

The Unit C4 Plant Manual from Pacific Power International outlines the keyed interlocking system available to allow works whilst the plant is online and includes a specific scenario with a failed charger.

However, the section references a separate volume covering online maintenance for the battery charger with warnings regarding potential interruptions to critical loads and the use of the keyed interlock protection system.[269]

1.5.10 SHUT DOWN PROCEDURE - BATTERY CHARGER – WITH MAIN SWITCHBOARD BEING SUPPLIED FROM ADJACENT SYSTEM

Step	Instruction
1	**Precautions:** Be sure that authority has been given to carry out this Shut Down procedure. **NOTE: By following this procedure interruption to critical loads may occur.** (Local Operation Only)

Figure 42 Shut Down Procedure

A compliant risk assessment would have provided an opportunity to identify risks in the restoration switching of the battery charger with the unit online.

19.7.6 Should the Switching Team Have Reversed the Switching Steps?

Since the switching step that initiated the loss of DC was the opening of the interconnector to Station DC power supply, a reversal of this step – if carried out immediately – would have likely restored DC supply to both the main switchboard and distribution board.

However, the procedural expectations on the switching team are that any variation to the switching sheet would only be carried out in consultation with the unit's Operator or other senior switching personnel.[270] This is consistent with industry expectations.[271]

On 25 May 2021, whilst the incident was unfolding, the switching team could initially not contact the operations control room and thus did not discuss whether to reverse the disconnection of the Station DC or to proceed with the next step to connect the Unit 4 battery.

At the time of the incident, the actions of the switching team were consistent with industry and CS Energy expectations as reinforced in their training. Furthermore, it is unclear as to whether the team could diagnose the problem based on the information they had available as the incident unfolded.

[269] C D 14 10581 C L 11 254 - Manual (O&M) - Callide C (CC) - Electrical - DC Electrical Works Volume 2 of 7, CSE.001.002.4455.

[270] Multiple Supply Electrical Equipment Isolation and Access (CS-OHS-53) 2016, CSE.001.103.0129.

[271] Queensland Electricity Entity Standard for Safe Access to HV Electrical Apparatus (2018), CSE.001.230.0031.

19.8 Summary

The process of developing the switching programs at the time of the incident required no operational risk assessments covering the switching to understand its impacts upon people, plant, and operations.

Furthermore, the PTW system risk assessment requirements are based on the Job Safety and Environmental Assessment (JSEA) with a focus on the personal safety of those persons performing the work designated by the permit. There is no requirement to carry out a risk assessment of switching to understand any impacts on the safety of the plant associated with the return to service of newly installed equipment.

Thus, opportunities to identify issues relevant to the restoration switching of the new charger were not in place at the time of the incident however these two processes themselves are unlikely to have prevented the incident.

20 THE BATTERY CHARGER

20.1 Introduction

When the interconnector between Station and Unit C4 was opened, the Unit C4 battery charger failed to maintain the voltage level in the Unit C4 DC system, which was an implicit requirement of the switching process. This chapter investigates the organisational factors that led to a battery charger being specified, installed, and tested that did not meet the requirements of the switching sequence.

20.2 Summary of Findings

The organisational investigation findings relating to the Unit C4 battery charger replacement (hereafter referred to as the battery charger project) are as follows:

(a) There is no evidence that the engineering team responsible for the battery charger project was aware that the battery charger was required to operate (without a battery) and maintain the voltage in the Unit C4 DC system when Station supply was disconnected, as per the switching sheet.

(b) The battery charger was not specified to meet the requirements of the switching process. Nor was it tested with respect to the requirements of the switching process. (While it had gone through a range of tests, the battery charger had not been tested for the specific requirements of this switching process).

(c) The battery charger project was a plant modification, but the CS Energy Procedure for Plant Modifications was not followed. While it was initially treated as a modification under the procedure, there was only partial compliance with the requirements.[272] Proper compliance with the procedure would have required the involvement of a wider and more diverse group to consider the project, and the process safety risks associated with it. The decision whether or not to proceed with the battery charger switching would have considered wider, and better informed, potential implications. The full and effective application of the plant modification procedure to the battery charger project would have increased the likelihood of identifying issues discussed in this section.

(d) The only evidence of process safety based risk assessment associated with the battery charger project is the completion of an Operations Plant Risk Assessment (OPRA). This OPRA, however, only considered the risk of *not* bringing the charger into service. There is no evidence of a risk assessment that considered the risks associated with bringing the new battery charger into service.

(e) The failure of the battery charger to maintain the voltage in the Unit C4 DC system when Station supply was disconnected, was set in motion by actions at the very earliest stage of

[272] The plant modification procedure requires a Plant Modification Quality Plan and Check Sheet to be completed at the outset, and this form is intended to be updated to track the project through the steps of the procedure, to completion of the project. The form was completed initially for all three battery charger replacements (together on the same form), and the project added to the plant modification register, but the procedure was not properly followed. The battery charger replacement exercise was also consistently referred to as a "like for like" replacement in correspondence and some formal documentation.

the project, and compounded by lack of procedural discipline, resource shortages and time pressures, which also prevented steps being taken to identify and apprehend issues.

(f) The Plant Modification Procedure has a number of deficiencies, including the failure to require oversight of the determination that work is not a plant modification (and therefore does not need to follow the Procedure). This means works that are actually modifications, with the associated risk, can bypass the Procedure.

20.3 Overview of Battery Charger Project

The 'end-of-life' replacement of the Callide C battery chargers for the Station, Unit C3, and Unit C4 occurred over several years, from 2018 until after the incident in 2021. The replacement of these three chargers, plus two inverters, was treated by CS Energy (and its systems) as a single project.

The formal proposal to replace the Unit C4 battery charger (and the battery chargers in Unit C3 and Callide C Station) was first raised in May 2017. It was tendered in late April 2018, and a supply contract was awarded to Magellan Powertronics in late June 2018.[273]

The Unit C4 battery charger was originally planned to be restored during a 'C4 mini overhaul' in April 2020.[274] But due to the ongoing impacts of COVID-19,[275] but also affected by workload on the site teams,[276] CS Energy resource shortages,[277] delays caused by Magellan[278] and CS Energy concerns about Magellan products,[279] the commissioning of the new Unit C4 battery charger did not occur until early 2021. The return to service commenced on 24 May 2021 while Unit C4 was online.

The Unit C4 battery charger was connected to the Unit C4 battery on 24 May 2021, in order to bring it up to a full state of charge, and then it was connected to the Unit C4 main switchboard on 25 May 2021.

20.4 What was Required of the New Battery Charger

In 'normal' operation, the battery charger converts incoming AC to output DC, and its role is to both supply the Unit C4 DC system and to charge the Unit C4 battery. In 'normal' operation, the battery charger is always connected to a battery, which provides redundancy in the event of a failure of the battery charger or a failure of the battery charger's incoming AC supply.

The battery charger, however, is required to also operate under conditions other than "normal" operation. On the day of the incident, a step in the switching process required the Unit C4 battery

273 Coupled with two other equipment replacement projects.

274 CSE.001.100.0897, schedule provided by Magellan on 15 January 2019, CSE.001.218.3880.

275 CSE.001.100.0084.

276 In March 2021, the Supervisor Instrumentation & Control advised other staff that the Callide Control Systems team would not be able to take on any more work due to existing backlog. They noted that what had been achieved in the previous year was due to a lot of overtime and the employment of an external contractor, CSE.001.100.1085.

277 External contractors, Provecta, were engaged to assist with workload: CSE.001.100.1085. [redacted] had to approach other budget holders to be able to retain a contract engineer for longer, CSE.001.100.1172.

278 There were issues with Magellan equipment which caused CS Energy to pause some work: CSE.001.100.0938, some issues with Magellan inverters, CSE.900.002.0165. There was also to and fro between CS Energy and Magellan to get the ITPs, test data and punch lists closed out prior to bringing the C4 charger back online.

279 The Project Lead who picked up the project in January 2019 raised concerns in March 2019, CSE.001.100.0907.

charger act as the sole source of DC supply to Unit C4 (the Unit C4 battery was not connected due to the requirements of the switching process). When the interconnector from Station was opened, the new Unit C4 battery charger (as the sole source of supply) did not maintain the voltage in the Unit C4 DC system, causing it to collapse to an irrecoverable level, and then be lost altogether.

There is no evidence that the battery charger was specified, could operate, or was tested to perform in a manner required by the switching sequence (i.e., act as the sole source of supply and maintain the voltage in the Unit C4 DC system).[280] Rather, it appears that the battery charger was specified and tested to satisfy "normal" operation only, i.e., intaking AC power, supplying power to the DC system and keeping the batteries charged.

20.5 The CS Energy Management of Change Process

CS Energy has a documented procedure for managing modifications to plant, set out in the CS Energy Procedure for Plant Modification, CS-AM-010, which recognises:

> Management of Change (MOC) is a critical and essential element of a robust and comprehensive risk-based asset management and safety management system, as changes to plant can introduce new hazards/ defects, or impact on existing risk control measures. There needs to be effective management of all changes to assets and asset systems.

Figure 43 CS-AM-010 – Plant Modifications Introduction

The project commenced when the 2016 version of the Procedure was current. The document was updated twice between the commencement of the project and the date of the incident, in 2019 and 2020. This report refers to the 2016 version unless otherwise noted, which was the version relevant for most of the battery charger project's duration.

Details of the Plant Modification Procedure are in Appendix X.

20.5.2 Replacement in Kind

There is recognition in the Plant Modification Procedure that changes that involve a 'replacement in kind', i.e. like for like replacement, are not subject to the Procedure. The definition[281] for 'replacement-in-kind' in the Procedure is:

A replacement of one item of equipment or component by another that satisfies the same design specification and performance characteristics and does not change the function of the plant / process. Replacements in-kind are not modifications and thus do not require any further action or documentation.

The Procedure also recognises the challenges in determining if a change is a replacement in kind and provides guidance.[282] It says, "*A change in supplier may indicate a modification*" and examples provided for what is a plant modification include:

- Replacing an item with a different make and model; and

[280] Nor is there evidence that testing was conducted to ensure that the battery charger would perform as part of the larger DC system. The testing undertaken treated the battery charger as a 'standalone' device, as opposed to an integrated part of the Unit C4 DC system.

[281] CS-AM-010 – Plant Modifications Section 1, Definitions.

[282] CS-AM-010 – Plant Modifications Section 4, What is a Plant Modification.

- Equipment / component replacements where documentation or information changes.

20.5.3 Was the Battery Charger Project a Plant Modification?

In the case of the battery charger project, an almost 20-year-old battery charger was being replaced with a new battery charger. Given the passage of time, the new battery charger would not be identical to the one it was replacing. The tender documents acknowledged that the new battery charger would likely be an improvement, or "enhancement" on the old one, by this inclusion in Section 2.1 Supply of Services and Equipment (emphasis added):

"Battery charger and UPS system failure detection, local indication and alarming shall be equivalent to the existing design <u>or shall be enhanced as per new equipment supplier's recommendation</u> (any additional protection formats to be interfaced to DCS system shall be communicated to site engineering and to be approved by CS engineering before implementation)."

As discussed, the Procedure provides definitions for Modification and Replacement-in-kind and in essence, with respect to the replacement of plant, if the work was a replacement-in-kind and it did not require any changes to documentation or the management of safety, compliance or maintenance, then it was not a plant modification. Otherwise, it was.

The examples included in Section 4 of the Plant Modification Procedure provide further clarity of what is a Plant Modification Procedure. The battery charger project fits with at least three of those:

- The supplier of the new battery charger would be different to the supplier of the old battery charger.
- The project was replacing an item with a different make and model.
- The project involved equipment / component replacements where documentation or information changes. Even if the battery charger replacement was regarded as a like for like replacement, the procedure captures like for like replacements when one or more of the technical and support requirements listed in section 3 of the Plant Modification Quality Plan and Check Sheets require supply, updating or replacing.

In the case of the Unit C4 battery charger, the old Hitachi battery charger was being replaced with a Magellan Power built battery charger (a different make and model), and it would require updates to drawings and O&M manuals, and training of personnel.

Attachment 1 to the Plant Modification Procedure contains a guide to assist with the identification of work as a modification. If the proposed work was assessed against the guide, several of the first nine questions would have to be answered as 'Yes', which requires the full Plant Modification Procedure to be followed.

Refer to Figure 44 which indicates those questions which would have been correctly answered as 'Yes'.

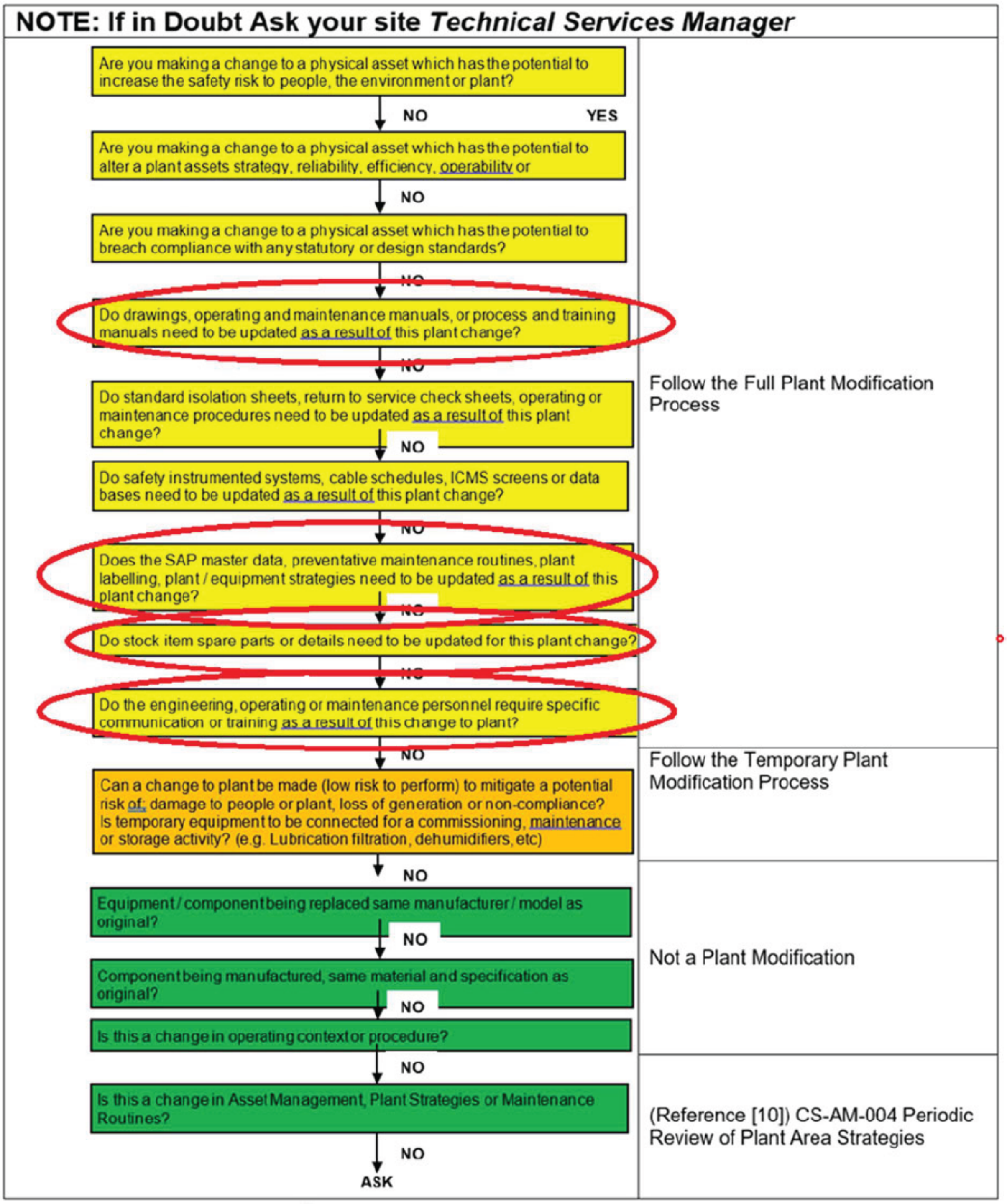


Figure 44 Assessment of the battery charger project against the guidance in Attachment 1 to the Plant Modification Procedure (2016). The red circling indicates those questions that would have been answered 'yes'.

In accordance with the Plant Modification Procedure, the replacement of the battery charger was a plant modification.

20.5.4 Was the Plant Modification Procedure Applied to the Battery Charger Project?

While there is evidence that supports the view that CS Energy personnel considered the battery charger project a like for like replacement, there is also evidence that it was treated as a plant modification. The project is repeatedly referred to in correspondence and some formal documentation as a like for like replacement, but a Plant Modification Quality Plan and Check Sheet was initially completed for the project, and there was an entry in the plant modification register. The Check Sheet, however, was only completed for the early stages of the project, and there is no evidence the procedure was complied with from that point onwards.

Between May 2017 and January 2018, several internal documents within CS Energy, in support of the battery charger project, including communications to the supplier identified the charger as

> *"a 'straight' replacement for our current charger"* [283]
>
> *"These chargers would be a straight swap and require minimal commissioning"*[284]
>
> *"'like for like' replacement"*[285]

Tender documents issued to the market in April 2018[286] included (underline added for emphasis):

> *"**2.4.4. Plant Modification Requirements/Change Management***
>
> *Plant modification is not anticipated to be required for this work. This aspect is to be managed by CS Energy.*
>
> *The Contactor shall ensure any changes to existing and approved new drawings are documented and submit as-built drawings in PDF and AutoCAD formats."*

The Plant Modification Quality Plan and Check Sheet template has six sections for documenting compliance with the requirements of the Plant Modification Procedure,[287] but on the Check Sheet for the three battery chargers (in Unit C3, Station and Unit C4), only the first three sections, up to the Design stage, were completed.[288]

The first signatures on the Check Sheet were dated 13 Feb 2018. The latest signature on the form was dated 20 Feb 2018, only seven days after the Check Sheet was initiated. Furthermore, this last signature signing off the design as completed, was applied two months before the project even went to tender and before the supplier was determined.

There is no further evidence that the Plant Modification Procedure was followed for the Unit C4 battery charger project beyond this point in time, despite the project continuing for a further three years to May 2021.

Figure 45 is a summary of the steps in the Plant Modification Procedure that were completed for the three battery chargers.

[283] Industrial Battery Charger - CS Energy - Request for Quotation, CSE.001.213.0044.

[284] A memo was prepared by the Technical Manager - Electrical, dated 31 May 2017, CSE.001.213.0072.

[285] CS18548 C UPS and Battery charger concept approval, CSE.001.225.0161.

[286] Invitation to Tender (ITT) Section C – Scope of Work, for the Callide C 220V DC Charger and 240V AC UPS Replacement, Version: 1.

[287] Section 18.14 provides further details of the Plant Modification Procedure.

[288] Plant Modification Quality Plan and Checksheet for the battery charger, CSE.001.225.0156.

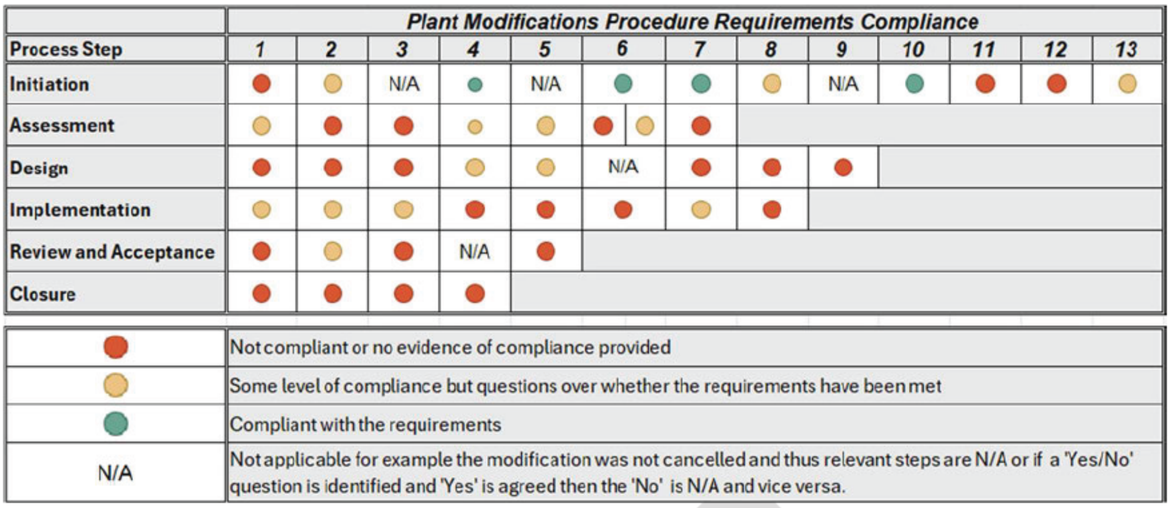


Figure 45 Compliance with the Plant Modifications Procedure for the Callide C battery charger replacement project

The green dots indicate compliance with the procedure, the yellow indicate partial compliance, and the red indicate no evidence of compliance. (Refer to the fuller explanations in the figure itself.) As discussed above, the Check Sheet was only completed and partially signed off in February 2018 during what was the Initiation stage of the project. Figure 45 above shows there is little evidence of compliance beyond this point.

A significant step in the Assessment stage, which was signed off on the Check Sheet as complete, was the risk assessment (the OPRA). The Procedure requires the Modification Officer to:

> *Assess risk in conjunction with other relevant specialists / disciplines as required. Use Operations Plant Risk Assessment Template. Basis of risk assessment: what potential hazards/risks may be introduced or current control measures affected by the proposed change?*

For the battery charger project, the OPRA involved just two people - the change Initiator and the Technical Services Manager (who signs off the Assessment stage of the Procedure). It did not involve other relevant specialists or personnel from other relevant disciplines. The OPRA covered the risk of plant interruptions if the chargers were not replaced, but it did not assess what '*potential hazards/risks may be introduced or current control measures affected by the proposed change*'.

Although no evidence of compliance has been located, steps in the later Design stage required the Modification Officer to:

> *Revisit risk assessment in conjunction with RPEQ's and relevant advisors in line with the final design.*
>
> *Consult / review with Stakeholders and gain Approval from RPEQ's / Advisors.*

Figure 45 shows that the Unit C4 battery charger replacement was not effectively managed as a change in accordance with the Plant Modification Procedure, despite the Procedure noting that management of change is a 'critical and essential element of a robust and comprehensive risk-based asset management and safety management system'.

20.5.5 Summary

It is not clear if the Callide C battery charger replacement projects were actually considered like for like replacements or plant modifications, as there is evidence of both positions. The project was repeatedly referred to in correspondence and some formal documentation as a like for like replacement, but a

Plant Modification Quality Plan and Check Sheet was initially completed, and there was an entry in the plant modification register.

Regardless, the project was able to progress to the return to service stage without any steps taken to enforce the use of the Plant Modification Procedure beyond the initial elements completed.

20.6 Pre-tender

20.6.1 CS Energy Email Seeking Quotes

As discussed above, from the very early stage of the project, it appears that the battery charger project was regarded as a straightforward swap of an old charger for new charger. This perception largely continued for the duration of the project.

The project did not start with an official tender process, but rather an informal email between CS Energy and Magellan Powertronics (referred to as Magellan). On 4 May 2017, the Technical Officer – Electrical emailed Magellan's Sales Engineer directly and requested a quote for a 900A DC battery charger:[289]

> Thanks once again for quoting on our inverter replacement.
>
> We are now also seeking quotes for the supply and installation of a 900A DC battery charger that will be used to charge a 220V battery bank.
>
> As per our inverter, our current charger is also reaching the end of its design life. I have attached the relevant section of our O&M manual but can assist if you require any further information. The required charger will need to be a 'straight' replacement for our current charger.

Figure 46 CSE.001.213.0044 Request for Quotation

It is unclear what section of the O&M manual was provided,[289] as there are seven sections spanning five documents.[290] The O&M manuals tend to focus on the configuration of the existing battery chargers, the maintenance routines, startup and shutdown procedures, and the ability of the DC system to be inter-connected via a trapped-key interlock system. There is no information in the O&M manual that indicates how the battery chargers were required to perform in dynamic switching operations.

Upon request from Magellan, the CS Energy Technical Officer provided a photo of the existing battery charger and its name plate. The photograph sent has not been located, however, for illustrative purposes Figure 47 is a photograph of a nameplate of one of the existing chargers, which was provided in the Specification for the Callide C battery charger replacements. Nameplates provide only basic information such as voltage and current.[291]

[289] We have not located the original email and so do not have the attachments to it. We have reviewed the email which is included in a longer email chain, CSE.001.213.0044.

[290] CSE.001.002.9237, CSE.001.010.3078, CSE.001.012.5762, CSE.001.012.5895, CSE.001.012.6374.

[291] Invitation to Tender (ITT) Section C – Scope of Work, for the Callide C 220V DC Charger and 240V AC UPS Replacement, Version: 1.

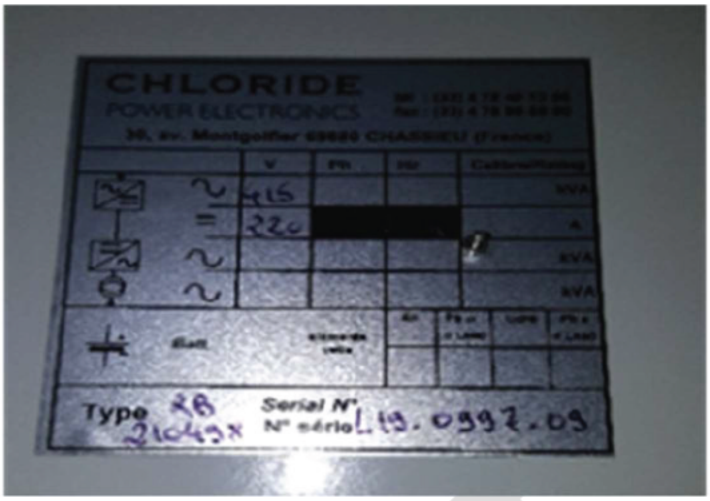


Figure 47 Old battery charger ratings plate

20.6.2 Magellan Provides a Quote

In response to CS Energy's request, Magellan provided a quotation on 19 May 2017.[292] This was then followed up with an amended quote on 7 June 2017,[293] which Magellan explained was due to a mistake in the original pricing provided by their transformer supplier.

The technical details provided by Magellan for the proposed battery charger was a brochure for a Magellan model MCRII DC Battery Charger, and the following (Figure 48):

[292] We have not been able to locate the quote provided on this date, but there is an email that makes reference to it.

[293] Email, CSE.001.213.0044, attached quote, CSE.001.213.0049.

MCRII Series Industrial Battery Charger with 220VDC and 900A output

Battery Charger:

- MCR-II series phase controlled Battery Charger, **Input:** 415Vac, 50Hz, 3 Phase
- **Output:** 220Vdc, 900A
- Australian made, Australian Standards compliant, Industrial type charger, rugged construction, high reliability with 30 years design life
- The product has the combination of the most rugged and reliable AC to DC conversion, which is transformer and thyristor bridge with the most advanced microprocessor controlled technology to ensure a 30 year design.
- Note: All cabling and internal layouts would be as per Magellan standards.

Protection:

- 3 Pole Input MCB
- Double Pole Battery Output MCB
- Double Pole Load Output MCB

Features Included:

- Alarm Relay Board (voltage free alarm relays – Mains Fail, Battery Fail, Charger Fail, DC High, DC Low, Earth Fault)
- Blocking diode
- Communication Board (RS232/RS485 Modbus, DNP3, TCP/IP, Web Server)
- Battery Temperature compensation

Enclosure:

- **C200-3** Enclosure *(1600mmW x 800mmD x 2000mmH)* RAL 7035 grey – IP-42 rated. This will accommodate the charger.
- **Top cable entry**
  (Please see brochure attached)

Battery Bank:

NA
(Battery Brochures are submitted with the proposal in separate .pdf file)

Figure 48 Details provided in Magellan's quotation dated 7 June 2017

The only questions raised by CS Energy in relation to the quote and details provided by Magellan were (with Magellan responses in blue, also dated 7 June 2017):[294]

Hopefully you guys have got the purchase order for the industrial inverter we have been discussing. Just had a few queries regarding the quotation you sent for the 900A battery charger.

1/ Please confirm that the cabinet will be suitable for top-entry of cables. Yes, top entry is ok. However, the dimensions will be now 2400mmW x 800mmD x 2000mmH

2/ Input voltage is listed as 415Vac, 3-phase. As a power generating site, our voltages are usually higher than their nominal rating. Could you please confirm the input tolerance (e.g. +-10%)? +/ 10% is not a problem. Would that be sufficient?

3/ The float voltage of the current charger is 240.8Vdc. Please confirm if this is possible with your charger. Yes, no problem, the float voltage will be 240.8VDC if you wish so.

4/ Is output voltage affected by input voltage? (I.E. If input voltage drops to 405Vac, should we expect to see the output DC voltage drop also?) No, its not, the output voltage is steady.

Figure 49 Queries to Magellan and Magellan's responses, 7 June 2017

The questions raised by CS Energy (as set out in Figure 49) relate to the operation of the battery charger under typical conditions.

[294] CSE.001.213.0044.

On 10 January 2018, this information was shared with the Technical Services Manager, and then sent on to the future Modification Officer for the battery charger project. The correspondence did not identify the reason for sharing the information, but the prices quoted by Magellan on 7 June 2017 appear to be the source of the $47,580 price quoted in an internal "justification" memo[295] (sent from Technical Services – Electrical team) dated 31 May 2017. It appears likely that the details were being provided to those that were taking the project forward.

20.6.3 Commencement

The justification memo[295] referenced in Section 20.6.2 was seeking approval of budget to replace the battery chargers in Unit C3, Station and Unit C4. The process was initiated because (as stated in the justification memo), the old battery chargers were requiring significant maintenance to keep them operational (with the associated costs), and there was a concern about the risk of loss of availability.

The memo states: "*These chargers would be a straight swap and require minimal commissioning.*"

20.6.4 Concept Gate Approval

The CS Energy project approval process appears to commence with a request for a "Concept Gate Approval", which is approval for the concept to be taken forward. The form appears to be mainly concerned with financial aspects of works.

A Concept Gate Approval request,[296] dated 17 January 2018, sought approval for the project (being the "Callide C UPS & battery charger replacement" project) from Concept to Execution. The work was described as "like for like replacement" on the Concept Gate Approval request form. The quote provided by Magellan on 19 May 2017 appears to be the basis for the budget included.

Documents indicate that the Concept Gate Approval was not given until July 2018[297].

20.6.5 Operations Plant Risk Assessment (OPRA)

The Plant Modification Procedure required an Operations Plant Risk Assessment (OPRA)[298] to be completed. This process should involve relevant specialists and disciplines to identify, assess and control "*potential hazards/risks that may be introduced or current control measures affected by the proposed change*".

The Check Sheet stated that (underline added for emphasis):

> *These customs [sic] made <u>critical power supplies</u> impose high LOA risk and must get replaced. The C3, C4 and station(C0) 220V DC chargers and 240V inverters are <u>used on equipment controls and instrumentation vital to the operations of Callide C station</u>.*

[295] CSE.001.213.0072. The quote from Magellan on 19 May 2017 has not been located but the quote dated 7 June 2017 of $69,000 was noted as being $21,420 more than the 19 May price and the memo states a price of $47,580 (i.e., $69,000 - $21,420).

[296] CSE.001.036.1593.

[297] CSE.001.036.1510.

[298] CSE.001.036.1952.

Despite describing the work as relating to a critical power supply, which impacted equipment vital to the operation of the power station, the OPRA completed on 18 January 2018 did not assess the risks of potential hazards being introduced nor what the impact on current control measures might be.

Instead, the OPRA only examined the risks associated with not replacing the battery chargers. It was essentially an options analysis between replacing and repairing the existing chargers, and it did not assess the risks of carrying out the replacement itself, including the risk to the DC system. Figure 50 shows a copy of the completed OPRA.

OPERATIONS PLANT RISK ASSESSMENT		
Activity	Callide C UPS and 220V Batteyr charger replacement	
Why do we need to carry out this activity?	Above chargers and inverters are original equipments since plant commissioning (2001) reached their useful life, internal electronic cards have started to failing due to aging and difficult to source the parts.	
Assessment Team's Residual Risk Level	SIGNIFICANT	
Assessment Team's Planned Risk Level	LOW	
Assessment Team's Recommendations	Option 1 is recommended	
Nominate the risks associated with this activity	Lack of project planning could impact completion delays. Risk = Low x Unlikely = Low	
Nominate the advantages of this activity	- Improved safety on operators and maintainers by replacing aged / unreliable equipment - Improved reliability of the plant and minimise potential LOA risk - Parts availability and new equipment design life is for rest of Callide C life -25 years - Reduced operating cost of repairs	
OEM's recommended action (if any)		
Risk Assessment Team Leader	[redacted]	
Risk Assessment Team Members		
Manager Review and Approval		
DATE APPROVED		DATE APPROVED TO (will need to be reviewed beyond this date)

Activity, Issue or Concept	Identified Hazards and Adverse Consequences	Existing Control Measures	Residual Risk Level: Consequence	Residual Risk Level: Likelihood	Recommended Control Measures / Treatment Actions	Planned Risk Level: Consequence	Planned Risk Level: Likelihood	Responsible Person
Callide C 220V battery chargers & UPS units are original equipments made in 2001, have already reached their end of life. We have already experienced two failure events of Callide C: station 220V battery charger and station invertor recently due to aged components. Above fault incident investigations and repairs involves with numerous amount of plant resources and time consuming to find out replacement parts .	Repairing these equipments will obviously be costly to design out the replacement with none OEM parts and it will also be a risk to unit production. In event of one charger or ups failure, there is a redundancy to feed from an other charger or feed UPS board from main switch board. Switching additional loads on to existing old chargers is not recommended considering aged equipments. Recovery of a failed charger will obviously be taken approximately 3-4 months. This could lead both units in to a significant LOA risk. **Operational Risk :** 30% probability for a 4 days unit down time for a temporary repair = one event per unit over next three years period is $725K	- Availability of system redundancy to configure the failed inverters out put to be fed from the main board - Failed 220V charger is in repair process - Failed station UPS was replaced with current UPS unit	Medium	Likely	**Option 1:** Upgrade with new chargers & inverters **Cost:** $500K **Risk :** Medium x Unlikely: Low	Medium	Unlikely	**Engineering / Asset management**
			Significant			Low		
					Option 2: Procure design out parts and change out at failure events. Use redundancy (other unit's charger/inverter) during repair period. **Parts Cost:** > $20K **Disadvantage**: Risk of LOA for design out ~$725K **Operational risk :** Medium x Possible : Moderate	Medium	Likely	**Engineering / Asset management**
						Significant		

Depending on the activity being assessed you will need to supply / attachment / link:

Supporting information

Equipment age / service duty / redundancy / modification history / maintenance history:

Failed 240V UPS - Repair was delayed due to lack of parts in market, This yunit was alraeady replaced with a new UPS

Failed 220V battery charger is waiting for replacement parts, and technical support after installation to return to service

Figure 50 Operations Plant Risk Assessment for the Callide C UPS and 220V battery charger replacement project, dated January 2018

If the plant modification procedure had been properly followed, and relevant specialists and disciplines had been involved to identify, assess and control potential hazards and risks associated with the change, the assessment would have increased the likelihood that of identifying the risks associated to bringing the DC system into service. Completed properly, the process would also have potentially provided awareness across the relevant Callide teams (and, depending on the residual risk level, escalation to more senior staff), of the work and the risks. This would have increased the likelihood of avoiding a major incident.

As it was, the OPRA was carried out by a risk assessment team comprised of only two people from the Asset Engineering Team. This included the Plant Engineer, who was also the Modification Officer, and the Technical Services Manager. As the risk assessment did not involve a range of disciplines, it lacked any scope for the consideration of risks outside the area of experience of these two personnel. Further, the Plant Manager and the Technical Services Manager are the only two signatories on the Check Sheet for non-financial and non-document management aspects, until the Review and Acceptance stage which occurs after implementation of the modification. So there was no input from any other fields to any aspect of the modification procedure which was carried out.

The OPRA found that while replacement of the battery charger reduced the risk from 'significant' to 'low', repair did not reduce the risk level. The Assessment Team recommended replacement as the preferred course of action. Because the residual risk was "low", the Risk Assessment was not required to be signed off by the Group Manager Assets. It did require sign off by the Technical Services Manager, but there is no evidence of this sign off (despite the Technical Services Manager being one of the two people who completed the risk assessment).

This OPRA was the only evidence of a risk assessment for the replacement of the Unti C4 battery charger, and it did not consider the risk associated with proceeding with the work.

20.6.6 JV Management Committee Approval

A further memo,[299] dated 28 February 2018, was sent to the JV Management Committee (JVMC) seeking approval of a budget of $500,000 for the replacement of three battery chargers and two inverters at Callide C (which is the project described in section 20.3). With the approval, the JVMC advised that further approval was not required, provided the cost remained below the approved budget.

This was the extent of JVMC visibility of the project.

20.6.7 The Plant Modification Quality Plan and Check Sheet

As discussed above, the only evidence that the Plant Modification Procedure was complied with at all (in part), is a partially completed Plant Modification Quality Plan and Check Sheet, and an entry in the Plant Modification Register.

A Plant Modification Quality Plan and Check List was completed for the stages of Initiation, Assessment and, partly, Design. All three of these sections were completed on the same date,[300] and all sections signed off for approval only one week later.[301] The form purported to cover the Unit C3 battery charger, the Callide C Station battery charger and the Unit C4 battery charger.

The four pages of the Check Sheet are in Figure 51 - Figure 54, but note that all signatures on the Check Sheet are dated prior to the battery charger project being tendered, including the signature in section 3(b), which is to indicate that design has been completed and is approved for implementation. It is not known on what basis the design was signed off in February 2018.

The modification was added to the Plant Modification Register (as one modification, even though the Check Sheet covered three battery chargers). But there is no evidence of the Plant Modification

[299] CSE.001.213.6777.

[300] 13 February 2018.

[301] 20 February 2018.

procedure being complied with from this point onwards. There is no other evidence of any compliance with the Plant Modification Procedure.

Title: PLANT MODIFICATION QUALITY PLAN AND CHECK SHEET
Form: S1977
Version: 10/16

csenergy

PLANT MODIFICATION QUALITY PLAN AND CHECK SHEET

Note: Refer to CS-AM-010 Plant Modification Procedure for further information

SITE:	☒ Callide ☐ Kogan Creek ☐ Wivenhoe	
STATION:	☐ A ☐ B ☒ C ☐ Common	☐ 1 ☐ 2 ☒ 3 ☒ 4

Modification Description:	CS21019 - Callide C 240V UPS & 220V battery charger replacement		
Plant Area Strategy:	CC-PAS-12-EQ08 & 09		
Plant KKS:	CC3*, CC4*, CC0*	**Plant Criticality (A,B,C,D):** (Refer to SAP Functional Location)	B

1	INITIATION						
1.1	SAP Notification Number	10531219 PR/18/~~24~~68 (CS~~21019~~) CS18548					
1.2	Problem Statement:	The Callide C Station power supplies are made in 2001 has reached their end of use full life. These customs made critical power supplies impose high LOA risk and must get replaced. The C3, C4 and station(C0) 220V DC chargers and 240V inverters are used on equipment controls and instrumentation vital to the operations of Callide C station. One 240V AC inverter was failed late last year and was replaced with a current invertor model due to high operational risk of LOA. Out of the three off battery chargers, one was failed last year and is not possible to repair due to incompatibility of parts available. Repairs of these custom-made equipment are costly and time consuming with significant resource involvement with complexity to source and redesign circuits around the ancient components. Concept paper C/D/18/819					
1.3	Suggested Solution:	Replace old charger and UPS units during FY19 and FY20 unit summer readiness opportunities					
1.4	Define Costs, Benefits & Justification:	• LOA risk reduction for rest of plant life; • Man, hours reduction on investigation and troubleshooting of obsolete equipment failures; • Spare parts and OEM service support availability; • NPV=$250,000; Pay Back 3 years.					
1.5	**Modification Endorsement** (Plant Engineer) Z3 Notification Status = CHECKED	☒ Yes ☐ No	[redacted]	Date	13	2	18
1.6	**Approval to proceed to Assessment** (Technical Services Manager) Z3 Notification Status = IN PROCESS	☑ Yes ☐ No	[redacted]	Date	20	2	18
1.7	Modification Officer (Nominated by Technical Services Manager)	[redacted]					
1.8	Prioritisation Score: "B/D/11/31607"	(Signature)	[redacted]	Score	250		
1.9	Preliminary assessment of Technical and Support Requirements. Refer to Section 3	(Signature)					
1.10	Z200 Work Order Number. Z200 Work Order Status = CREATED	No WO is required from above Z3 notification. A project work order will be created after on line approval granted					
1.11	Create TRIM folder and enter details into the Register	(Signature)	[redacted]	Date	13	2	18
1.12	Reference TRIM Record No. in the SAP Notification & Work Order:	(Signature)	[redacted]	Date	13	2	18

THIS DOCUMENT IS UNCONTROLLED IN HARD COPY FORMAT Page 1 of 4

Figure 51 Plant Modification Quality Plan and Check Sheet, page 1 of 4. This section has been completed in full except for part 1.9, though the Technical and Support Requirements in Section 3 had been completed.

Title: PLANT MODIFICATION QUALITY PLAN AND CHECK SHEET
Form: S1977
Version: 10/16

csenergy

2	ASSESSMENT						
2.1	Prepare Design Brief. (Modification Officer)	(Signature)	[redacted]	Date	13	2	18
2.2	Complete Risk Assessment for plant change:	What potential hazards or risks may be introduced or current control measures affected by the proposed plant change/s?					
		"B/D/13/15225"	TRIM Record No:	C/D/18/852			
	Risk Level – Introduced or affected by plant change:	(Residual Risk) ☒ Low	☐ Moderate	☐ Significant	☐ High		
	NOTE: "Significant" or "High" residual risks require Group Manager Assets to review and approve.						
	Comments:						
2.3	Risk Assessment Approval: (Technical Services Manager)	(Signature)		Date:			
2.4	Risk Assessment Approval: (Group Manager Assets)	(Approved for Significant or High Residual Risks)		☐ Yes ☒ N/A			
		(Signature)		Date:			
2.5	Financial Approval to Proceed to Design Phase (Note 1) (Financial Delegate)	Cost Centre	(Signature)	Date			
2.6	Technical Approval to Proceed to Design Phase (Technical Services Manager) Z200 Work Order Status = RELEASED	☑ Yes ☐ No	[redacted]	Date	20	2	18

Note 1
Costs for the completion of Phase 1 and Phase 2 (Initiation and Assessment) are carried by Technical Services.
Costs associated with Phase 3 (Design) are to be settled to the Cost Centre provided in 2.5 above.
If the modification is to be funded by Capital through the Project Management Framework, a Z210 work order is to be created and all future costs settled to the nominated internal order. Any costs settled to the initial Z200 work order are to be journaled to the internal order.
The Z200 must remain open until the modification is implemented and closed. This will allow for the electronic tracking of the modification status.

THIS DOCUMENT IS UNCONTROLLED IN HARD COPY FORMAT

Page 2 of 4

Figure 52 Plant Modification Quality Plan and Check Sheet, page 2 of 4. This section was completed as required with respect to the non-financial aspects, though quality of the Risk Assessment is questionable.

Title: PLANT MODIFICATION QUALITY PLAN AND CHECK SHEET
Form: S1977
Version: 10/16

csenergy

3 DESIGN				
3 (a) TECHNICAL AND SUPPORT REQUIREMENTS				
Technical and Support Requirements to be Revised / Created	REQUIRED Technical Services Manager must initial if checking "No"	FINALISED Technical Services Manager must initial each as "Finalised"	Description of what evidence is required to demonstrate completion.	Comments / TRIM Record No.
ITP:	☑ Yes ☐ No	☐ Yes	Hard copy of ITP	
Work Packs:	☐ Yes ☑ No	☐ Yes	List of the documents contained in the work pack.	
Plant Area & Equipment Strategies:	☑ Yes ☐ No	☐ Yes	Copy of relevant pages updated in Equipment Strategy.	
Drawings: (CS-AM-001)	☑ Yes ☐ No	☐ Yes	Copy of email confirming registration and attachment to functional location in SAP.	
O&M Manuals:	☑ Yes ☐ No	☐ Yes	Copy of email confirming registration and attachment to functional location in SAP.	
Process & Training Manuals: (Including Operating Procedures)	☑ Yes ☐ No	☐ Yes	Copy of revised operating procedures or advice to operators.	
Standard Isolation Sheets:	☐ Yes ☑ No	☐ Yes	Identification of any SIS that will be impacted.	
Return to Service Check Sheets:	☑ Yes ☐ No	☐ Yes	Documented commissioning and hand over procedure.	
Spares Inventory: (Old-Obsolescence, New – Additional spares, catalogued, BOM identified, standardisation)	☑ Yes ☐ No	☐ Yes	Copy of ZSIR. Copy of BOM.	
Safety Instrumented Systems:	☐ Yes ☑ No	☐ Yes	Copy of the entry in SIS dossier.	
Cable Schedules:	☐ Yes ☑ No	☐ Yes	Copy of entry in cable schedule.	
Lubrication Schedules:	☐ Yes ☑ No	☐ Yes	Copy of PM Change form for lubrication schedule.	
Statutory Registration – Design & Plant: (CS-AM-012)	☐ Yes ☑ No	☐ Yes	Copy of advice to DWPH&S.	
Fire Systems:	☐ Yes ☑ No	☐ Yes	Evidence of compliance with standards.	
KKS Database: (New / Delete)	☐ Yes ☑ No	☐ Yes	Copy of changes or additions to KKS numbering.	
KKS Plant Labels: (New / Delete)	☐ Yes ☑ No	☐ Yes	Photo of labels in place on plant.	
SAP Master Data: (Classification Data)	☐ Yes ☑ No	☐ Yes	Evidence from Planner of implemented changes.	
SAP PM Routines:	☐ Yes ☑ No	☐ Yes	Evidence from Planner of implemented changes.	
ICMS Screens:	☐ Yes ☑ No	☐ Yes	ICMS screen shot showing changes.	
ICMS Databases:	☐ Yes ☑ No	☐ Yes	Copy of Bemex page showing new settings.	
Pressure Equipment: (Register, Manual, Matrix, Forms)	☐ Yes ☑ No	☐ Yes	Copy of email from Chief Mechanical Engineer.	
Staff Training: (Effected Personnel Trained Appropriately)	☑ Yes ☐ No	☐ Yes	Details of training dates and training scope.	
Communication: (Change Effectively Communicated to all Personnel)	☑ Yes ☐ No	☐ Yes	Copy of communications to relevant staff.	
Hazardous Area Dossier:	☐ Yes ☑ No	☐ Yes		
Other:	☐ Yes ☑ No	☐ Yes		
Requirements Finalised: Technical Services Manager	(Signature)		Date:	

THIS DOCUMENT IS UNCONTROLLED IN HARD COPY FORMAT

Page 3 of 4

Figure 53 Plant Modification Quality Plan and Check Sheet, page 3 of 4, with the Technical and Support Requirements completed but not signed off by the Technical Services Manager.

Title: PLANT MODIFICATION QUALITY PLAN AND CHECK SHEET
Form: S1977
Version: 10/16

csenergy

3 (b)	**DETAILED DESIGN**					
3.1	Design Prepared:	☒ Yes ☐ No	TRIM Record No:	C/D/18/~~1873~~ 1874		
3.2	**RPEQ, Safety and Environmental Advisors – Approval to Implement:**	**Where discipline RPEQ or Advisor is not required, tick NO** (Technical Services Manager must Initial)				
	Discipline / Advisor	Required?	RPE Number	Name	Signature	Date
	Electrical (Power):	☐ No				
	Electrical (Control):	☐ No				
	Mechanical:	☐ No				
	Civil:	☐ No				
	Chemical:	☐ No				
	Risk & Safety Advisor:	☐ No				
	Environmental Advisor:	☐ No				
	Operations:	☐ No		[redacted]		
	Inventory Specialist:	☐ No				
3.3	**Design completed and Approval to Implement Modification:** (Technical Services Manager) Z200 Work Order Operation 010 status = FINAL CONFIRMED	(Signature)			Date:	20 2 18

4	**IMPLEMENTATION**			
4.1	**Is this project to be implemented as:** • Operational expense • Project capital • Overhaul capital	☐ Opex ☑ Project ☐ Overhaul (Signature) *Finance Representative*		Date:
4.2	**Implementation complete and in accordance with approved design.** (Project Manager or Delegate)	(Signature)		Date:
4.3	**Implementation complete and in accordance with approved design** (Modification Officer) Z200 Work Order Operation 020 Status = FINAL CONFIRMED	(Signature)		Date:
5	**REVIEW AND ACCEPTANCE**			
5.1	**Accepted for Operation:** Technical Services Manager	(Signature)		Date:
	Plant Manager, Production Manager. Z200 Work Order Operation 030 Status = FINAL CONFIRMED	(Signature)		Date:
6	**CLOSURE**			
6.1	Technical and Support Requirements Finalised.	(Signature)		Date:
6.2	Modification Work Order Closed.	(Signature)		Date:
6.3	Modification Register Finalised.	(Signature)		Date:
6.4	Modification File Closed. Z200 Work order = TECO	(Signature)		Date:

THIS DOCUMENT IS UNCONTROLLED IN HARD COPY FORMAT Page 4 of 4

Figure 54 Plant Modification Quality Plan and Check Sheet, page 4 of 4, with the Design signed off as completed and ready for implementation, even though the project had not even been tendered at this time.

20.6.8 Summary

The Plant Modification Procedure states that management of change is a critical and essential part of a risk-based asset management and safety risk management system, and recognises that changes can introduce new hazards or defects.

Although a Plant Modification Quality Plan and Check List was completed for the first stages of the Procedure, the delivery of the project did not follow any further stages of the Procedure. The stages that were completed were also not in accordance with the Procedure.

The key missed opportunity was to carry out a risk assessment which involved the relevant specialists and disciplines, to identify, assess and control potential hazards and risks associated with the change. Had this been done, the assessment would have increased the likelihood of identifying the risks associated with bringing the new battery charger into service. It would also have potentially provided awareness across the relevant Callide teams (and, depending on the residual risk level, escalation to more senior staff), of the work and the risks. This would have increased the likelihood of avoiding a major incident.

20.7 Tender

20.7.1 Technical Requirements

Despite receiving a quote from Magellan in May 2017 for the replacement of the battery chargers, CS Energy issued a tender package to the market in or around the end of April 2018 .[302] By way of technical requirements, it contained only the following for the Specification for the Callide C4 Battery Charger, under "Detailed Scope of Work" in the Invitation to Tender, Section C – Scope of Work document:

> *Input: 3 Phase, 415V, 50Hz,*
>
> *Output: 220V DC, 900Amp*

These the requirements are consistent with the battery charger in 'normal' operation. There was nothing in the Specification that specified requirements for the dynamic response of the charger required by the switching process. At a minimum, this would have included specification for how the charger was to operate when there was no battery connected, as well as how two chargers were to operate when connected to the same system (in other words, operated in parallel).

It goes on to provide the following information on the battery (which the battery charger was going to be connected to):[303]

> *Note: Callide C station 220V DC system consists of three battery strings.*

---

[302] Tender Documents (ref to be provided)

[303] There had been a planned change to the float voltage system for some time, but it had still not been implemented by the time of tendering of the C4 battery charger, so this was also included in the specification:

Callide engineering team has decided to change the current float voltage (240.84VDC) setting to 227.46V in a future modification. This modification will be applied by the time of implementation of these work. Therefore, the Contractor needs to be aware of the change in battery voltage.

> *Each C3, C4 and station (C0) battery strings consist of 108 off PowerLYTE PXL 2v2000 Valve regulated Lead- Acid (VRLA) Flame Retardant 2.23V batteries, replaced in year 2015.*

Notably, this once again specifies how the battery charger was to operate under normal conditions. It gives no information on how the battery charger was required to operate without a battery connected (as per the switching process on the day of the incident).[304]

20.7.2 Other Requirements

There was no further information specific to the design of the charger, and there was no detail about testing requirements.[305]

20.7.3 Risk Assessment

The only risk assessments required by the Specification were Job Safety and Environment Analyses (JSEAs),[306] which only focused on personal safety, and not process safety (in this case potential impacts the new battery chargers could have on the wider system).

20.7.4 Standard Specifications

The Specification referenced standard CS Energy and Australian Standards documents. The CS Energy standard documents did not provide information regarding operational requirements of the battery chargers.

20.7.5 Absence of Reference to AS 4044 – 1992: Battery Chargers for Stationary Batteries

The Australian Standard for battery chargers, *AS 4044 – 1992: Battery chargers for stationary batteries,*[307] was not referenced. This standard sets out the design requirements for the type of battery charger being procured.

The scope of AS4044, as described in the Standard is:

[304] The Concept Gate Approval request, dated 17 January 2018 says "Project execution could be done when units on line" and "Execution risk – No need of unit outages, can be done when units on line." (CSE.001.036.1593). The memo to the JV Management Committee seeking approval, dated 12 March 2018 says "Project execution can be undertaken with the units on line or off line" (CS.001.036.1603). The tender documents were issued to the market in April.

[305] The remainder of the Detailed Scope of Work section of the Specification contained requirements that were not specific to the equipment being supplied, such as "install new chargers and inverters" and "Test and commission, submit signed ITP's and test sheets". There were only general requirements for the contractor to provide inspection and testing data and certificates, and a commissioning plan. The test procedures required approval by CS Energy, but there was no guidance on what was required – CS Energy therefore relied completely on the supplier to prepare procedures that met CS Energy's requirements. Section 18.8.6 and 18.8.7 provide further details.

[306] Specified in section 2.1, Detailed Scope of Work – Supply of Services and Equipment, and section 6.1, Risk Assessment – Work Risk Assessment in the Invitation to Tender (ITT), Section C – Scope of Work.

[307] Australian Standards are subject to copyright so cannot be reproduced in full in this document. It is available at https://store.standards.org.au/product/as-4044-1992

1 SCOPE This Standard specifies requirements for stabilized constant-potential battery chargers that are designed to supply direct current power from an alternating current source, while charging a float-type stationary battery, and which may simultaneously supply power to a connected direct current system load.

Figure 55 Scope section from *AS 4044 – 1992: Battery chargers for stationary batteries*

This standard sets out the design requirements for such a battery charger, and the approach to testing. Specifically, Appendix A contains 'Information to be Supplied by the Purchaser', which sets out what the purchaser should specify to better ensure it gets the battery charger it requires. A copy of this is contained in Figure 56 and Figure 57.

APPENDIX A
INFORMATION TO BE SUPPLIED BY THE PURCHASER
(Informative)

1. Direct current loads (describe type): ____________________
   ____

2. Input voltage a.c. Nominal ____________
   Frequency ____________ Hz + ____________ Hz
   Phases desired ____________

3. (a) Battery type Lead-acid ____________ Nickel-cadmium ____________
   Other (specify) ____________
   (b) Capacity ____________ ampere hours at ____________
   hour rate to ____________ volts per cell
   (c) Number of cells ____________

4. Charge-discharge cycle Ampere hours removed from battery during power failure ____________
   Allowable recharge time ____________ hours

5. External load on charger during recharge period: Amperes minimum ____________ amperes maximum ____________
   Describe duty cycle ____________

6. Factory preset output voltage range
   (a) Floating ____________ volts minimum to ____________ volts maximum
   (b) Equalizing ____________ volts minimum to ____________ volts maximum
   (c) Boost ____________ volts minimum to ____________ volts maximum
   (d) Ripple voltage ____________ %
   (e) Noise ____________ level and method of measurement to be specified by the purchaser

7. Mounting Wall ____________ Floor ____________ Relay rack size ____________
   Portable ____________ Other (specify) ____________

8. Maximum dimensions Height ____________ Width ____________ Depth ____________

9. Type of finish ____________

Figure 56 Appendix A from AS4044-1992, page 1 of 2

AS 4044—1992 10

10. Other requirements:

- ____________ 0 to 24 hour equalizing timer
- ____________ 0 to 72 hour equalizing timer
- ____________ Ground detector switch (voltmeter)
- ____________ Ground detector lights
- ____________ Ground detector alarm relay
- ____________ a.c. power failure alarm relay*
- ____________ d.c. low-voltage alarm relay*
- ____________ d.c. high-voltage shutdown circuit*
- ____________ d.c. high- and low-voltage alarm relay*
- ____________ Charger failure (loss of output) relay*
- ____________ Low d.c. current alarm relay*
- ____________ a.c. pilot light
- ____________ IP rating
- ____________ a.c. line filter
- ____________ Parallel operation (describe) ____________
- ____________ Load sharing
- ____________ Temperature compensation

* Specify time delay, if any.

11. Any other information ____________

NOTE: Unusual service conditions may require specific design considerations and the following unusual service conditions should be brought to the attention of the manufacturer:

(a) Exposure to damaging fumes.
(b) Exposure to vapours of oil or other substances.
(c) Exposure to excessive moisture.
(d) Exposure to steam.
(e) Exposure to weather or dripping water.
(f) Exposure to salt air.
(g) Exposure to excessive dust.
(h) Exposure to abrasive dust.
(i) Exposure to abnormal vibration, shocks, or tilting during transportation or operation.
(j) Exposure to unusual transportation or storage conditions.
(k) Exposure to unusual electromagnetic fields.
(l) Operation at ambient temperature below 0SC (32SF) or above 50SC (122SF).
(m) Operation at altitudes above 1000 metres (3300 feet).
(n) Exposure to abnormal radiation.
(o) Exposure to insects, vermin, or fungus.
(p) Operation with switching or negative resistance loads.
(q) Operation without a battery.
(r) Operation from a supply with a high level of distortion.

Figure 57 Appendix A from AS4044-1992,[308] page 2 of 2

20.7.6 Concept Gate Approval

The Concept Gate Approval was not given until 10 July 2018, to take the project from concept to feasibility.

20.7.7 Feasibility Gate Approval Request

On 13 July 2018 a Feasibility Gate Approval request[309] was prepared for the three Callide C battery chargers and the two inverters. This is primarily concerned with financial aspects of the project.

An approval of the Feasibility Gate Approval request has not been located.

20.7.8 Tender Assessment

CS Energy received six tenders from parties invited to tender for the Callide C work which included the replacement of three battery chargers (including Unit C3, Unit C4 and Station) and two inverters. Refer Table 6.

Table 6 Tender prices received for the Callide C project

Party	***Tender Price***	***Tender Evaluation Score***
Century Yuasa	$584,149.49	6.69
CPS National	$639,194.10	2.28
Magellan Power	$531,800.00	6.55
Prysmian	Declined	N/A
Voltstar	$406,540.00	1.75

In the tender assessment Magellan Power scored marginally lower than the top scoring tender submitted by Century Yuasa. There was, however, an error in the compilation of the scores: Magellan Power's final score should have been 7.682, compared to 7.5985 for Century Yuasa's tender – a very similar score. Magellan's price was cheaper than Century Yuasa by approximately $52,000.

The technical review of Magellan's tender[310] noted (amongst other things):

(a) "2 page brochure supplied for battery charger. No technical info on any electrical equipment" and

(b) "equipment standardised against existing installed plant. No additional requirement for modifications, training, tooling, or parts stocking/allocation".

Magellan was scored an 8 out of 10 against the technical criteria: "meet required technical specs", despite there being no technical information provided in the tender. There is no evidence that indicates further information was provided to Magellan, or that Magellan made enquiries to obtain further information about how the battery charger was to operate. There is no evidence of how CS

[308] AS 4044 – 1992: Battery chargers for stationary batteries.

[309] CSE.001.036.1505.

[310] CSE.001.080.0121.

Energy satisfied themselves that Magellan should score 8 out of 10 given they had provided 'No technical info on any electrical equipment'.

20.7.9 Contract Award

In addition to the tender for the Callide C battery chargers and inverters replacement project, Magellan had also tendered on two other projects. At the end of June 2018, it was recommended by the Plant Engineer that Magellan be awarded the Callide C[311] at the same time as two other projects, primarily because of the perceived potential to negotiate the prices down for all three projects, see figure below.

> I have also put together the attached tender summary document taking into account the following associated works;
>
> 488466 B2 220V DC Charger and 240V AC UPS Replacement
> 488445 Callide B1 B2 48V DC Charger Replacement
>
> Given the similar nature of all three packages, and potential commercial, execution, and project management synergy's I am recommending that we award all three packages to Magellan. As a result I would recommend that we contact Magellan advising them as such in order to obtain a more competitive price.

Figure 58 CSE.001.216.7579 Recommendation to award.

A final price for all three projects of $1,232 070 was agreed with Magellan (reduced from the tendered total price of $1,310,830), with the Callide C project price reduced to $506,000 from $531,800.00. The contract for the three projects was executed on 2 October 2018.

The information submitted by Magellan, and the notes from CS Energy's assessment of Magellan's tender (including the high technical scoring), suggest that neither party understood the full operational requirements of the battery charger. The evidence suggests that the battery charger project was being treated as if it was only a battery charger, as opposed to a critical piece of equipment.

20.7.10 Summary

The Specification contained in the tender documents issued by CS Energy for the battery charger project specified the requirements for the Unit C4 battery charger under 'normal' operation. There was nothing in the Specification that specified requirements for the dynamic response of the charger required by the switching process used to bring the new battery charger into service.

The Specification also failed to make reference to *AS 4044 – 1992: Battery chargers for stationary batteries*, which sets out the design requirements for the type of battery charger being procured.

The tender submitted by Magellan Powertronics lacked technical information about the battery charger it proposed to install, but CS Energy anticipated that a reduced price could be obtained from Magellan if the Callide C battery charger and inverter project was awarded to Magellan at the same time as two other battery charger and inverter projects at Callide B, which it did, and so all three projects were awarded to Magellan.

[311] CSE.001.216.7579.

20.8 Project Delivery

20.8.1 Challenge to the 'Like for Like' Position

Prior to the execution of the contract in October 2018, and although the battery charger replacements were being treated by the project team as like-for-like replacements, there appeared to be some within CS Energy who regarded the work as Plant Modifications.

On 2 July 2018, it was flagged by Head of Projects that the 'MOD' forms needed to be completed before they would sign off the Callide C battery charger replacement project.[312] at the time of approval of the Concept Gate on 10 July 2018,[313] the Major Projects Services Manager / Project Governance Manager approved it to the feasibility stage, but stated "*Get plant change request signed off as the design is been [sic] done by a third party*".

As discussed, although the Plant Modification Procedure was commenced for the battery charger project, there is no evidence it was completed. The Modification Officer / Project Manager / Asset Engineering Electrical Engineer, replied that the MOD form was "updated and attached" in reply to the direction relating to the 2 July 2018 sign off,[314] but no MOD form updated since February 2018 has been found.

There is no evidence that the MOD forms were completed and the mod closed out. There was also no evidence that the directions to complete the modification forms were followed up on to ensure it was done.

20.8.2 Change of Key CS Energy Staff

In January 2019,[315] CS Energy's Technical Lead for the project left CS Energy, and the Project Lead was handed over to a new starter to CS Energy. It is not clear who was intended to be assigned as the new Technical Lead, and it appears initially, no-one was.

20.8.3 Magellan Commence

Magellan commenced work based on a purchase order for the Callide C 220V DC Charger and 240V AC UPS Replacement project[316] around 10 August 2018. The Unit C4 battery charger was originally part of Phase 2[317] of the program, which was due for delivery in January 2019.[318]

It is unclear why, but the Unit C4 Battery Charger work was delayed, and in March 2019 the focus was on the Unit C3 Battery Charger, which appears to be the first item for delivery by Magellan under its contract for the Callide C work.

[312] CSE.001.216.7657. It is not completely clear what sign off is being referred to as we have not located the original email and its attachments, but it is believed to be in relation to the Feasibility Gate Approval request.

[313] CSE.001.036.1510.

[314] CSE.001.216.7657. We do not have the original email or the attachments, but email is in the email chain in this file.

[315] CSE.001.100.0002.

[316] CSE.001.217.9061.

[317] CSE.001.217.8873.

[318] CSE.001.218.1584.

20.8.4 Magellan Issues

At this point in the project, there appeared to have been a more concerted effort, driven by the new Project Lead, to impose some rigour to the battery charger project.

On 12 and 13 March 2019, the Project Lead requested[319] several documents from Magellan including the detailed schedule, ITP (inspection test plans) and commissioning plans, and JSEAs (Job Safety ad Environment Assessments) and SWMS (Site Work Method Statement) for the Unit C3 Battery Charger.

On 13 March 2019 the Project Lead also emailed the CSE Manager – Electrical Instrumentation and Controls[320] and, with reference to the Unti C3 Battery Charger, suggested "that CSE step in to establish QA, ITP & Commissioning plan expectations. This can be benchmarked for the remaining 13 units."

The next day, on 14 March 2019, the Project Lead sent a further email[321] to the CSE Manager – Electrical Instrumentation and Controls[322], raising concerns about the compliance of previously installed inverters and charger cubicle designs managed by staff who had moved on from CS Energy, when the specification for the works is compared against the specification for the original Hitachi equipment's specification, and suspects that they won't be compliant with the CSE Preferred Equipment Standards (which was a requirement of the contract), ending with:

> "*It looks as though we have all inherited a real cluster*."

In a follow up email[323] they noted "*it looks as though the Callide C 900A & Callide B 500A 220V Charger designs have not been reviewed and vetted by CSE*" and attached an email[324] from Magellan flagging that this had not been done. (Section 2.1 of the Invitation to Tender (ITT) Section C – Scope of Work required "Issue draft drawings to CS energy site contact for execution approval by RPEQ Engineer. This includes schematics and the equipment GA drawings.") The Project Lead notes that to do this exercise at this stage would be retrospective (as the manufacture of the battery charger was already underway).[325] There is no evidence that this was completed.[326]

---

[319] CSE.001.100.0100.

[320] CSE.001.100.0100.

[321] CSE.001.100.0907.

[322] CMP-TL-0045 – Standard Specification – Preferred Electrical Equipment specifies the manufacturer, make and in some cases model required for supply and purchasing of electrical equipment at CS Energy sites, and applies to any work undertaken for CS Energy whether by contractors and subcontractors or CS Energy staff. It specifies items such as circuit breakers, control valves and actuators, light fittings, plugs and sockets.

[323] Email: CSE.001.100.0851.: CSE.001.100.0864.

[324] CSE.001.100.0864. This was an email from Magellan highlighting that the drawings for the 500A and 900A chargers had not been approved by CS Energy.

[325] Correspondence indicates that by March 2019, at least one of the Callide C chargers was manufactured and work on the other two had commenced: CSE.001.218.1584, dated 5 October 2018, states that purchasing for phase 2 (which includes the second and third charger) would have commenced; CSE.001.218.2186 dated 6 November 2018 says "Callide C charger assembly would be in progress by now"; CSE.001.218.3840, dated 11 January 2018 says that the Callide C station battery charger was to be installed in March 2018.

[326] Drawings for the Callide C Station battery charger were signed off as preliminary by CS Energy in August 2018, CSE.001.055.1593, and for construction in September 2018, CSE.001.055.2655, but no signed off drawings have been located for Unit C4 battery charger.

On 19 March 2019, the Project Lead proposed internally[327] that CSE should prepare some documents to "*assist with the Magellan battery charger & UPS projects*", which included an ITP and commissioning plan, and a Manufacturing Data Report[328] (MDR). This suggestion was soon after the email of 14 March 2019, and coincided with a request by CS Energy on 20 March 2019 for Magellan to provide a MDR for equipment supplied by Magellan (the email is not specific about which piece of equipment). Magellan's response indicated that they were not familiar with providing an MDR.[329] There is no evidence of a response to this request.

The procurement of the battery chargers (and other items of equipment) from Magellan was troubled by many issues originating from Magellan. The frequency and nature of these issues should have been identified as a significant risk to the battery charger project. But they were not, and in particular these issues were not considered in the planning for the battery charger's return to service.

20.8.5 Discussion of Installation Date

On 5 March 2020[330], the Project Lead advised that the Unit C4 battery charger would be installed by Magellan "during the C4 mini overhaul". The "Callide C4-Minor FY20" overhaul was originally planned for 4 April 2020, but was deferred to 1 August 2020 due to COVID-19.[331]

It appears the work on the Unit C4 battery charger was then further delayed. On 24 November 2020 the Project Lead emailed Magellan[332] enquiring about progressing the work. They then followed up on 30 November 2020, directing that the work should be pushed back to January 2021, which appeared to be due to internal CS Energy workload.

On 5 Jan 2021 Magellan provided[333] the commissioning plan, ITP and Installation report to CS Energy for review. It took some time for Magellan to provide further documentation required by CS Energy and on 10 February 2021, the forward switching for the C4 Charger was rescheduled to 15 Feb 2021.[334]

Due to the delays in the completion of the Unit C4 battery charger replacement, by May 2021 there was pressure being felt to get the new battery charger into service.

20.8.6 Commissioning and Testing

Magellan was required to carry out various tests and provide evidence that the battery chargers they supplied met the requirements of the specification.

This included a Factory Acceptance Test (FAT), which is carried out at the location of manufacture before it is shipped to site. For the Unit C4 battery charger, this tested that the battery charger was capable of operation with respect to the specification. It also included a start-up test, which tested that

---

[327] CSE.001.100.0899.

[328] A Manufacturing Data Report (MDR) is used in manufacturing to demonstrate that a manufactured product is in accordance with specified standards.

[329] CSE.001.100.0946.

[330] CSE.001.100.0897.

[331] CSE.001.079.7103, CSE.001.100.0083.

[332] CSE.900.002.0165.

[333] CSE.001.056.5699.

[334] CSE.001.100.0912.

the required output was achieved, as well as the time it took to reach that output level. There is no evidence that the FAT considered the requirements of the switching sequence.

The Site Acceptance Test (SAT) was almost the same as the FAT, and it was carried out by Magellan Power, as the manufacturer, at site where the battery charger was installed. It was carried out before the battery charger was connected to the live system. Some tests conducted in the factory were not repeated on site.

The specification required certain documentation to be prepared by Magellan, as well testing to be carried out by or on behalf of Magellan, to demonstrate that the battery charger supplied met the requirements of the specification. These were as follows.

(a) The Inspection Test Plan (ITP): Prepared by Magellan, this plan set out the full suite of checks and tests to be undertaken to confirm the correct operation of the battery charger. However, the commissioning and testing focussed on confirming the battery charger was capable of operating in its 'normal' manner, as opposed to the requirements in the switching process. There is no evidence that the ITP considered the requirements of the switching process.

    The ITP was signed off by CS Energy as accepted on 22 April 2021.[335]

(b) The Factory Acceptance Test (FAT):[336] This test also checked that the battery charger was of operating in the 'normal' manner, such as working with the required input power and putting out the required power. A start up test was conducted, which tested that the required output was achieved, and the time it took to reach that output level. There is no evidence that the FAT considered the requirements of the switching process.

    A copy of the FAT provided, and signed off, by Magellan, has been located but we have not located a copy countersigned as approved by CS Energy.

(c) The Site Acceptance Test (SAT):[337] This test was almost the same as the FAT, but some of tests conducted in the factory were not repeated on site. There is no evidence that the SAT considered the requirements of the switching process.

    There is a copy of the SAT, signed off as approved by CS Energy on 22 April 2021, but there is another version[338] on which the section indicating compliance with CS Energy standards has been updated to "N", dated 6 May 2021. Figure 59 contains a screen shot of this updated section of the form.

[335] CSE.001.056.8892.

[336] CSE.001.056.8899.

[337] CSE.001.056.8886.

[338] CSE.001.004.0151.

CS Energy Technical Standards	Compliant (Y/N)	Departures/ Comments
C/D/17/11568 Standard Procedure - CMP-TL-0047 - Standard Specification - Electrical Equipment Installations (08/2017) - Callide Registered	N Y [redacted]	
C/D/17/16301 Standard Procedure - CMP-TL-0045 - Standard Specification - Preferred Electrical Equipment (08/2017) - Callide Registered	N Y [redacted]	
C/D/17/11564 Standard Procedure - CMP-TL-0048 - Standard Specification - Electrical Design Criteria (08/2017) – Callide Registered	N Y [redacted]	

Contractor Approval	
Name/ Position	[redacted]
Signature	[redacted]
Date	22/4/2021

CS Energy Approval	
Name/ Position	[redacted] Asset Engineer
Signature	[redacted]
Date	22/4/21

Figure 59 Excerpt from Site Acceptance Test for the unit C4 battery charger

In response to an email, in which the CS Energy Project Lead proposed internally that CSE should prepare some documents to "*assist with the Magellan battery charger & UPS projects*",[339] a CS Energy electrical engineer 'finds' AS4044.[340] It seems that up until this point, nobody involved on the battery charger project had been aware of this Australian Standard. It appears it was referred to in the development of testing in the FAT and SAT, as these incorporate some tests listed in Appendix A to AS4044.[341]

The commissioning plan[342] (which sets out the actions to be undertaken to prepare the equipment for service) required checks for incoming and outputting power, including the effects of various circuit breakers operating, and the performance in charging the batteries (including in the context of a battery discharge test). The only test associated with switching the charger on, was that there was output voltage available.

The Installation plan involved a list of visual checks for physical installation (such as correct labels and correct cables) and an attached punchlist (which documents the incomplete or deficient items which need to be addressed prior to the work being considered complete. The punchlist items are categorised in accordance with criticality). The ITP required that the punch list was closed out prior to the battery charger being handed over to operations to be returned to service.[343]

Also on 22 April 2021,[344] just a month before the incident, there was internal CSE email discussion about the rating of the Unit C4 battery charger. In the design, Magellan assumed a battery temperature based on an airconditioned room, but it should have been designed with an assumed ambient air temp of 40°C. Due to the lower design temperature assumed by Magellan, it was considered by the CS Energy Asset Engineers Electrical that the charger should be downrated from

339 CSE.001.100.0899.

340 CSE.001.100.0899.

341 CSE.001.100.0901.

342 This is the commissioning plan prepared by Magellan, CSE.001.056.5701.

343 Email correspondence shows that CS Energy required only the Category A punch list items to be closed out before bringing the battery charger back into service. CSE.001.225.1508, CSE.001.056.8872. The punchlist dated 14 May 2021, CSE.001.056.8898.

344 CSE.001.100.0924.

900A current limit to 650A, in order for the charger components[345] to operate within safe limits. The impact of this would be that the battery charger could not supply 900A if loads demanded it, though it was considered that this would not be an issue. It was very unlikely that this would ever occur, and if it did it would be possible to safely manage the systems to avoid problems. It would also have had the effect of taking longer to charger the batteries due to the lower current.

But it was ultimately agreed by the Manager, Electrical Instrumentation and Controls, that the battery charger should be rated at the full 900A because the battery room was airconditioned, and the room would be monitored, and if the average ambient air temp went above 25°C, the rating could be reduced.[346] They also noted that operationally, it wasn't expected that the battery charger would be run above 650A.

The ITP was fully signed off by 22 April 2021, even though there were items still open on the punchlist. It also allowed the commissioning checklist to be closed out sufficiently to allow the RTS of the charger. A copy of the punchlist immediately prior to 25 May 2021 has not been located, but other than the issue relating to the rating of the battery charger, many of the other items on the punchlist related to documentation or items that could be addressed after the return to service. None of the items were material to the incident.

20.8.7 Project Resources stretched

The project team was under resourcing pressure for much of the delivery timeframe. there is evidence of the Project Lead asking for engineering support and it not being supported.

Variation documents, dated 19 February 2019, were submitted by the Project Lead for approval of a variation of $164,000 for the Callide C Battery Charger & UPS Projects.[347] The variation was primarily related to additional project management required on the projects.

The variation appears to have been rejected.[348]

In mid-June 2020 the Project Lead had to ask around for budget[349] in order to keep the contract engineer working on the battery charger project for longer. The contract engineer had been brought on originally because the CS Energy engineering team was too stretched to be able to properly support the project.

The Project Lead of the battery charger project was managing three projects of high complexity, one project of medium complexity and two projects of low complexity, all at varying stages of delivery. At various time additional resources were requested to assist with the workload.

20.8.8 Time Pressures

The Unit C4 Battery Charger project was running years behind schedule, partly because of the effects of COVID-19 in delaying production and travel to the Callide site. By early 2021 there was a growing urgency to bring the new battery charger into service. This was in part due to an unexplained sawtooth

[345] The busbar in the battery charger has a limit on current it can operate at in order to avoid overheating. An increase in ambient temperature reduces the operating current limit of the busbar and therefore the battery charger.

[346] CSE.001.225.1508.

[347] CSE.001.036.1543.

[348] CSE.001.036.1611.

[349] CSE.001.100.1172.

wave in the DC supply to Unit C4 from Station[350] that could not be investigated until Unit C4 could be separated from Station. There was also a recognition that there was a risk related to the lack of system redundancy while the new Unit C4 Battery Charger was not in service.[351]

By 4 May 2021 there were alarms on Unit 4 from Station 220V supply, prompting the Project Leader to seek internal feedback as to whether they were "*comfortable enough to place C4 charger back in service?*"[352] There were punchlist items that would normally be closed out before switching the battery charger into the larger system, but it was determined to be acceptable for these to be closed out later.

On 13 May 2021 and again on 16 May 2021, Shift Supervisors were pushing to have the C4 Battery Charger brought back into service[353] as it had been "*sitting waiting for a while now*."

On 24 May 2021 the Project Lead asked the Supervisor Maintenance to process with the return to service of the battery charger.[354] Although there were still some open items on the punch list, they noted that these can be resolved after the unit is back online.

20.8.9 RPEQ Sign Off and Punch List

Magellan Signoff

It wasn't until 8 March 2021 that Magellan provided the first lot of RPEQ signed off as-built drawings for the Unit C4 battery charger.[355] Initially Magellan stated that RPEQ sign off wasn't required under the contract (on 24 February 2021),[356] and in the email exchange with the CS Energy Project Lead, the Project Lead notes that this had been already covered off with Magellan staff "several times". Magellan engaged a third party to provide the RPEQ sign off. We have not located a clear statement of when the RPEQ sign off was completed but it seems to have occurred around the end of April 2021.[357]

In April 2021 CSE followed up with Magellan several times to close out items on the punch list[358] for C4 battery charger. On 21 April 2021 the Project Lead advised[359] internally that Magellan had closed out items satisfactorily enough that one Category A item could be dropped to a Category B so that "RTS activities" could be continued that afternoon.

However, on 23 April 2021 the Project Lead confirmed that the C4 charger wasn't to be put back into service until the project commissioning checklist had RPEQ lines signed off by CS Energy.[360] There were also still some items on the punch list that needed to be closed out before the charger could be put into service. On 4 May 2021 the Project Lead sent an internal email to the engineers asking "Are we

[350] CSE.001.102.0076, CSE.001.102.0238, CSE.001.54.0285.

[351] CSE.001.225.1756.

[352] CSE.001.056.8872.

[353] CSE.001.045.0001, CSE.001.102.0275.

[354] CSE.001.045.0004.

[355] CSE.001.100.0924.

[356] CSE.001.100.0952.

[357] CSE.001.056.8872.

[358] CSE.001.056.8898.

[359] CSE.001.225.1508.

[360] CSE.001.100.0943.

comfortable enough to place the C4 Charger in service?"[361] They noted that there were still some issues, but that they were administrative and so could be managed via the punch list and contractual mechanisms.

On 7 May 2021 the Project Lead advised the battery charger had been released for service and required Magellan to confirm rectification actions for items on the punch list by 14 May 2021.[362]

On 14 May 2021, Magellan returned the updated punch list,[363] where Magellan had added proposed rectification actions. They also provided the FAT for sign off by CS Energy,[364] SAT test results signed off by CS Energy,[365] signed off ITP and installation report[366] for the C4 battery charger, the latter noting that some Category A items not yet closed off but needed to be by the end of Stage 3 commissioning which is when the unit is energised but not yet returned to service.

CS Energy Signoff

On the 4 May 2021, the Project Lead emailed[367] internally noting that the "*remaining issues are administrative & can be managed through the Punchlist & contractual / payment withholding processes.*"

The Project Commissioning Checklist[368] was signed off by the CS Energy RPEQ on 6 May 2021, which indicated that the battery charger was released for commissioning and available for return to service. A screen shot of the signed sections of the form are in Figure 60.

4.1.6	Project released for commissioning			6/5/2 [redacted]
4.1.7	Project available for RTS			6/5/2 [redacted]

Figure 60 Project Commissioning Checklist for CC4BTL10 (the Callide C4 battery charger)

20.8.10 Release for Service

On Friday 7 May 2021 the battery charger was released for service.[369,370] As above, the punch list and ITPs were followed up for close out with Magellan. There were some follow up communications from

[361] CSE.001.056.8872.

[362] CSE.001.056.8872.

[363] CSE.001.225.0073.

[364] CSE.001.225.0074.

[365] CSE.001.225.0088.

[366] CSE.001.225.0094.

[367] CSE.001.056.8872.

[368] CS Energy document, for Callide C4, CC4BTL10, TRIM Record No C/D/21/3561.

[369] CSE.001.056.8872.

[370] CSE.001.225.0059.

shift supervisors about completing the return to service.[371] The preparations for the return to service were carried out.[372]

The project team was feeling the pressure to get the new battery charger into service, for a variety of reasons. This is discussed further in section 20.8.8.

20.8.11 Initial Startup

After the completion of the commissioning and the return of the Permit to Work, the switching of the new battery charger was handed over to operations and was no longer being dealt with by the project team.

On 24 May 2021, there was an attempt to start up the new Unit C4 charger, using Magellan's start-up procedure. The charger behaved in a strange manner, with erratic current and voltage readings, and the DC output breaker tripped, followed by abnormal sounds from within the charger. The start up was abandoned. CS Energy contacted Magellan by email,[373] requesting clarification on the start up procedure, We have not located a response from Magellan, but a second attempt was made and the charger started. The C4 batteries, which had a low charge after being isolated since 8 Feb 2021, were charged overnight.

20.8.12 Return to Service

At this point a battery charger had been specified and installed without consideration of the switching process. Further all testing conducted was with respect to specification, so none of the tests confirmed the effectiveness of the battery charger in the switching process. At this point the battery charger was about to be put into service using a switching process that had neither been designed or tested for with Unit C4 online and exporting.

On 25 May 2021 the switching process was undertaken and the battery charger failed to maintain the voltage in the Unit C4 DC system pick up the load of Unit C4 after the interconnector between Station and Unit C4 was opened.

20.9 Summary

The procurement of the new Unit C4 battery charger was characterised as a like for like replacement from the very earliest stage of the project, and this had a significant influence on the way the project was conducted, most notably in the disregard of the Plant Modification Procedure.

The lack of oversight and review, and particularly the lack of proper risk assessment and risk management, meant the effects of the shortcomings of the project Specification were not identified and mitigated until late in the project, and the substandard competency of Magellan Power was not acted on until the battery charger had already been manufactured, and at best, only damage control was possible.

---

[371] CSE.001.045.0001, CSE.001.102.0275.

[372] CSE.001.003.1999.

[373] CSE.001.100.0884.

Also, the requirement for the battery charger to act as the sole source of DC supply during the switching in sequence, remained unaddressed, (and unknown), and the battery charger designed and installed was unsuitable for its use.

20.10 If the Plant Modification Procedure Been Followed Effectively

Central to the effectiveness of the Plant Modification Procedure is the risk assessment, which is required to be carried out in the second stage of the Procedure (Assessment) and reviewed during the Design stage, in light of the final design. The Procedure requires[374] that "*risk is assessed in conjunction with other relevant specialists / disciplines as required*" and the basis of the risk assessment is "*what potential hazards/risks may be introduced or current control measures affected by the proposed change*" and that the review involve RPEQ's and advisors.

While it cannot be said that compliance with the Procedure would have enabled avoidance of the incident, had the risk assessment been carried out in accordance with the Procedure, this would have significantly increased the likelihood of identifying potential issues and putting mitigation measures in place.

20.11 Summary of Shortcomings of the Plant Modification Procedure

The Procedure touches on the things that are important for the adoption of a change into a process – risk assessment, design in accordance with relevant standards and review and approval, identification of records that must be updated, identification of people to be engaged with. But it has a number of deficiencies:

- The failure to require oversight of the determination that work is not a plant modification (and therefore does not need to follow the Procedure). This means works that are actually modifications, with the associated risk, can bypass the Procedure.
- A "one size fits all" approach. A process which is too onerous for minor modifications will be worked around, which will become the norm for all modifications.
- There is no clear direction for grouping or separating modifications for the purposes of the Procedure.[375]
- There is a lack of specific direction for the risk assessment, including specific requirements for who should be involved in order to maximise the quality of the risk assessment. The risk assessment is a key element of this Procedure.
- The risk competency within CS Energy is a wider issue than this Procedure, but it does significantly impact the Procedure.
- There is no requirement for the preparation of a technical specification that provides clear design requirements.

[374] Plant Modification Procedure, CS-AM-010 dated 06/10/2016, section 5.2 – Assessment.

[375] For e.g. the Check Sheet for the battery charger project included the three Callide C battery chargers, which were being introduced to different parts of the power station at different times, so they were not able to be assessed for risk, or managed in the systems as individual items of work.

- The Procedure can be easily compromised (intentionally or unintentionally) without a mechanism for prevention or detection.

Further details of the shortcomings of the Plant Modification Procedure are provided in Appendix X.

21 THE UNIT C4 AUTOMATIC CHANGEOVER SWITCH

21.1 Introduction

The Unit C3, Station and Unit C4 DC systems each have has a switch, known as the automatic changeover switch (ACS)[376]. This ACS can automatically respond to a loss of DC supply in one of these systems to partially restore DC supply. In the case of Unit C4, the ACS is located between the Unit C4 main board and Unit C4 distribution board, see Figure 61.

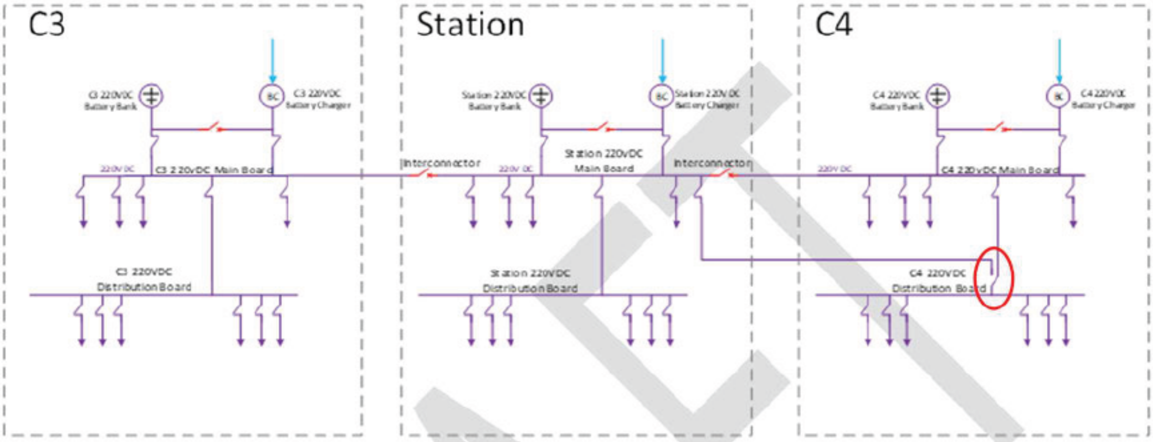


Figure 61 Location of Unit C4 Automatic Changeover Switch

On the day of the incident, the Unit C4 ACS was inoperable in automatic mode, resulting in it being unable to respond to the collapse of DC. If it had operated successfully and restored DC supply to the Unit C4 distribution board, it would have likely mitigated the severity of the incident, as discussed in detail in Section X.

The purpose of this Chapter is to examine the organisational factors that led to the ACS being inoperable in automatic mode on 25 May 2021.

21.2 Summary of Key Findings

The key organisational findings that relate to the ACS are:

(a) On 25 May 2021, the Unit C4 ACS was inoperable in automatic mode. It was unable to automatically respond to the voltage collapse in the Unit C4 DC system and partially restore DC supply to the unit.

(b) The Unit C4 ACS was inoperable in automatic mode because it had been damaged, its fuses had been blown (which prevented it operating in automatic mode), and these fuses were also likely removed. This damage, as well as the blown and potentially pulled fuses, likely occurred in an incident in January 2021.

[376] This is also known in CS Energy as an Automatic Transfer Switch but for consistency in this chapter will be referred to as the Automatic Changeover Switch, ACS.

(c) CS Energy appear to have made a deliberate, but undocumented, decision to leave the Unit C4 ACS in an unrepaired (and thus non-operational in automatic mode) state. There was no evidence of process safety risk management associated with this decision.

(d) Apparently separate to the Unit C4 ACS, the Unit C3 and Station ACSs were rendered inoperable following the incident in January 2021. In response to this incident an interim solution was put in place which allowed the removal of the restrictions placed on Callide C by AEMO. CS Energy did note that this interim solution, which included the isolation of the Unit 3 and Station ACSs, resulted in the removal of designed redundancy regarding the ACSs.

(e) The interim solution should have been considered a plant modification by CS Energy, but was not. If the plant modification procedure, or a formal risk management process, had been applied to this interim solution, then it is likely to have considered the status of the Unit C4 ACS and the time period that this solution would remain in place.

(f) Fundamentally, the Unit C4, Unit C4 and Station ACSs were left inoperable in operable in automatic mode at the time of the incident without any assessment of process safety risk for this situation. CS Energy knew that this status resulted in a loss of design redundancy.

21.3 How the Automatic Changeover Switch Works

The ACS is a switch that provides partial redundancy to the DC systems on each of Unit C3, Station, and Unit C4. With respect to Unit C4, the battery and battery charger provide supply to the Unit C4 mainboard. Supply from this main board is then routed to the distribution board, as per the figure below.

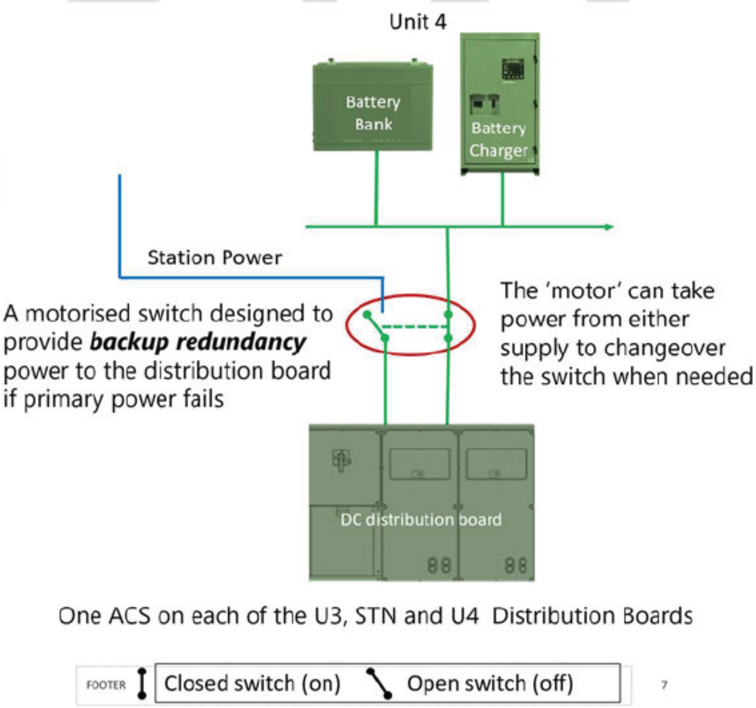


Figure 62 Operation of Automatic Changeover Switch

If DC supply is lost to the main board, it will also be lost to the distribution board. The Unit 4 DC distribution board contains a number of key systems which are important in relation to the incident on 25 May 2021 and ACS is designed to provide backup redundancy from the Station supply to the Unit C4 distribution board. These key systems include:

- One is the 'Y protection' which includes the ability for the unit to detect motoring which occurred on the day of the incident.
- The second is the generator circuit breaker power supply which energises the generator circuit breaker to disconnect the unit from the grid.

The ACS can operate in automatic (or motorised) mode, where the control circuitry detects a drop in voltage (below ~190 V) in supply from the Unit C4 main board. In this case the ACS automatically switches to the alternate Station supply. The ACS can also be set to manual mode, which requires an operator to access the switch and use a lever to rotate the switch between the two power supplies.

The ACS for Unit C4 is in the Unit C4 DC switch room, on the same set of electrical cabinets as the main switches that were used in the switching process on 25 May 2021. The ACS is located in two cabinets, one of which contains the motorised changeover switch itself whilst the other manages the auto changeover circuitry. One is the 'muscles' and one is the 'brains' of the system.

21.4 Status of the Unit C4 ACS on the Day of the Incident

A previous incident had occurred in January 2021, referred to in this report as the January 2021 incident, which resulted in a trip of both Unit C3 and Unit C4. Following this incident, CS Energy became aware that the Unit C4 ACS control circuits were damaged, which likely occurred as a result of the January incident.

The damage to the control circuitry would prevent the Unit C4 ACS operating in automatic mode. There is no evidence that CS Energy planned to repair the ACS control circuity as no notification or work order has been found.

The damage also caused Unit C4 ACS fuses to blow. The blown fuses would have also resulted in the Unit C4 ACS being unable to operate in automatic mode (in addition to the damaged circuitry). In response to the blown fuses, a notification was raised for a work order to '*repair of the fuses and check the control circuit and ensure the ACS will work in the result of a loss of supply*'[377].....".The notification placed a category 4 (low consequence) on the work, and there is no evidence of why this notification was given a low-level categorisation.

This notification, however, never resulted in a work order being raised. Instead, in response to wider issues relating to the January 2021 incident (and discussed below), a redesign of all three ACS circuitry was proposed. In the meantime, it appears that the blown fuses were removed from the ACS by CS Energy and not replaced.[378]

Therefore, prior to May 2021, the Unit C4 ACS had sustained circuitry damaged, had blown fuses, and potentially had those fuses removed. Any one of these events would have resulted in the Unit 4 ACS being unable to operate in automatic mode.[379]

There is no evidence of a formal risk assessment having been carried out regarding leaving the ACS in an inoperable state in automatic mode for an extended period of time. By the time of the incident on

[378] There is no evidence to confirm that the fuses were removed from the ACS, except from photographic evidence taken many months after the incident, which shows the fuses removed from the Unit C4 ACS.

[379] CSE letter to s122C notice to give information to the Regulator, CSE.001.226.0009.

25 May 2021, the ACS had been in this status for four months, and the redesign work had not commenced.

There is no evidence the status of the inoperability of the Unit C4 ACS in automatic mode was considered in the restoration switching of the new battery charger.

21.4.2 Summary

The automatic changeover switch is a switch that provides partial redundancy to the DC systems on each of Unit C3, Station, and Unit C4. It can operate in automatic (or motorised) mode - when the control circuitry detects a drop in voltage (below ~190 V) in supply from the Unit C4 main board to the Unit C4 DC system, it will automatically switch to the alternate Station supply. The ACS can also be set to manual mode, which requires an operator to access the switch and use a lever to rotate the switch between the two power supplies.

Prior to May 2021, the Unit C4 ACS had sustained circuitry damaged, had blown fuses, and potentially had those fuses removed. Any one of these events would prevent the Unit 4 automatic changeover switch from operating in automatic mode on the day of the incident.

21.5 The January 2021 Incident

21.5.1 Introduction

The status of the Unit C4 ACS should be considered in the context of changes that were made to status of the Unit C3 and Station ACSs. These changes were made in response to the January 2021 incident. This section sets out what occurred in this incident, explores the changes that were made to the Unit C3 and Station ACSs, and examines the lack of both management of change and risk assessment applied to these decisions.

21.5.2 Details of the January 2021 Incident

As discussed above, 13 January 2021, an incident occurred that resulted in Unit C3 and Unit C4 tripping by the same mechanism. This ‘dual’ trip led to the Australian Energy Market Operator (AEMO)[380] imposing restrictions on the output of the power plant.[381]

CS Energy conducted an investigation into the incident with the focus primarily on developing a solution to the dual trip issue that would allow AEMO to lift the restrictions as shown in Figure 63.[382]

[380] AEMO - The Australian Energy Market Operator performs an array of gas and electricity market, operational, development and planning functions.

[381] Essentially they limited the amount that could be generated so that if there was another dual unit trip it would only remove X amount of generation from the grid.

[382] B D 21 1418 Callide C3 and C4 double Unit Trip 13 January 2021 - Investigation Report.pdf (CSE.001.004.0002)

As a result of the loss of both Callide C Units from a single fault AEMO declared the simultaneous loss of both Callide C Units a credible contingency event. CS Energy mobilised rapidly towards implementing the modifications to decouple the DC systems of both Units and lift the reclassification.

Figure 63 CS Energy Investigation Report Introduction

There appears to be a lack of consideration on the cause of the event or the risks of the proposed changes (and interim solution) from a process safety perspective.

21.5.3 Pressure to Resolve the Situation

It is also evident that there was pressure applied to CS Energy to resolve this situation regarding the restrictions, refer to Figure 64.

AEMO has requested us to get a solution implemented by Wednesday 27th, even if it is an interim solution as they are having reserve deficiencies during this day coupled with the heat wave. We have some simple tests and/or interim solutions in mind that we will like to discuss

Figure 64 Correspondence between CS Energy and AEMO[383]

AEMO requested a solution be implemented by Wednesday, 27 January, due to reserve deficiencies during the day and the heat wave.

21.5.4 The Solution to the January 2021 Incident

The incident investigation identified four actions designed to permanently remove the future possibility of the dual trip event recurring by the same mechanism:

- Complete replacement of MCBs (motor circuit breakers) and protection devices in Generator Transformer Circuits due to end of life.
- Isolation of Station, Unit C3 and Unit C4 DC supplies by re-design of components in the Automatic Changeover Switch control circuitry and interposing relay panels.[384]
- Segregation of supply to existing MW transducers to three independent supplies.
- Reduction of over-range signal health detection delay in ICMS analogue input card for MW transducers.

Whilst there were some actions that could be completed relatively quickly, it was accepted that the modifications to the ACS control circuitry would require budgetary approval and would not be completed until November 2021. Thus, an interim solution was required to manage the dual trip risk until the action had been completed.

Although the above actions and the interim solution were technically logical to prevent the recurrence of the dual trip event, there was no consideration of process safety risk while the interim solution remained in place.

[383] DC supply coupling meeting invite, CSE.001.102.0235.

[384] Specifically, redesign of diode auctioneered circuits by the use of isolated DC/DC converters

21.5.5 The Interim Solution

21.5.5.1 Overview of the interim solution

The interim solution involved electrically separating the DC supplies between the Unit distribution board supplies. This would be achieved by isolating the Unit C3 and Station ACSs by opening isolators (switches)[385] that provide standby power if an automatic changeover should occur.[386] This would then render the Unit 3 and Station ACSs inoperable in automatic mode. (Unit C4 is not discussed in any of the associated documentation). These isolations meant that the Unit C3 and Station ACSs would have no standby supply to either automatically operate or restore DC supply.[387]

Figure 81 below shows the status of the three ACSs in Unit C following the January 21 incident. This was also the status of the Unit C ACSs in May 2021.

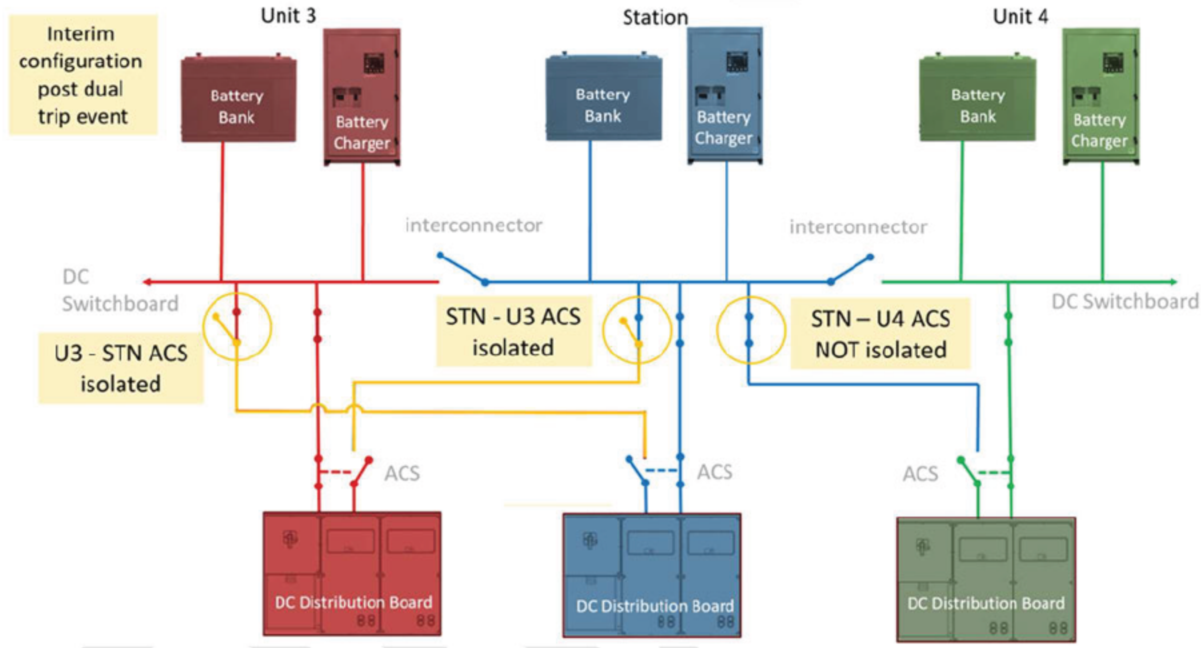


Figure 65 ACS configuration post the 13 January 2021 incident

Note that there is no evidence that this isolation was made to the Unit C4 ACS. It is unclear whether this was because CS Energy never specifically intended to isolate Unit C4 (in the same manner as Unit

[385] RE Callide C Double Unit Trip - Investigation Report CSE - AEMO emails, CSE.001.102.0254.

[386] CS Energy could provide no evidence for why the Unit C4 Automatic Changeover Switch was not isolated like Unit C3 and Station, nor of who authorised the isolations of the Automatic Changeover Switch standby supplies as the interim solution. There is no evidence that indicates why the isolations to the Automatic Changeover switches standby supply was decided as the interim solution.

[387] The automatic changeover switches for Unit C3 and Station would not now operate in either automatic or manual mode. To operate in manual mode, the isolation would first need to be reversed (i.e., the standby power supply would need to be re-enabled), then the Automatic Changeover Switch operated manually.

C3 and Station) or if they held the view that the Unit C4 ACS was already inoperable in automatic mode (because of the damage or blown/pulled fuses), so there was no requirement to disable it.[388]

21.5.5.2 Interim solution removes design redundancy

Whilst the interim solution achieved the goal of isolating the two units DC systems from one another, it also resulted in the loss of automatic functionality of the ACSs.[389]

CS Energy, in their investigation report into the January incident,**Error! Bookmark not defined.** explicitly acknowledged that the interim solution would result in the removal of the designed redundancy from the unit.

> The DC Isolations were effective but left the Unit DC system without the designed redundancy contained in the Automatic Transfer Switches and the interposing relay panel.

Figure 66 Extract from CS Energy 13 January investigation report

Whie this was acknowledged by CS Energy in the investigation report, it was not explicit in the communications with AEMO. In an email to AEMO on 27 January 2021[385] in response to a query by AMEO asking how CS Energy would maintain DC redundancy to the system, CS Energy indicated that redundancy would be addressed by manually operating the interconnectors between the Unit and Station DC systems.

> - DC supplies for each unit - Confirm that if one DC supply fail you have a back up supply to switch over.
>
> Callide C has 3x independent 220VDC DC supplies (C3, C4 and Station). As part of eliminating the risk for a double Unit trip, the automatic changeovers to the 220VDC Distribution Boards have been isolated as these were the location where the DC coupling occurred. The main 220VDC switchboard bus-ties are still available to be manually switched (key interlocked) and tie the Unit 3 and Station OR the Unit 4 and Station main DC SWBDS in the case of a failure of the main battery chargers or battery banks (see drawing below).

Figure 67 Communication with AEMO on Jan 27, 2021

21.5.5.3 Consequences of the interim solution

The interim solution, with respect to Unit C3 and Station, in combination with the damage (and blown/removed) fuses in Unit C4 resulted in the following:

(a) No ACS could function in automatic mode in the event of a loss of DC supply from the main board.

(b) From the perspective of the 25 May 2021 incident, when the interconnector was opened and the battery charger did not behave as required, the station DC voltage collapsed to 120 volts. This drop below 190 volts, which is the threshold for causing the operation of the ACS,

[388] It is believed that it was not necessary to isolate the Unit C4 ACS. The Isolation of Unit C3 and Station separated these two systems. Therefore, while Unit C4 was connected to Station, but Station was not connected to Unit C3, the two unit's DC systems were effectively separated. Whether or not this was CS Energy's intention is not known due to an absence of evidence.

[389] CS Energy can provide no evidence on why the isolations to the Automatic Changeover switch was decided as the interim solution. Isolation (powering down) of the of the control circuitry would have provided an effective interim solution whilst still rendering all the ACS units operable in manual mode.

should have caused it to switch but it could not respond because it was inoperable in automatic mode.

(c) Thus, the loss of DC in the Unit C4 main board directly resulted in the loss of DC to the Unit C4 distribution board resulting in all equipment in the DC system connected to the distribution board being lost. This included the Y protection ability to detect motoring and the second source of generator circuit breaker power supply such that it was not possible to disconnect from the grid.

It is also important to stress that while the Unit C4 was left in an inoperable state in automatic mode following the January incident, the decision to isolate Unit C3 also exposed it to the same vulnerability as Unit C4.

The interim solution put in place satisfied AEMO and the restrictions were lifted on 28 January 2021. AEMO were aware that this interim solution would be in place until November 2021, but there is no evidence that CS Energy communicated that there was a removal of designed redundancy although they were aware of an increased risk of a single unit trip.[390]

21.6 A Failure of Risk Management of the ACS

21.6.1 Risk Management of the Changes to the ACS

CS Energy has in place a specific process to identify and manage risks associated with plant modifications and changes, such as those implemented as part of the ACS interim solution in the wake of January 2021 event.

The application of, and compliance with these processes, and their effectiveness is discussed below.

21.6.2 Plant Modifications

The interim solution leading to the loss of redundancy via the isolations of the Unit 3 and Station ACSs and damage to the Unit 4 ACS was not considered a change requiring the application of the Plant Modification Procedure[8].

Thus, there is no evidence that the Plant Modification Procedure was followed.

The stated purpose of this procedure is to:

> To establish the minimum requirements for managing changes to physical plant and support systems including the:
>
> - Identification and assessment of risks relating to the proposed change
> - Establishing the authorities and responsibilities for authorisation and management of the proposed changes, and
> - Proper documentation of the change and updating of all associated technical and support requirements.

Figure 68 Communication with AEMO on Jan 27, 2021

[390] As discussed below, CS Energy did inform AEMO that it would increase the risk of a single unit trip. (REF)

The procedure provides definitions of change which includes:

> Any change to the physical asset or process from the "As Built" status which may result in a change in process, operation, maintenance or performance, requires a new drawing or a change to an existing drawing / procedure, and which may affect the safety or integrity of people, process or plant.
>
> Modifications can be permanent, temporary or emergency changes
>
> - changes which are performed on a temporary or trial basis
> - changes to plant protection or design/safe operating parameters

Figure 69 Definitions of Change in the Plant Modification Procedure

With specific reference to temporary changes, the application of the procedure is still required, and they must not exceed 60 days.

> While Temporary Modifications have a limited duration they may affect plant performance, risk and design. They require control and rigor to regulate their use. Temporary modifications shall have a specified end date.

Figure 70 Temporary Change in the Plant Modification Procedure

21.6.3 CS Energy View of Why It Was Not a Modification

It was stated[391] that the changes being implemented would not be considered as a plant modification due to them being temporary changes.

> The change to the ACS proposed in my email **[CSE.900.001.1584]** was not a modification because it was a temporary change for the purpose of fault finding.
>
> The isolations for the ACS were not the subject of the modification procedure and risk assessment process, discussed at 48 above. This would have occurred if the change was permanent. As explained above at paragraph 48, the change was interim to facilitate fault finding. As set out in the January Incident Report **[CSE.900.003.0001]** at section 4.4.1, it was envisaged that a redesign of the ACS would occur as part of a modification process.

Figure 71 Extract from Statement Final CS Energy Engineer

[391] Statement Final CS Energy Engineer 1, CSE.001.093.0336.

This is not consistent with the plant modifications procedure definitions and highlights a lack of understanding or compliance with the procedure which is further discussed in Section X.

21.6.4 What would it have looked like if it had gone through the modification process?

The key elements for review and approval for plant modifications are highlighted in the steps within the procedure[8] shown below.

A fundamental step in the assessment stage is to complete a risk assessment as described which was not completed.

2	*Modification Officer*	*Assess risk in conjunction with other relevant specialists / disciplines as required.* *Use* Operations Plant Risk Assessment Template. Basis of risk assessment: what potential hazards/risks may be introduced or current control measures affected by the proposed change?

Figure 72 Risk Assessment requirement from Plant Modifications Procedure

As discussed previously, should a risk assessment have been carried out without a risk frame of reference, such as the MAE bowtie, it is left to judgement as to what residual risk the interim solution would be. However, the accepted loss of design redundancy would indicate this should have been considered as significant or high. This would have required the Head of Engineering to approve and evaluate the change and also have triggered a HAZOP study.

In addition, the review and acceptance step would require the involvement of the Maintenance and Production Managers which would have enabled the full understanding of the change and its communication and training with key personnel.

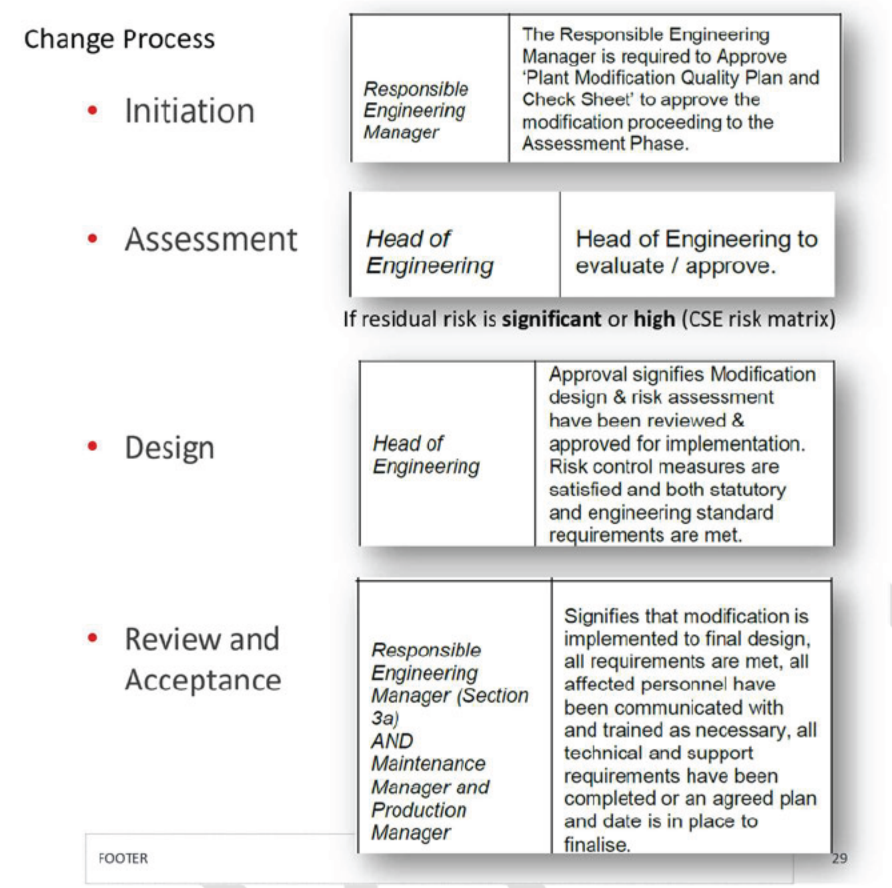


Figure 73 Review and Approval Requirements of the Plant Modifications Procedure

Thus, it is considered that the application of this procedure would have provided the opportunity for relevant specialists and senior personnel in the plant and within the corporate organisation to review and challenge to the proposed actions and to the application of the interim solution leaving the Unit DC system without the designed redundancy.

22 THE LOSS OF AC

22.1 Introduction

This chapter provides a brief discussion of the loss of Unit C4 AC supply. In the incident, the collapse of Unit C4 DC supply led to a loss of Unit C4 AC supply. The loss of Unit C4 AC supply then led, in turn, to the loss of DC supply because the Unit C4 battery charger failed to recover. Finally, the AC supply to the Unit C4 emergency board could not be restored because the Unit C4 DC system was unavailable to configure the Unit C4 AC switchgear to route the AC accordingly.

22.2 DC Collapse Leading to Loss of AC

It is highly unlikely that the mechanisms for the loss of AC could have been anticipated (the mechanism is dependent on the specific nature of the DC collapse).[392]

The specific nature of the DC collapse led to the operation of the arc flap protection, resulting in a trip of the 6.6kV circuit breaker and a loss of AC to Station and Unit C4. While the arc flap protection is triggered by the removal of the DC voltage at its input, DC supply is required to successfully initiate the trip of the AC. It has been demonstrated (and likely understood by Callide operators) that a sudden removal of DC supply to the arc flap protection relay and 6.6kV circuit breaker does not cause the circuit breaker to operate – while it may cause the protection relay to detect a loss of DC (before the protection relay shuts down), this has no affect because DC is needed for the circuit breaker to operate.[393]

However, the loss of AC on the day of the incident did not occur because of a loss of DC, but rather because the DC voltage collapsed in a specific manner — it collapsed to a level low enough to trigger arc flap protection, yet remained high enough to allow successful operation of the AC circuit breakers. There seems to have been no understanding that this scenario could occur.

22.3 Loss of AC Leading to A Loss of DC

There was no appreciation that when operating a battery charger with no battery, a loss of AC would lead to a loss of DC. This occurs because the battery charger itself is powered by AC power. A loss of AC supply, therefore, leads to the battery charger shutting down. If this battery charger is the sole source of supply at that time, this shutting down of the battery charger results in a loss of DC supply to the system.

[392] There have been instances of a loss of AC in the past due to disturbances in the DC, but no evidence of a loss of AC caused by the same mechanism (arc flap protection). (Prior incidents in 2002 and April 2021 resulted in a loss of AC.) On these occasions, there was sufficient DC supply available to trip the unit — and in at least one case, the unit was already offline when the AC was lost. (April 15, 2021 incident.) Prior incidents involving switching in the DC system have also resulted in Unit trips without a loss of AC. (Prior incidents in 2010 and 2013 caused by switching in the DC system resulted in Unit trips.)

[393] This is likely to have been understood because there is no evidence that suggests removal of the DC supply (e.g. for maintenance reasons) had ever resulted in a trip of the circuit breakers via arc flap protection.

22.4 The failure of the Emergency Diesel Generator to restore AC to the Unit C4 Emergency Board

In the event of an unexpected loss of AC, the DC system provides power to emergency equipment to facilitate safe shutdown of the Unit. The emergency diesel generator also starts, and supplies AC to the Station emergency board. AC supply can also be routed from the Station emergency board to the Unit emergency board by configuring the AC switchgear. Configuration of the AC switchgear does, however, require DC supply to be available.

An incident in 2002 seems to have identified some risks associated with a loss of both AC and DC. An extract from Work Order 4097305, Notification 10059216 is presented below.

> Problems to be overcome include 'Break before make' changeover on distribution boards when isolating Main Switchboards, X/Y protection system behaviour on loss of power (note both channels lose power together isolating main board due to make before break changeover, And Trip of 6.6 kV boards (and more than likely 415 boards) on loss of 220 VDC control supply to the boards.
>
> Procedure may require the introduction of a standby (portable?) control source to the switchboard control circuits.

Figure 74 Extracts from work order 4097305

Although it is not clear if this work order discusses the impact of an entire loss of AC and DC systems, or a loss to parts of the system only, the wording seems to suggests an awareness that in the event of a loss of DC, the ability to reconfigure the AC switchgear may be impacted.

The Emergency diesel generator was routinely tested to ensure that it operated in the event of a loss of AC. This indicates that whilst the risk of an unintended loss of AC was understood, there is no evidence that indicates any consideration as given to the impact that a loss of AC would have had at various stages in the switching operation. Specifically, the subsequent risk of a loss of DC when the charger is the sole source of supply to parts of the DC system.

23 ORGANISATIONAL CONCLUSIONS

(Repeat of Executive Summary)

This page is intentionally blank

Brady Heywood.

Glossary of Acronyms and Terms

GLOSSARY OF ACRONYMS AND TERMS

A	
Word	Definition
Second Word	Second Definition

B	

C	

D	

E	

F	

G	

H	

I	

J	

K	

L	

M	

N	

P	

Q

R

S

T

U

V

W

X

Y

Z

This page is intentionally blank

Brady Heywood.

Appendix Part A
Technical Investigation Appendices

This page is intentionally blank

Brady Heywood.

Appendix Part B
Organisational Investigation Appendices

This page is intentionally blank