

INDEPENDENT INVESTIGATION OF ALICE SPRINGS SYSTEM BLACK INCIDENT ON 13 OCTOBER 2019

A report to the Minister in accordance with section 6(1)(g) of the *Utilities Commission Act 2000*

22 November 2019 (updated 2 December 2019)

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INTRODUCTION

Purpose of the Report

On 15 October 2019, the Treasurer (Regulatory Minister) asked the Utilities Commission (the Commission) to conduct an independent investigation into the Alice Springs System Black incident that occurred on 13 October 2019 and report the findings and advice of the Commission to the Minister.

This report sets out the findings and the advice of the Commission in relation to the Terms of Reference referred to the Commission by the Minister on 18 October 2019 and is provided in accordance with section 6(1)(g) of the *Utilities Commission Act* (the Act).

In conducting the investigation and preparing this report, the Commission has had regard to the legislative objectives listed in section 6(2) of the Act. In particular, in performing this function the Commission has had regard to the need to protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries.¹

Confidential Information

This report and the attached Entura report to the Commission have been prepared using information provided by the Power and Water Corporation (PWC), Territory Generation (TGen) and Uterne Power Plant Pty Ltd (Uterne), in response to a notice from the Commission under section 25 of the Act.

The Commission has obligations to preserve the confidentiality of information if it could affect the competitive position of a licensed entity or other person, or is commercially sensitive for some other reason.²

Accordingly, the Commission provided a copy of the draft final version of this report to PWC, TGen and Uterne and requested they identify confidential information to the Commission by blacking out the relevant parts of the report. While identified confidential information has been excluded, which was limited to the list of interviewees, it is possible that a person to whom the information relates may make this claim in the future.³ Therefore, the Commission discloses any information which may be considered confidential under section 26 of the Act to the Treasurer and the Minister for Renewables, Energy and Essential Services in accordance with and as authorised by section 26(2)(c) of the Act.

This section allows the Commission to disclose confidential information if it is authorised or required under any Act or law - in this case, as required by section 6(g)(1) of the Act, to advise the Minister on any matter referred by the Minister.

Sensitive Information

This report contains sensitive information and adverse findings about parties involved in the Alice Springs System Black incident that occurred on 13 October 2019. The report was

¹ Section 6(2) of the *Utilities Commission Act*.

² Section 26(1) of the *Utilities Commission Act*.

³ Section 26(4) of the *Utilities Commission Act*.

prepared at the request of, and for the Treasurer, with express permission to provide a copy to the Minister for Renewables, Energy and Essential Services.

The parties involved in the incident, and to which the report relates, have not had the opportunity to respond to the adverse findings for inclusion in this report.

However, copies of the report were provided to PWC, TGen and Uterne for fact checking, and where the Commission considers appropriate, associated changes have been made in this final Report and in the Entura final report.

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COMMISSIONER'S OVERVIEW

As with most, if not all incidents, the Alice Springs system black on 13 October 2019 cannot be attributed to a single point of failure. There were multiple failures both in the events that led to the system black and the subsequent restoration.

Key failures in the lead up to the system black include operating the system in an insecure state with insufficient spinning reserve and limited regulating reserve, and issues with the automatic generator control (AGC), Jenbacher generator controls, battery energy storage system (BESS) and the settings of the under frequency load shedding scheme.

Key failures in the restoration include a lack of or inadequate black start procedures, Jenbacher generator limitations and the delayed availability of Ron Goodin power station unit R9 due to poor maintenance decisions. Several failings in the restoration process were pivotal, and led to a significantly longer restoration process.

The Commission is concerned that past decisions, such as the new Jenbacher generators installed at Owen Springs power station (not a consideration of this report), which appear to have experienced delays in commissioning and commercial operation due to the need for numerous engineering solutions, has led to either explicitly or implicitly pressuring a rushed timeline to decommission Ron Goodin power station and transition to synchronous generation solely at the Owen Springs power station.

While accepting that the transition to Owen Springs power station and the decommissioning of Ron Goodin power station is going to occur, and not all issues can be identified until this happens, the Commission considers this transition should not be rushed, noting further engineering solutions and testing are likely required for the Jenbacher generators as a result of issues discovered before they can be considered to be contributing to a secure system. The necessary time and attention needs to be given to the transition to avoid subjecting customers in Alice Springs to unnecessary experimentation on the grid, with ongoing observation necessary to detect and address issues as a priority.

The Commission notes, and agrees with Entura, that the sudden unforeseen (by those managing the system) reduction in solar generation due to cloud which precipitated the system black is not considered a root cause of the system black, as a power system should be designed as far as practical to be sufficiently robust to withstand this.

However, it is further evidence that the current systems (including Darwin/Katherine and Tennant Creek) may not be agile and robust enough to support an early transition towards the Territory Government's 50 per cent renewables by 2030 target. Management of system security and reliability becomes more complex as increased amounts of asynchronous generation (solar in the case of the Territory) is added to the systems and, in the case of rooftop solar, electricity current flows become bi-directional. The risk and cost of getting settings wrong increases and care and time needs to be taken to get it right and minimise the costs of the transition. Consumers place a very high value on system reliability and security – keeping the lights on.

Accordingly, consistent with its 2017-18 Northern Territory Electricity Outlook Report, the Commission considers a measured approach to achieving the 50 per cent renewables target is necessary, to allow for the transition to be appropriately considered, coordinated and managed, while keeping cost increases to a minimum consistent with maintaining system security.

The Commission notes that the addition of the BESS, particularly given the increasing levels of rooftop solar photovoltaic generation in addition to the existing Uterne Solar farm and associated complexities of the evolving system, appears to be a positive addition to the Alice

Springs system. However, consistent with its technical consultant's (Entura's) observation, it appears that insufficient work has been done to understand and test its current or potential operation, and also determine if it has a role to play in system restoration.

The Commission has observed that changes and upgrades to the power system do not seem to be made in a considered or coordinated manner, rather they appear to be implemented in a reactive and isolated manner. The Commission believes that a lack of an adequate system model, system control resources and overall system planning and thinking may be contributing to this. The Commission raised these concerns through its past Power System Reviews, and most notably in the recent 2017-18 Northern Territory Power System Performance Review (NTPSPR), which was delivered to the Treasurer (as Regulatory Minister) on 20 June 2019 and published. Notably in the 2017-18 NTPSPR, the Commission provided warnings of the heightened risk of an Alice Springs system black incident.

Consequently, the Commission is concerned that recommendations made in its past Power System Reviews, including the 2017-18 NTPSPR, past reports to Government and recommendations made by System Control in major incident reports, are not being given due consideration and implemented in a timely manner, if at all, by the relevant parties. To this end, and in line with Entura's recommendations, the Commission will increase its focus on determining if its recommendations are implemented as part of its annual review of the power system and associated public report. It also recommends that Government consider developing a process to require the Power and Water Corporation and Territory Generation Boards to regularly report against these recommendations.

Through the investigation, the Commission has identified possible non-compliance with the System Control Technical Code (the Code), in relation to the requirement for black start procedures. This coupled with the Commission's concerns around System Control's compliance with incident reporting obligations, which has been communicated several times to PWC's Chief Executive and publically through the Commission's 2018-19 Annual Compliance report, highlights a potential need for the Commission to review its approach to compliance.

As indicated to the previous Regulatory Minister, in its Darwin-Katherine System Black Incident 12 March 2014 report, the Commission considers that its powers in relation to the enforcement of compliance are limited under the current framework to either minor action, such as letters to the relevant licensee and public reporting, or major action, such as taking over a licensee's operations, with no ratcheting of actions between the two extremes.

While this investigation was specific to the Alice Springs system black incident, it should be noted that the Commission in its 2017-18 NTPSR has highlighted concerns with the performance of the Tennant Creek power system, which is supported by more recent Commission observations, where Jenbacher generators have also been installed. The Commission notes a high frequency of generator incidents during 2018-19, with many incidents impacting the majority of the system and in some part, are related to the new Jenbacher generators. Based on this, the Commission recommends consideration be given to whether any recommendations implemented or changes made in the Alice Springs power system also need to be made in Tennant Creek.

The Commission would like to highlight the dedication of the staff on the ground to get the lights back on during the incident, which included staff assisting in the restoration that were not necessarily duty bound to do so. Further, it is clear that staff are passionate in finding the right long-term solution for Alice Springs, which while meeting various targets and commitments, should be developed with the long-term interests of Territory consumers in mind, being price, reliability and quality for the Alice Springs community.

The Commission thanks the more than 40 stakeholders it met with in undertaking its investigation, particularly those that made themselves available outside their rostered hours. Commission staff were impressed with the level of expert knowledge and experience of staff on the ground, particularly in Alice Springs. The Commission recommends that PWC and TGen, and the Territory Government more broadly, should leverage this valuable resource as much as possible.

ABOUT THE INVESTIGATION

Background

On 13 October 2019, the Alice Springs power system went black at 14:18hrs, with approximately 12,000 customers affected for periods varying between 30 minutes and up to 10 hours. The Alice Springs Hospital and communities as far as Haasts Bluff (approximately 250km from Alice Springs) were affected, with many businesses forced to close.

On 14 October 2019, the Territory Government announced that it had 'called an independent review into the incident to identify and investigate any system-wide issues that led to the problem occurring and the adequacy of responses, both short and long term'.

On 15 October 2019, pursuant to section 6(1)(g) of the Act, the Treasurer wrote to the Commission requesting that it conduct an independent investigation into the Alice Springs and connected communities system black.

Subsequently, on 18 October 2019, the Treasurer wrote to the Commission requesting that the investigation be undertaken in accordance with the enclosed Terms of Reference (at Attachment A). The objectives of the investigation are to identify:

- the causes of the incident, its severity and duration
- broader implications for future power system reliability and security for Alice Springs and connected communities
- appropriate remedial measures to infrastructure, systems and processes.

The Terms of Reference requires delivery of an investigation report to the Treasurer and Minister for Renewables, Energy and Essential Services by 18 November 2019 and that key stakeholders be consulted as part of the investigation, including relevant electricity entities, workers' unions, the Northern Territory Government and employees involved in the incident and restoration.

On 11 November 2019, the Commission requested a four day extension to the due date to deliver the report to the Minister, to 22 November 2019. The request was to allow the Commission sufficient time to enable it to provide the Minister with a higher quality report based on deeper technical analysis that will ultimately benefit Alice Springs electricity consumers and the residents of Alice Springs and connected communities more broadly, assuming the report's recommendations are supported and implemented. On 14 November 2019 a letter was received from the Minister approving the extension.

This summary report provides the Commission's key findings and recommended actions arising from the investigation of the Alice Springs System Black incident which occurred on 13 October 2019.

The Entura report, which is included at Attachment B of this report, provides a more detailed assessment of the incident and constitutes part of the Commission's overall response to the Terms of Reference. Both the Commission's summary report and the Entura report combine to address the matters raised in the Terms of Reference. Accordingly, the Commission encourages all stakeholders to read both reports in their entirety, and in conjunction with one another.

Both the Commission's and Entura's reports have been updated from that originally provided to the Treasurer and Minister for Renewables, Energy and Essential Services on 22 November 2019, to correct or provide additional information in relation to the facts following release of the reports to PWC, TGen and Uterne for a fact check.

Investigation process

Entura, a specialist power consulting firm, was engaged by the Commission on 21 October 2019 to provide technical advice and an associated report to the Commission, which is to address each of the matters listed in the Treasurer's Terms of Reference.

Entura has assisted the Commission with the last five power system reviews and is currently engaged to assist the Commission with the 2018-19 Power System Performance Review. Accordingly, Entura has the extensive knowledge of the Territory's power systems and good working relationship with Commission staff and stakeholders needed to assist the Commission with the investigation.

Following the engagement of, and with input from Entura, information requests were emailed to PWC, TGen, Jacana Energy and Uterne, on 22 October 2019, in accordance with section 25 of the Act. Further information was sought from the relevant licensees on 30 October.

All relevant licensees were responsive to the information requests and generally provided everything requested within the required timeframe except where the party identified the information was not easily obtained.

Commission staff with Entura met with more than 40 stakeholders in Darwin and Alice Springs over approximately two weeks to gather feedback on the incident and other relevant information, including senior executives from TGen and Jacana Energy, the System Controller, System Control operators and engineers, TGen Remote Operations Centre (ROC) operators and power station operators, the Minister for Renewables, Energy, and Essential Services and Ministerial staff and Electrical Trades Union (ETU) representatives.

DESCRIPTION OF SYSTEM BLACK INCIDENT AND RESTORATION

System Black incident

The following is a brief summary of the System Black incident of 13 October 2019. Section 4.1 of the Entura report provides a detailed description of the sequence of events, including discussion on the associated cascading plant and system failures.

1. Unforeseen (by those managing the system) cloud cover significantly reduced the output of Uterne solar power station and reduced the output of embedded rooftop solar photovoltaic (PV) installations.
2. The AGC did not adjust the Owen Springs power station (OSPS) MAN unit #1 because it had withdrawn out of AGC control four hours earlier with no one from System Control or the ROC identifying and rectifying the issue.
3. Automatic generator control (AGC) drove the OSPS Jenbacher units to their nameplate rating (greater than the units' maximum sustainable capability given the high ambient temperatures on the day).
4. The frequency fell marginally, but remained within the normal bounds, so under frequency load shedding (UFLS) did not occur.
5. First Jenbacher machine tripped on high cooling water temperature.
6. The frequency fell approximately to 49.6 Hz.
7. The battery energy storage system (BESS) began to generate energy causing frequency recovery to approximately 49.8 Hz.
8. Second Jenbacher machine trips on high cooling water temperature.
9. BESS output increases to ~6MW causing frequency recovery to approximately 49.6 Hz.
10. Third Jenbacher machine trips on high cooling water temperature.
11. BESS is commanded to maximum output (8MW), however actual output increases to 8.7 MW.
12. BESS LV circuit breaker opens on overcurrent as a result of the BESS's output exceeding its maximum rated capability.
13. Frequency falls significantly and Stage #1 UFLS trips some customers.
14. Fourth, fifth and sixth Jenbacher machines trip.
15. Stage #2 UFLS trips further customers.
16. Stage #3 UFLS fails to trip.
17. System collapses and final machines go offline leaving the system black.

Restoration

Section 5.1 of the Entura report provides a detailed description of the sequence of events for the restoration of the Alice Springs system following the system black. Given the volume and complexity of the steps taken in the restoration process, and associated issues, only a high level description is provided below.

Ron Goodin Power Station

Ron Goodin power station (RGPS) is currently being decommissioned in a staged fashion where it will move from hot standby to cold standby then emergency availability. It is currently required to be in hot standby, but at the time of the incident, RGPS was in a state that the Commission and Entura consider to be neither hot nor cold standby in accordance with the definitions provided in the original Advisian report, which are considered by Entura to represent normal industry understanding. The station was manned with a senior generator operator and a generator operator.

Immediately following the event at 1418hrs, RGPS operators followed the operators' own pre-prepared checklist and achieved black start of a small island including the Alice Springs Hospital and CBD within approximately 30 minutes of system black.

In Entura's opinion, RGPS was unable to black start and restore the remainder of the network because there were insufficient machines available for service with Ron Goodin unit R9 requiring a relatively minor repair and with the necessary parts in the store room⁴.

Owen Springs Power Station – 14:18hrs through until 16:30hrs

During this period, the focus of activity at the OSPS was on black starting a portion of the Alice Springs system (to Lovegrove) using the MAN machines, being OSPS units #1, #2 and #3. However, the OSPS operator could not locate a copy of the black start procedure. The OSPS operator sought to follow the black start procedure from memory.

There are some discrepancies in the sequence of events during this period. Specifically, while the OSPS operator sought to follow the black start procedure from memory, it appears that an instruction may have been given to the operator from the ROC⁵ to start OSPS unit #3 prior to closing OSPS unit #1, which was up and running, contrary to the order of actions set out in the black start procedure. Upon attempting to start OSPS unit #3, both OSPS #1 and #3 suffered protection trips. The shutdown of OSPS #1 was neither a standard machine trip nor a standard machine shutdown. This may have placed OSPS unit #1, the auxiliary supplies for OSPS unit #3 and the fuel supplies for OSPS units #1 and #3 into an unusual state, leaving both machines unavailable for return to service.

⁴ Ron Goodin machine availability is discussed elsewhere in this report.

⁵ There is discrepancy between Territory Generation and System Control's information and feedback in relation to where this possible instruction originated, however the Commission consider regardless of which party may have given an instruction, the overarching issue was the lack of access to a black start procedure and/or practice of those procedures.

Owen Springs Power Station (OSPS) – 16:30hrs through until 18:35hrs

During this period, the focus of activity at the OSPS was on black starting a portion of the Alice Springs system (to Lovegrove) using the Jenbacher machines OSPS units #5 – #14. This process was based on an unapproved and insufficiently tested draft procedure.

Numerous Jenbacher units were started and then tripped or were attempted to be started and failed. Each time a Jenbacher unit tripped, its associated Dia.ne control system had to be rebooted. Various load, network and generator circuit breakers also tripped.

The network was restored sequentially from OSPS to the Lovegrove 22 kv busbar at around 18:27hrs, however following a reduction in system frequency, the feeder tripped followed by Jenbacher machines OSPS units #8, #9 and #5 in a cascading manner, returning the system to black status.

Owen Springs Power Station (OSPS) – 18:35hrs through until 00.00hrs

During this period, the focus of activity at the OSPS turned to a hybrid black start model using both the MAN units and the Jenbacher units, which eventually worked following a number of generator trips, both MAN and Jenbacher units, multiple Dia.ne control system reboots and significant manual sectionalising of the network. There was no black start procedure for restarting the system in this manner.

KEY FINDINGS

The following section outlines the Commission's key findings from its investigation into the 13 October 2019 System Black incident. These key findings have been identified through consideration of the information and evidence provided as part of the investigation process, including through face-to-face interviews with those employees involved in the system black incident and restoration.

It should be noted that these key findings are not listed in any particular order, and do not necessarily address each of the items listed in the Terms of Reference, noting some of the items have been combined as appropriate for the purpose of this section of the Commission's report.

As noted earlier, the Entura report at Attachment B constitutes part of the Commission's overall response to the Terms of Reference. The Entura report contains more detail and addresses all items in the Terms of Reference, noting Entura's key findings and recommendations are endorsed by the Commission.

Power system situation prior to system black incident

At the time of the incident the power system was not in a secure operating state, with insufficient spinning reserve (in breach of the spinning reserve policy) and limited regulating reserve.

The Commission notes that Entura found no evidence of any intentional breach of the system security provisions leading up to the system black event. The system was operated with inadequate regulating reserve but this was due to latent technical issues with the AGC and generator control systems.

Automatic generator control

It is understood that in the months (and years) leading up to the system black incident operational staff at System Control and TGen expressed concern about the fitness for purpose of the AGC. One concern in particular is that the OSPS MAN units regularly switch from AGC to manual control without an operator command, thereby causing a deficit of regulating reserve.

Of relevance, approximately seven hours prior to the system black, OSPS unit #1 came out of AGC control. The machine was returned to AGC control 10-15 minutes later by operator intervention. Following this, four hours prior to the system black, OSPS unit #1 came out of AGC control again. This change of control mode was not detected by the operators at System Control or at the ROC.

Ron Goodin Power Station

Just prior to the incident, the RGPS was clearly not in effective hot standby (defined in the original Advisian report⁶, which documents undertakings made by TGen as part of the decommissioning process, as including at least one Ron Goodin machine online and

⁶ The Advisian report, as provided by Territory Generation, includes the original August 2018 *Review of Operator Concerns Ron Goodin Power Station* report, a July 2019 Addendum to the August 2018 report and a September 2019 Revision 1 of the Addendum to the August 2018 report.

operating at minimum load), as evidenced by the fact that no machines were in service⁷. The Commission notes that prior to the system black incident, the hot standby to cold standby transition was understood to be scheduled for 22 October 2019 subject to there being no forced outages on the Jenbacher units.

Further, it is questionable, whether RGPS was even in a cold standby state (defined in the original Advision report as no Ron Goodin machines in service but all sets that are operational at the commencement of cold standby, to be maintained in a state of readiness that they could be started at any time) as several machines were unavailable for service and there was no plan in place to return them to a serviceable condition despite having a number of major components required to repair the units on hand⁸.

Root causes of the incident

The initiating event for the system black was the sudden unforeseen (by those managing the system) reduction of solar generation from Uterne solar farm and from rooftop solar installations, which resulted in a discernible increase in load on dispatched synchronous generation. However, sudden cloud cover is not considered to be a root cause.

The Commission agrees with Entura that cloud cover is a credible event, and therefore should not lead to a system black. Power systems must be designed as far as practicable to be sufficiently robust to withstand all credible events. The Alice Springs system was not sufficiently robust to avoid a system black.

Key weaknesses in the system at the time were:

- spinning reserve requirement was breached
- regulating reserve was less than the operators believed because OSPS unit #1 was not in AGC control
- OSPS unit #1 had a maximum AGC control set-point of 8 MW (considerably lower than its maximum rating 10.8 MW)
- the Jenbacher units had insufficient controls to maintain their operating temperature within acceptable limits
- the BESS had insufficient controls to maintain the unit within acceptable limits
- UFLS stage #3 was faulty
- UFLS, generator droop and machine control settings were not adequately coordinated.

⁷ Territory Generation has indicated at the time of the incident System Control did not require a machine at Ron Goodin power station to be in service and operating at minimum load, as per Advision's definition of hot standby in its original report. In Advision's September 2019 Revision 1 of the Addendum to the August 2018 report, Advision state that it considers the period of four weeks in hot standby is still relevant, whether or not a set at RGPS is operating.

⁸ Units 6 and 8 had been noted by Advision as uneconomical to repair, however it is understood the replacement parts for one of the machines were on hand. Territory Generation has indicated management of Territory Generation were told by Ron Goodin power station maintenance staff that R9 would operate without the AC Oil Mist Fan by utilising the DC oil mist fan. As mentioned in the Entura report, Entura does not have direct expertise on the risks presented to gas turbine plant upon failure of the oil mist fan(s) and cannot comment on whether the machine could be safely shut down following a failure of the backup DC oil mist fan, however Entura consider at the time of the incident R9 was not fully serviceable.

Response of the generators, protection and AGC systems

Owen Springs MAN generator units

A single Owen Springs MAN unit was in service at the time of the system black (unit #1). It has been indicated that the unit was understood by operators at System Control and the ROC to be in AGC control with an upper limit of 8 MW configured (compared to 10.8 MW rated). The reduced maximum output was in accordance with a System Control risk notification prior to the event. However, the machine was not in AGC control because of a control system shortcoming that was well known to System Control and TGen, but had not been rectified.

Entura consider, had this unit been in AGC control, an additional 3 MW of regulating reserve would have been available to the system. This would have resulted in the Jenbacher units taking less load. It is unlikely that the reduction would have been enough on its own to avoid the cascading tripping of machines.

However, had the MAN machine been in AGC control with an upper limit of around 10-10.9 MW, then Entura believe it is possible that load reduction on the Jenbacher machines would have been enough to avoid the cascading failure. Nonetheless, the Commission notes that this would not have been an option as there was a System Control risk notification in force during the incident.

Owen Springs Jenbacher generator units

During the power system event the Jenbacher machines increased their power output automatically. Ultimately, that power increase exceeded the machine's capability and caused most of the Jenbacher machines to trip on cooling water over temperature.

The control systems on any generator should control the machine so that it does not need to trip. This includes limiting the machine output under all control modes so that the cooling water does not exceed the trip setpoint. The Jenbacher machine operation is not currently consistent with this design principle⁹.

Battery Energy Storage System

The BESS responded aggressively to the trip of OSPS unit #8 by injecting approximately 2 MW into the network to support frequency. When OSPS unit #9 tripped, the BESS output increased to approximately 6 MW or 75 per cent of the total lost generation. When the third Jenbacher machine tripped, the BESS was commanded to 8 MW, however output exceeded

⁹ PWC have indicated to the Commission that proper compliance testing of machines was carried out in full accord with all requirements of the System Control Technical Code and industry best practice. PWC has implied that changes may have been made to the Jenbacher machine programming since commissioning that could have caused the failures observed during the System Black event, and the occurrence of such changes may explain why these particular machines responded as they did during the "real world" black restart on 13 October 2019, when prior testing under similar test conditions was successful. The Commission notes an investigation in relation to this is not within the terms of reference for the Alice Springs System Black Incident investigation, however recommendation 8 and 9 require investigation and changes to the Jenbacher generators.

this and went to 8.7 MW. Subsequently, the total MVA output of the BESS exceeded its short time capability and an internal protection element tripped the BESS from service¹⁰.

There is some evidence that the aggressive intervention of the BESS (and the Jenbacher units) may have been counterproductive. By injecting more power than the equipment can sustain, the power system frequency was held close to 50 Hz and the UFLS scheme was unable to detect that the power system was under severe stress. Had the frequency been allowed to fall, the UFLS would have removed load from the power system (causing loss of power to some consumers) but system black would have been avoided.

Under Frequency Load Shedding

UFLS is a common demand reduction technique used to maintain power system stability by removing the overload in some part of the system, generally in 'stages'.

For the Alice Springs system black, the investigation determined that stages #1 and #2 of UFLS operated as designed and Stage #3 failed to operate. However, it is noted that the operation of load shedding including Stages #1 and #2 was not optimised for the power system event that occurred.

If UFLS Stage #3 had operated correctly the power system would likely have suffered a "technical black", but a system black would have been avoided and system restoration would have occurred more quickly.

During a technical black the majority of customers lose supply but a small number of generators remain in service and the network remains energised ready for the reconnection of customers. In all probability, if a technical black had occurred on 13 October then the duration of the outage would have been reduced such that 80 per cent of customers would have been restored within 90 minutes.

Automatic Generator Control

During the interviews there was almost universal agreement that the current AGC system is not fit for purpose. Entura's review of how the AGC functioned on 13 October 2019 determined that some of the associated outcomes are not features of a well-engineered AGC system.

If the AGC, Jenbacher generators, BESS and UFLS had functioned as expected¹¹ then the initiating event would not have led to a system black.

¹⁰ PWC have indicated to the Commission that it has fulfilled its obligation to approve the BESS for connection to the system by thoroughly testing it prior to its commissioning, notably beyond the expectations of the Australian Energy Market Operator (AEMO), and its response under the most onerous circumstances of system disruption was satisfactory when those tests were carried out. Further, it has implied that it is possible that the settings of the BESS may have changed subsequent to the completion of the compliance testing. The Commission notes an investigation in relation to this is not within the terms of reference for the Alice Springs System Black Incident investigation, however recommendation 10 requires changes to the BESS.

¹¹ The word 'expected' is used several times in this report to mean an asset or system that did not operate in a manner that would generally be expected within the industry. It does not necessarily mean an asset or system malfunctioned or operated in a manner different to how it was designed or configured.

If two or more of AGC, Jenbacher generators, BESS and UFLS had functioned as expected then a system black would likely have been avoided or limited to a technical black, resulting in a reduced restoration period.

System risk mitigation procedures and performance

Regular training, exercise (role play), and practice of black start procedures are inadequate. These activities should be conducted both individually at power stations, the ROC and System Control and also in coordination with each other.

The Commission has concerns with System Control's management of incident reporting obligations under the System Control Technical Code, which it has communicated to the CEO of PWC on several occasions. Specific concerns include the length of time System Control takes to produce and distribute final reports and generally the low priority that incident reporting has been given.

The Commission's view is that this incident reporting is vital to ensure that System Control is identifying and addressing problems with relevant system participants, and learning lessons from this to, among other things, ensure ongoing reliability and quality of electricity services and supply. The Commission notes that PWC has committed to clear the backlog of incident reports greater than six months old by the end of the calendar year, which is a positive step. The Commission is tracking progress with this commitment.

Related to concerns regarding System Control's incident reporting is the Commission's concern that incident report recommendations are not being adequately considered, programmed, tracked or implemented, and that repeat issues and recommendations may not be recognised. This increases the risk of repeat issues and ultimately poor reliability and quality of supply for electricity customers.

Adequacy and speed of response to the incident

Emergency management, external communication and vulnerable customers¹²

The leader of the Public Utilities Group (PUG) is the PWC General Manager, Core Operations. According to PWC, the leader was notified of the system black event within 15 minutes of the event occurring. However, as there was a general expectation that the restoration was perpetually close to complete, there was a failure of PWC to stand up the PUG in a timely manner and to subsequently advise the Emergency Management Group. Consequently, based on feedback from those interviewed, communications to Government, the public, emergency services and vulnerable customers were inadequate.

Discussions with some stakeholders indicate that there may be a gap in relation to allocating explicit responsibility to a party, such as PWC or the Department of Health, to advise vulnerable customers, including those requiring life support equipment at home and aged care facilities, to implement their emergency action plans in the case of a system black or other unplanned interruption.

¹² Information in this section is based on written information provided by PWC on 1 November 2019 as part of an additional information request sent by the Commission to PWC on 30 October 2019. PWC has since indicated to the Commission that it engaged with the Department of Health, Alice Springs Local Council, Telstra and the Police Night Commander (as proxy for the Regional Controller) during the incident.

A review of the Territory Emergency Plan, including responsibilities allocated to the PUG and the Medical Group led by the Department of Health appears to support this feedback, noting the Medical Group's responsibility involving the 'coordination of medically vulnerable clients' is not considered explicit enough to cover vulnerable customers in their homes.

While PWC as the network provider is required under the Electricity Retail Supply Code (from 1 December 2019) to keep an up to date register of customers' premises that require life support equipment, and the Department of Health is likely to have its own list of vulnerable residents in Alice Springs and connected communities, the Commission does not have a view on which party should be allocated this responsibility, noting it is primarily a communication role.

System Control communication

The investigation found through interviews with stakeholders that there is confusion about who is overall in charge during a system black restoration. Some staff believe that the Grade 3 system control operator is in charge while others consider that the Real Time Operations Manager (RTOM) is in charge when present.

A further level for potential confusion occurred because both the RTOM and the Operations support coordinator were in the control room at times during the restoration, along with engineering staff. Also some Grade 2 system control operators had less access to their Grade 3 operator than they required, due to the number of additional personnel present.

Accordingly, communications failures, caused in part by too many advisors being present, contributed to the duration of the system black.

Remote Operations Centre (ROC)

According to TGen documents, it is TGen's intention that the ROC be the single point of contact during both routine and abnormal (e.g. system black) conditions. Nonetheless, the Commission notes that System Control has the authority to take any action it reasonably considers necessary to restore power system security. This might include bypassing the ROC if they consider that is necessary to restore system security.

Several interviewees indicated that System Control and the ROC agreed that communications would deviate from TGen's intention and be direct from System Control to the power stations during the restoration. The Commission considers that this was an appropriate decision as the ROC potentially added little value as a "post box" for information adding unnecessary steps, time delays and the potential for miscommunications.

System Black procedures

Clause 5.7 of the SCTC requires generators to develop a Black System Procedure for each of its power stations and the System Controller to develop a Black System Restart Procedure for each of the regulated power systems. The System Controller is required to review its Black System Restart Procedure each year.

The following deficiencies and possible non-compliance existed at the time of the system black and contributed to the adequacy and speed of the response:

- The black start procedure for Owen Springs power station (MAN units 1-3) was not readily available to staff and departures from that procedure severely impacted the restoration time.
- There was no approved black start procedure for the Owen Springs power station Jenbacher units 5-14 and failed attempts to black start the system using these machines severely impacted the restoration time.

- The approved black start procedure for RGPS had not been updated to reflect changes at the power station (installation of the BESS) and was not considered user friendly by operators. Despite this, and the power station being in a standby state, staff and operators successfully black started the station restoring service to the Alice Springs Hospital and the CBD using their own pre prepared checklist.
- System Control's Alice Springs Black System Restart Procedure was outdated and did not include significant changes to the Alice Springs system, having been released on 17 June 2014. There is no evidence that the procedure has been reviewed annually or updated to incorporate subsequent changes to power station black start procedures.

Planning and power system modelling

During the interview process the claim was made many times that there is no power system model for the Alice Springs power system. However, the Commission notes that PWC has previously provided models (in an older format) and subsequently the Commission's 2015-16 and 2017-18 Power System Reviews recommended significant development and verification occur for the Alice Springs dynamic models.

An accurate power system model would allow simulations of system black to be completed. During those simulations the incorrect reactive power setting of the Jenbacher automatic voltage regulators may have been discovered. Furthermore if the models were accurate, then the Jenbacher's inability to accept load increments exceeding 10 per cent may have been discovered. Addressing either of these issues would likely have reduced the duration of the restoration.

Outlook for Alice Springs system over the next 12 months

The suite of system black procedures currently in place is not sufficient to allow RGPS to be decommissioned. Accordingly, until an approved and sufficiently tested black start procedure is created, with multiple contingencies, it is inappropriate for RGPS to move from a hot standby state. Furthermore, the RGPS machines that are in a serviceable or near serviceable state should continue to be maintained to acceptable levels.

As discussed earlier in this report, the BESS is a very effective piece of equipment with a variety of characteristics that are helpful to avoid system black. However, insufficient work appears to have been done to determine if the BESS has a role to play in system restoration, noting feedback from interviewees found conflicting understanding of its purpose. It is likely that because of the BESS' remote location relative to OSPS that the BESS cannot be of assistance for system restoration.

The next chapter of this report provides the Commission's recommendations as a result of its investigation. Items marked as 'high' priority are considered to be either easily / quickly implemented or critical to the restoration of the system from system black. Until these items have been completed, as discussed above, the RGPS should be maintained in a state that it could quickly black start the entire system.

Subsequent investigations

A number of short investigations are recommended to be undertaken by PWC and TGen.

Further, it is recommended that the Territory Government consider allocating explicit responsibility to an appropriate party, and associated processes, for ensuring vulnerable customers are contacted in the case of a system black or other unplanned interruption, and for reporting and implementation of recommendations of this other major event reports by PWC and TGen.

These recommended investigations and considerations are set out in the next chapter of this report and discussed in more detail in the Entura report.

COMMISSION'S RECOMMENDATIONS

The following recommendations are copied directly from the Entura report and are endorsed by the Commission.

As discussed earlier, the Commission's report is a summary, with Entura's report providing a more detailed assessment of the incident. Both the Commission's summary report and the Entura report combine to address the matters raised in the Terms of Reference.

Recommendations are placed into the Entura report at the appropriate location. Each recommendation is then paraphrased in this section along with a section reference to where the context can be found within the body of the Entura report. Consequently, the 'full' recommendation within the text of the Entura report is to be considered the recommendation to be actioned.

Items marked as 'high' priority are considered by to be either easily / quickly implemented or critical to the restoration of the system from system black. Until these items have been completed Entura recommends, and the Commission supports, that the Ron Goodin power station be maintained in a state that it could black start the entire system thereby providing an alternative for the possibility that the OSPS MAN machines are not available. In our view all high priority items could be completed within eight weeks.

All other items are marked as 'medium' priority. In Entura's opinion, which the Commission supports, these items could and should be completed within eight months. Where the output of the recommendation item is a report, the implementation of that report's findings should not take longer than a further eight months.

ID	Recommendation	Entura report reference	Responsible	Priority
1	Modify the System Control operator screens at Hudson Creek control centre to improve their operational awareness: <ul style="list-style-type: none"> • add alarms that rapidly bring to their System Control operator's attention that a generator has come out of AGC control • track spinning reserve and regulating reserve separately so that it can be seen when the two are not equal. 	4.4.2	System Control	High
2	Consider solar forecasting in addition to the existing load forecasting procedures. In particular: <ul style="list-style-type: none"> • System Control and TGen collaborate to determine how a solar forecasting system can be used to improve security of the Alice Springs system • data from the solar forecasting system be held by the party responsible for maintaining spinning reserve. 	4.5	System Control and TGen	Medium

ID	Recommendation	Entura report reference	Responsible	Priority
3	<p>Clarify and communicate protocols around how System Control is to operate during a system black event. We recommend the following principles:</p> <ul style="list-style-type: none"> • prepare a complete plan for who may be in the control room during a major system event • only the RTOM or the Operations support coordinator should be present. The person who is not present should be making preparations to takeover if the event extends beyond the fatigue limit of the duty person • modify the operating protocols such that the formal primary path for communication during major system events be directly between System Control and the power stations. 	6.2.2, 6.2.3	System Control and TGen	Medium
4	<p>Complete a review of the AGC system to determine if it is fit for purpose and if still deemed necessary how to improve its function and reliability.</p>	4.3.2	System Control	Medium
5	<p>TGen prepare a report considering options to simplify the starting and loading of generators during black start. In particular the report should consider options to reduce the risk of generators tripping due to reverse power during restoration. Options for review should include:</p> <ul style="list-style-type: none"> • Switching arrangements that allow the Brewer load to be used to stabilise the operation of the machines • Any other switching arrangements that allow a stable load block to be formed without energising the 66 kV portions of the network • Installation of a thyristor controlled load bank at Owen Springs • Relocation of the BESS from Ron Goodin to OSPS so that it can function as a load bank during restoration • Determining if the reverse power protection settings are more sensitive than is necessary during a black start. 	7	TGen	High

ID	Recommendation	Entura report reference	Responsible	Priority
6	<p>The apparent confusion between TGen and System Control about who is responsible for dispatch and load following should be resolved. Operating protocols need to be thoroughly consulted upon and communicated. We recommend the following principles:</p> <ul style="list-style-type: none"> • System Control should be required to determine the amount of synchronous generation needed to be in service at each point in time taking into account the need for spinning reserve, the state of Uterne and the state of the BESS, because these are system security issues. • TGen and PWC review each other's operation document and the two documents made consistent and agreed • TGen could be responsible for determining which machines to place into service to meet that spinning reserve requirement and System Controls other system security requirements. • Implement measures to avoid spinning reserve falling below 8 MW during the day for even for brief periods. 	4.3.1, 4.6	TGen and System Control	Medium
7	<p>Other procedural recommendations include:</p> <ul style="list-style-type: none"> • A System Control Black System Restart Procedure be prepared • PWC amend the PUG procedure to require that the PUC be convened within 90 minutes of system black for any future event • make changes to provide that during restoration the current split of responsibilities between System Control and OSPS should be at the station 66 kV busbars • a formal set of black start procedures to be updated, harmonised, printed and stored prominently at all control room and power station sites • system black procedure be amended to give the station operator more autonomy • various system black procedures should be rehearsed at regular intervals, both individually and in coordination • all technical staff (operators, electricians, engineers) should have a simple training record based on the Engineers Australia CPD model (for example) with targets for each type of training and mode of delivery including technical classroom training. 	5.2.3, 6.2.1, 6.2.4, 6.4.2, 6.4.3	PWC and TGen	<p>High</p> <p>Medium</p> <p>Medium</p> <p>Medium</p> <p>High</p> <p>High</p> <p>Medium</p>
8	<p>Make engineering changes to avoid the Jenbacher units becoming overloaded during power system events:</p>	4.4.3	TGen	High

ID	Recommendation	Entura report reference	Responsible	Priority
	<ul style="list-style-type: none"> • modify OSPS control system so that AGC raise signals are not passed to Jenbacher machines that are operating above their de-rate limit. • do not add a further power control loop outside of an existing power control loop. • consider designing the outer control loop so that it automatically suspends its own operation, when the system frequency is a small margin below the UFLS stage 3 setpoint. 			
9	<p>Make further control changes and investigations of the performance of the Jenbacher units:</p> <ul style="list-style-type: none"> • investigate and address issues in relation to the need for Dia.ne control system reboot after a unit trip • remove all power factor limiters and replace them with limiters that reflect likely mechanisms of damage to the machines • review and adjust the under frequency settings to ensure that they are no more sensitive than is necessary to protect the machines from damage • determine and address the source of an apparent inability of the Jenbacher machines to respond to sudden application of load exceeding 10% of their rating 	5.2.4	TGen	High
10	<p>Make engineering changes to avoid the BESS becoming overloaded during power system events:</p> <ul style="list-style-type: none"> • check and adjust the limiter settings to ensure that the BESS does not trip during power system disturbances • Determine the inrush current of the BESS to determine how it should be used during a system black event 	4.4.5, 5.2.2	TGen	High
11	<p>Address issues adversely affecting system security. In particular:</p> <ul style="list-style-type: none"> • investigate and implement modifications to stop the Man units (or any other unit) coming out of AGC control without an operator command or unforeseeable fault condition • add alarms that rapidly bring to the ROC operator's attention that a generator has come out of AGC control • Track spinning reserve and regulating reserve separately 	4.4.2	TGen	High
12	<p>Improve the under frequency load shedding scheme (UFLS). In particular a review and report should be prepared by System Control that addresses:</p> <ul style="list-style-type: none"> • UFLS scheme optimised setpoints and time delays 	4.4.4, 4.4.5, 6.3	PWC	Medium

ID	Recommendation	Entura report reference	Responsible	Priority
	<ul style="list-style-type: none"> • coordinated changes to the BESS droop settings • coordination of the settings of the UFLS system with the spinning reserve policy • failure of UFLS stage #3 during the system black • whether the BESS output should be capped at its long term rating (5MW) until after UFLS stages #1 and #2 have operated for system security purposes. 			
13	System Control prepare a tracking spreadsheet to the satisfaction of the Commission incorporating all recommendations from all system black events back until January 2015.	6.1	System Control	High
14	<p>The Utilities Commission place a focus on determining if the recommendations of this report and other major event reports have been tracked and implemented during their annual power system reviews.</p> <p>Government consider developing a documented process for the reporting and implementation of the recommendations of this and other major event reports by System Control and TGen, with a potential role for the Commission or another independent body.</p>	8	Utilities Commission and Government	Medium
15	Government consider allocating explicit responsibility to an appropriate party to advise vulnerable customers, such as those requiring life support equipment at home, to implement their emergency action plans in the case of a system black or other unplanned interruption.	6.2.6	Government	Medium

ATTACHMENTS

Attachment A: Terms of Reference from the Regulatory Minister

TERMS OF REFERENCE

INDEPENDENT INVESTIGATION OF ALICE SPRINGS SYSTEM BLACK INCIDENT OF 13 OCTOBER 2019

On the afternoon of Sunday, 13 October 2019, an extended system black power outage in Alice Springs and connected communities affected about 12 000 customers, some for a period of up to nine hours.

The Power and Water Corporation and Territory Generation are investigating the incident.

Referral

Pursuant to section 6(1)(g) of the *Utilities Commission Act 2000*, the Utilities Commission is to conduct an independent investigation into the Alice Springs and connected communities system black incident that occurred on 13 October 2019.

Objectives

The objectives of this investigation are to identify:

- the causes of the incident, its severity and duration
- broader implications for future power system reliability and security for Alice Springs and connected communities, and
- appropriate remedial measures to infrastructure, systems and processes.

Scope

The investigation is to address the following matters:

- the power system situation that existed prior to the system black incident (having regard for the current transition process from Ron Goodin Power Station to Owen Springs Power Station), the sequence of events leading to the incident and the state of the power system after the incident, plus any related subsequent incidents
- the root causes of the incident from a technical standpoint including any operational and maintenance activities
- the Alice Springs power system's history of major incidents, their investigation and implementation of remedial actions
- the response of generators to the disturbance and their protection systems
- the response of automatic dispatch and automatic generator control systems during the incident
- standards and procedures followed by System Control to mitigate the risk of system insecurity and their performance against these standards during this incident (including black start procedures and adequacy of employees training)
- any other causal factors and factors contributing to both the occurrence and severity of the incident

- the adequacy and speed of the response to the incident, including established emergency management protocols, external communication and mitigations taken to protect vulnerable consumers
- the time taken to restore the system, including any issues that may have negatively impacted the restoration time, and compliance with and adequacy of current power system restoration procedures, including the identification of any gaps
- the adequacy of the Alice Springs spinning reserve policy and automatic generator controls to respond to system events thereby providing reliable and secure power in the future
- actions that may be required to prevent a recurrence of such an incident including the design of the power system and related power system operation and maintenance practices
- whether limits of normal operation of automated generator control are understood and, therefore, at what point operations determine that system security is at risk and remedial action needs to be taken, including the implementation of system constraints
- the outlook for the system over the next 12 months, including how the plans for the retirement of the Ron Goodin Power Station and the battery commissioning (separately and combined) are assisting or undermining the capacity of the network to manage these incidents, and whether the plans and emergency responses are adequate for each phase, and
- subsequent investigations and appropriate timing, if the above matters are unable to be addressed within the specified timeframe.

Delivery

The Utilities Commission is to draw on external technical resources as it considers appropriate.

The Commission is to provide an investigation report to the Hon Nicole Manison MLA, Treasurer and the Hon Dale Wakefield MLA, Minister for Renewables, Energy and Essential Services by 18 November 2019.

Stakeholders

Key stakeholders are to be consulted during the course of the investigation, including but not limited to:

- Territory Generation
- Power and Water Corporation System Control
- Power and Water Corporation Networks
- Epuron (in relation to Uterne Power Plant Pty Ltd)
- Licenced retailers
- Workers' unions
- Northern Territory Government, and
- Employees involved in the event and restoration.

Budget

The Department of Treasury and Finance will provide funding to meet the Commission's costs for external technical resources to conduct the investigation.

Attachment B: Entura report – Alice Springs System Black 13 October 2019

The report from Entura is provided in a separately attached document. The Entura report includes the following components:

- executive summary
- introduction
- investigation approach
- System black
 - Sequence of events leading to the system black
 - Initiating event (root cause)
 - Automation response
 - Machine and protection response
 - Causal factors
 - Standards and procedures to avoid major events
- Restoration
 - Sequence of events during restoration
 - Duration of restoration
- Management systems
 - History of major events
 - Communications, standards and procedures for responding to major event
 - Spinning reserve
 - Knowledge and training
- Outlook including Ron Goodin closure
- Summary of Recommendations
- Acknowledgement.