UTILITIES COMMISSION
OF THE NORTHERN TERRITORY

Northern Territory Power System Performance Review

2020-21

Disclaimer

The Northern Territory Power System Performance Review (NTPSPR) is prepared using information sourced from participants in the electricity supply industry, Northern Territory Government agencies, consultant reports and publicly available information. The NTPSPR is in respect of the financial year ending 30 June 2021. The Utilities Commission understands the information received to be current as at April 2022.

The NTPSPR contains analysis and statements based on both the Commission's and, on behalf of the Commission, Entura's interpretation of data provided by Territory electricity industry participants. The Commission has sought to align its data reporting with the other Australian jurisdictions where possible, to enable comparison. However, there are some differences and any comparisons should only be considered indicative.

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Any questions regarding the NTPSPR should be directed to the Utilities Commission, utilities.commission@nt.gov.au or by phone 08 8999 5480.

About this review

Since 2018, the Utilities Commission of the Northern Territory (Commission) has published an annual Northern Territory Power System Performance Review (NTPSPR), which focuses on generation and network performance of the Darwin-Katherine, Alice Springs and Tennant Creek power systems. Where possible, the NTPSPR compares current performance to industry benchmarks and historical data to identify trends.

The 2020-21 NTPSPR is prepared in accordance with section 45 of the *Electricity Reform Act 2000* and is restricted to the Darwin-Katherine, Alice Springs and Tennant Creek power systems.

The NTPSPR's main purpose is to inform the responsible minister, government, licence holders and stakeholders of the 2020-21 generation and network performance in the Darwin-Katherine, Alice Springs and Tennant Creek power systems, and highlight any areas of concern.

Regular reporting on the electricity supply industry should help increase understanding and transparency of issues and, consequently, improve planning, investment, understanding of value for money (price compared with level of service) and general performance by holding electricity businesses accountable for their performance and impacts on customers.

The content of the NTPSPR was largely produced by Entura on behalf of and with the assistance of the Commission, and with input from licensees (Power and Water Corporation (PWC) Power Services and System Control, EDL NGD (NT) Pty Ltd (EDL), Territory Generation, Uterne Power Plant Pty Ltd, BSF Co Pty Ltd and HCPS Co Pty Ltd), with the inclusion of more comprehensive stakeholder consultation in this year's review than previous years. The Commission supports the analysis, conclusions and recommendations made on its behalf by Entura.

Key findings and recommendations

Overall performance

Overall the review found power system performance in 2020-21 to be satisfactory in Darwin-Katherine, however generation performed poorly in Alice Springs and the overall performance in Tennant Creek was poor. In general, the standards of service and adequacy of the network and generating units are being maintained but key performance gaps are evident in each of the three power systems, particularly relating to generation in Alice Springs and the power system as a whole in Tennant Creek.

The Darwin-Katherine power system continues to be affected by the inability to manage faults on the single 132 kilovolt (kV) transmission line between Darwin and Katherine. This is not the only issue facing the power system but is the most impactful, especially for customers in the Katherine region. The connection of a large-scale solar farm in the Katherine region and then subsequent large-scale solar farms in the Batchelor and Manton Dam regions will raise both the importance and complexity of managing this line. The Commission understands PWC Power Services is working to improve the switching on the line.

Unreliable generation remains a constant across the three power systems and, while the issue differs slightly between power systems, the impact is the same: less robust generation often impacting customers due to load shedding. The number of single unit trips remains high in the Darwin-Katherine and Alice Springs power systems and, while these trips are managed within spinning reserve margins (at a cost to the overall system), and therefore do not impact customer access to power, they betray an underlying vulnerability that must be addressed. Entura has observed improved processes from Territory Generation in relation to this issue and has some confidence that these processes will lead to improved generator reliability over time.

Discussions with licensees during consultation for this review suggest the capacity of PWC Power Services and System Control to meet the demands of new connections, ongoing operational challenges, and the large-scale transitions occurring in the Darwin-Katherine and Alice Springs power systems is potentially insufficient.

This is an issue across most jurisdictions in Australia. The level of activity in the power system planning, network connections and system operations space is extremely high, and the availability of experienced personnel to augment in-house capability to a useful extent is very low.

While there is not a specific recommendation, it is for the licensees to discern the effectiveness of their resourcing levels and priorities, and determine appropriate strategies and tactics. Future NTPSPRs will consider the success or otherwise of those strategies and tactics.

Many of the recommendations from previous NTPSPRs remain in progress, noting the recommendations are those of the Commission and not enforceable unless they relate to non-compliance. While many performance improvements can be driven through the recommendations in PWC System Control major incident reports, the recommendations in this review and the Commission's other publications are more general and overarching improvement opportunities.

While progress has been slow, the Commission considers that intentional work is being undertaken to address recommendations and there is some evidence the pace of progress may be increasing. Where progress is being made, the benefits are showing in the performance of the power systems. A summary of progress against these recommendations follows the individual power system performance summaries in this section of the review.

Summary of recommendations

The following recommendations, listed in order of importance, result from the investigations and analysis undertaken as part of the review:

1. Katherine island operation (page 22)

Many of the major incidents in the Darwin-Katherine power system over the last few years, and particularly during 2020-21, relate to the management of the Katherine end of the power system when a disconnection (separation event) occurs along the 132 kV transmission line between Darwin and Katherine. The line runs from Channel Island in the north through Manton Dam and Pine Creek to Katherine in the south and can open (or a fault can occur) at each of those points. The current arrangements require active intervention when the line opens. Relevant licensees are required to change the control modes of the generating units that remain connected to the newly formed island. This ensures satisfactory recovery from a separation event.

Entura understands that generating units in the Katherine region are typically operated in power factor control at a power set point. That is, they do not respond to frequency or voltage variations other than to maintain their set points. This means that if the 132 kV transmission line trips with some power flow on it, the Katherine generating units will not respond to address any load imbalance in the ensuing island, nor will they act to control voltage. Entura does not consider this to be the most suitable mode of control.

It is recommended that PWC System Control investigates how these units could be normally operated in both voltage and frequency droop modes to assist power system recovery from a separation event.

2. Unusual system conditions

The following recommendations relate to managing unusual system conditions either arising from contingency events or rare dispatch scenarios, or a combination of both.

a) Islanding investigation (page 22)

While a recommendation has been made above to investigate the best method of controlling the Katherine region when islanded from the rest of the power system, this is only one of many islands in the power system, and the mode of generation control in the Katherine region only addresses a small subset of all possible island conditions in that region of the network.

With the range of dispatch scenarios likely to widen as more solar power becomes available, it is likely there will be many more island or weakened areas of the network that can form in the aftermath of a contingency event.

It is recommended that PWC System Control, in consultation with PWC Power Services and relevant licensees, investigates these possible events and uses a risk-based approach to determine which of these scenarios require planning actions. Planning actions may take the form of constraints, network investment or localised ancillary service requirements, among others.

b) Focus on recovery phase (page 53)

Entura has observed from the major incidents during 2020-21 and system average interruption duration index (SAIDI) trends that the duration of outages appears to be increasing in many instances. Over a number of reviews, Entura has observed that events occur across the three power systems at a potentially higher rate than in other jurisdictions. This being the case, the logical way to reduce the impact on customers is to reconnect them in a timely manner. It is recommended that the processes and procedures used for reconnection and incident recovery be reviewed. This review should include an assessment of the usefulness of each generating unit type for restart services under different conditions, the order of switching and communication, and coordination between PWC System Control, generators and field crews.

3. Incident reporting

The following recommendations relate to the content of PWC System Control's major incident reports.

a) Incident recovery (page 49)

Further to the recommendation above relating to the recovery phase after major incidents, It is recommended that more focus on this phase of an event in PWC System Control's major incident reports. For instance, in system black reports, Entura often sees customer reconnection curves. The major incident reporting template should be updated to allow for greater detail on the recovery phase. Subsequent NTPSPRs could then determine why or how the outage durations appear to be worsening. The cause of delays to reconnecting and the compounding effects these delays have on the overall incident recovery should become clearer with improved reporting transparency.

b) Clarity on generation SAIDI and system average interruption frequency index (SAIFI) apportioning in incident reports (page 29)

While the Electricity Industry Performance Code (EIP Code) requires generators to report on their SAIDI and SAIFI performance, noting the EIP Code is under review, then it is recommended that PWC System Control clearly identify and apportion the customer impact for a particular event between the relevant licensees in each major incident report.

4. Responsiveness to calls (page 81)

Entura notes a sharp rise in the average time taken for PWC Power Services to answer incoming calls in relation to networks and a coinciding rise in the number of abandoned calls. The level of abandoned calls compares poorly to appropriate industry benchmarks. It is recommended that PWC Power Services reviews its practices relating to call answering.

Darwin-Katherine

A review of generation and network performance in the Darwin-Katherine power system in 2020-21 found satisfactory performance, as summarised in Table i. While the performance trend is assessed to be flat and deteriorating for generation and networks, respectively, warning signs remain that indicate significant issues must be addressed to maintain or improve performance in the future.

The frequency of single unit trips fell slightly in 2020-21, however remains high. This remains a vulnerability in a power system that is undergoing a transition to include more variable renewable forms of generation. Previously, the NTPSPR has recommended analysing the reason for these trips more thoroughly, however, there has been little improvement to date.

The generating fleet in the Darwin-Katherine power system is starting to show its age with constraints being applied to keep the failing units out of operating zones where they were once stable. This throws focus on the next tranche of generating systems to be connected, however these solar farms are struggling to meet the requirements for network and model compliance developed under the Network Technical Code and associated guidelines.

Issues relating to managing the Katherine region of the power system continue, especially when a disconnection occurs along the 132 kV transmission line between Darwin and Katherine. This management will only become more difficult once new solar farms are connected to this southern end of the power system.

In contrast, it is encouraging to see more rigorous systems around licensees communicating with each other. The regular dialogue and other administrative controls appear to be delivering better performance and an improved culture of collaboration.

Details on the performance of the Darwin-Katherine power system in 2020-21, including comparisons to historical data, comprehensive discussion relating to identified issues and concerns, and highlights, is provided in Chapter 1 of this review.

Table i: Generation and network performance in the Darwin-Katherine power system in 2020-21

	Performance	Trend	Issue/concern	Highlights
Generation	Satisfactory	Flat	• Over-reliance on Channel Island • Advanced age of generation fleet • Katherine/Pine Creek island operation is not robust • Testing and abnormal plant condition management • Longer, more frequent incidents affecting customers[1] • Delays associated with getting new generating systems into commercial service • Forced outage factors climbing • Increased constraints due to the condition of generators	• Incident recommendation tracking improving • Territory Generation taking risk-based approach to increasing unit reliability • Increasing customer reliability through constraints, however likely with some cost to generators • Increased preventative maintenance
Network	Satisfactory	Deteriorating	• Low voltage network voltage regulation is increasing beyond preferred levels. • Islanding controls and operational protocols are not adequate • Customer impact in Katherine region from islanding is not adequate	• Planning for managing peak demand is effective • Improvements in outage coordination • Duration of network-related outages reduced

1 The whole Darwin-Katherine power system was impacted by a single event which contributed to most of the SAIDI minutes. Conversely, customers in the Katherine region of the power system suffered from more frequent interruptions.

Alice Springs

A review of generation and network performance in the Alice Springs power system in 2020-21 found network performance is satisfactory, however the generating units are not performing adequately, as summarised in Table ii.

The Alice Springs power system remains in a state of recovery and transition, following the system black that occurred on 13 October 2019, with key recommendations from the Commission's report into the incident only recently completed, noting one recommendation is still in progress. These recommendations are key to allowing the new generating units at the Owen Springs power station to unload the ageing generating units at the Ron Goodin power station. Several factors have hampered progress including ongoing performance issues with the battery energy storage system (BESS) and new generating units at the Owen Springs power station, as well as difficulties in arranging on-site support amid the ongoing COVID-19 pandemic. This transition of generation, coupled with the connection of a significant industrial load to the network in the near term, means further significant changes to the operation of the power system lie ahead. Planning is underway to manage these changes.

The continuing reliance on the Ron Goodin power station due to delays in gaining full reliability from the new generating units at the Owen Springs power station remains a concern (and a system cost). Territory Generation is working well to keep as many generating units at the Ron Goodin power station as functional as possible, however the age of the generation units is leading to poor reliability. There remains a high number of single unit trips in the region, and these trips are occurring across the generation fleet, however are not affecting customers' access to electricity due to adequate spinning reserve margins insulating customers (which comes at a cost to system).

Details on the performance of the Alice Springs power system in 2020-21, including comparisons to historical data, comprehensive discussion in relation to the identified issues and concerns, and highlights, are provided in Chapter 2 of this review.

Table ii: Generation and network performance in the Alice Springs power system in 2020-21

	Performance	Trend	Issue/concern	Highlights
Generation	Poor	Improving	• BESS teething issues • Reliance on older generation at Ron Goodin power station • Robustness of generating plant • Forced outage factors increased	• Frequency of single generator trips has normalised • Frequency and duration of generator incidents decreased • No customer impact from single unit generation incidents • Customer minutes without supply from major incidents significantly reduced
Network	Satisfactory	Flat	• Load balance between Sadadeen and Lovegrove zone substations needs attention	• Improvement in low voltage network voltage management • Quality of service maintained • Customer minutes without supply from major incidents maintained • SAIDI and SAIFI within relevant benchmarks

Tennant Creek

A review of generation and network performance in the Tennant Creek power system in 2020-21 found neither the generation nor the network is performing adequately, as summarised in Table iii. However, the performance of the Tennant Creek power system has improved for the second straight year, with discussions with Territory Generation and PWC Power Services suggesting further improvement can be expected as both parties investigate enhanced protection and switching capacity.

The overall performance remains poor relative to the other power systems discussed in this review and expectations for a power system of this nature. There are fundamental elements of good electricity industry practice that are not evident in the operation of the power system, leading to low levels of generation availability, high concurrence of network and generator incidents, and protection equipment failures.

The performance of the Tennant Creek power system relies on strong coordination between the network controls and capabilities of the generating units. As demonstrated in the Alice Springs power system, the Jenbacher generating units are slow to accept additional load during under-frequency events. While this is an important consideration in Alice Springs, it is even more critical in the Tennant Creek power system. There is a design challenge yet to be addressed relating to the under-frequency settings, governor capacity of generators and generator protection that may provide more robust performance under some circumstances. While the performance of the Tennant Creek power system is showing some improvement across 2019-20 and 2020-21, more fundamental changes will be required if the performance is to become comparable with the Darwin-Katherine and Alice Springs power systems.

There appears to be an intent from the relevant licensees to address these performance issues in the near future. The performance of the power system will always be variable by virtue of its nature (long lines, low demand and small generating units). Current performance trends are positive, and these are being built on by the licensees to attempt to consolidate recent improvements.

Details on the performance of the Tennant Creek power system in 2020-21, including comparisons to historical data, comprehensive discussion in relation to the identified issues and concerns, and highlights is provided in Chapter 3 of this review.

Table iii: Generation and network performance in the Tennant Creek power system in 2020-21

	Performance	Trend	Issue/concern	Highlights
Generation	Poor	Improving	• Reduced generation availability • Planned outages increased	• SAIDI and SAIFI consistent with historical average • Increased system security, however through the implementation of spinning reserve constraints, which likely add to costs
Network	Poor	Flat	• Continuing trend of network incidents leading to generation incidents and under frequency load shedding (UFLS) operation • UFLS recovery appears to be slow with less frequent but longer disruptions • Low voltage network voltages are higher than preferred levels most of the time	• Investigations underway to improve robustness of distribution network during and after electrical faults • Feeder loading well below nominal ratings • SAIDI consistent with and SAIFI under the long-term average

Review of progress on previous recommendations

The following table summarises Entura's assessment of the status of recommendations from the 2019-20 NTPSPR, noting the recommendations are those of the Commission and, where the recommendations do not relate to non-compliance, such with licence conditions or relevant legislation, are not enforceable. Recommendations from previous NTPSPRs are included in appendices A and B.

Table 4 Recommendations from the 2019-20 NTPSPR Table 5

Recommendation	Comments on observed progress	Overall assessment
1 **More thorough investigation of single unit trips** It is important for generation licensees to understand why their generation units trip. Single generator trips will continue to occur (and seemingly at greater frequency) unless more thorough investigation of the cause of single unit trips and identified issues are addressed.	Discussions with Territory Generation indicate a changed approach to single unit trips. Essentially, the approach is to identify the cause of trips and attempt to identify patterns. Territory Generation indicated the analysis to date does not reveal any patterns. This is consistent with Entura's interpretation of the data. In the absence of failure patterns, Territory Generation described a risk-based approach that identifies causes likely to have high consequence. This approach means effort is targeted at remedying the causes of likely future trips. Entura considers this is consistent with good electricity industry practice and the approach should, over time, lead to a reduction in the frequency of these trips.	In progress
2 **Alice Springs power system operability** Appropriate power system modelling needs to be undertaken to determine how the Alice Springs power system can be operated once generation is solely or predominantly located at the Owen Springs power station.	Discussions with licensees in the process of undertaking Entura's review provide assurance the future state of the Alice Springs power system is under active consideration.	Complete
3 **Investigate alternatives to the Weddell power station constraint** A constraint imposed on the operation of the Weddell power station under certain load conditions due to thermal capacity limits in the network to allow for secure operation.	During consultation, Territory Generation indicated it is open to practical solutions to the constraint and is seeking engagement from PWC Power Services and System Control.	In progress
4 **Better post-commissioning support mechanisms** A need for more effective management of post-commissioning performance.	Discussions with licensees in the process of undertaking Entura's review indicate there is an acceptance of the importance of maintaining commercial relationships with original equipment manufacturers for the purposes of ensuring timely responses to performance issues as they arise. Entura is satisfied this recommendation is complete.	Complete
5 **Coordination of generation protection and network requirements** The setting of protection limits for over and under voltage and frequency on generating units should always represent the capability of the generation units themselves rather than the power system limits.	Discussions with licensees in the process of undertaking Entura's review indicate both Territory Generation and PWC Power Services are working to improve the interoperability of generation and network assets in the Tennant Creek power system. Work has commenced, however Entura considers it not sufficiently progressed to mark the recommendation as complete.	In progress

continued

Recommendation	Comments on observed progress	Overall assessment
6 **Management of voltage in Alice Springs** A need for investigation of, and potential investment in, managing supply voltages in the low voltage parts of the distribution network in the Alice Springs power system.	The range of the low-voltage supply improved in 2020-21. However, Entura considers further improvement and consolidation is required before this recommendation can be marked complete. The retirement of generation units at the Ron Goodin power station will require a change to the current control mechanisms. The impact of this change should be planned for and monitored by relevant licensees.	In progress

Contents

1 Darwin-Katherine power system

This chapter focuses on the 2020-21 generation and network performance of the Darwin-Katherine power system. Where possible, it compares 2020-21 performance with historical data to identify trends. Specifically, this chapter considers:

- incidents
- generator performance, observed UFLS and single generator trips, generation availability, non-reliable periods and generation constraints
- network performance, network utilisation, network and power system-wide constraints, network power quality and network complaints.

Power system description

The Darwin-Katherine power system is the largest power system in the Northern Territory. It supplies Darwin and Palmerston city centres, suburbs and surrounding areas, the township of Katherine and its surrounding rural areas.

The energy sent out by licensed generators over the last four years is shown in the Table 1.

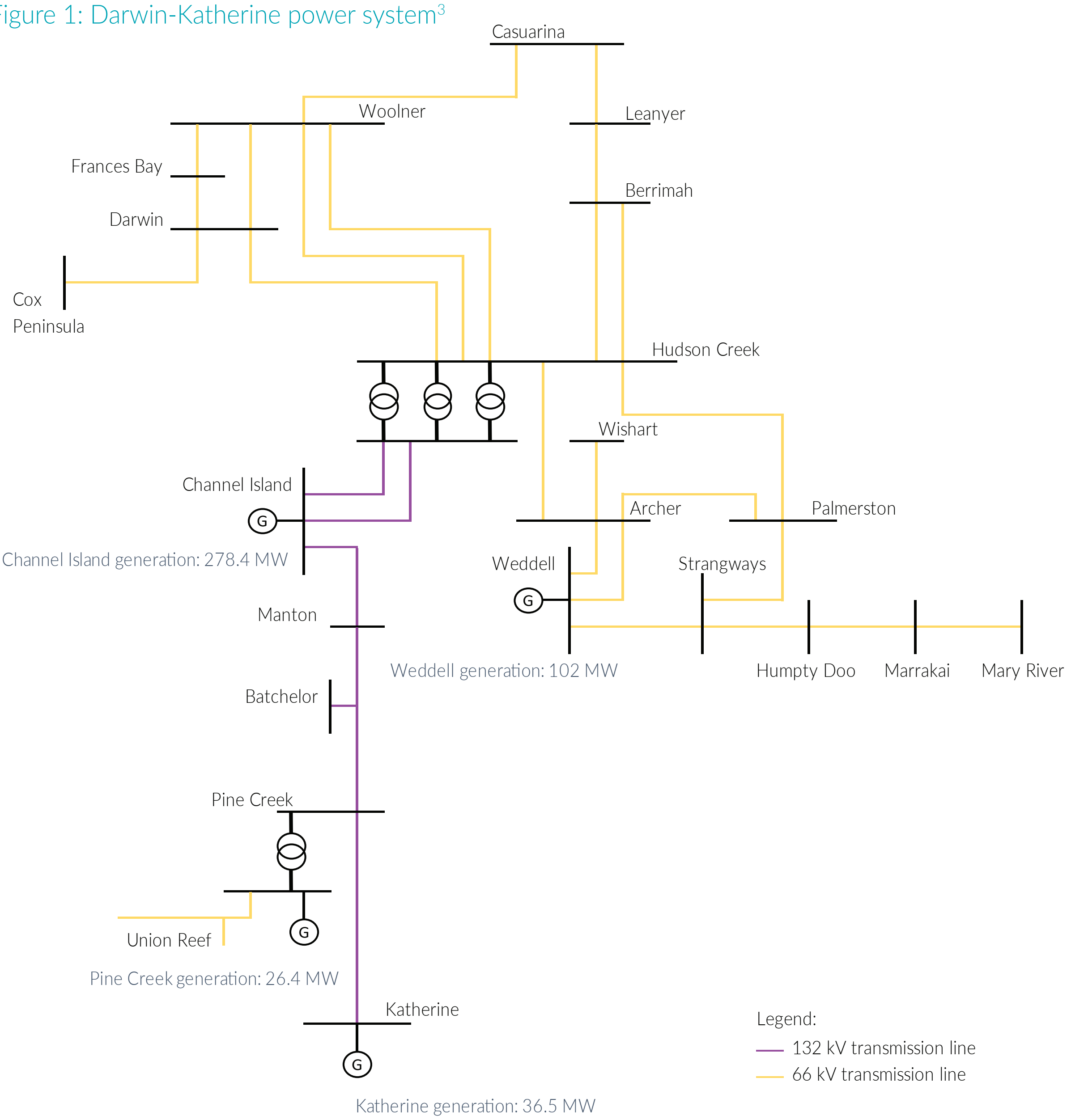
Table 1: Darwin-Katherine energy sent out in 2020-21[2]

	Energy sent out (gigawatt hours (GWh))			
	2017-18	2018-19	2019-20	2020-21
Darwin-Katherine	1 620	1 573	1 506	1 466

Figure 1 shows a simplified representation of the Darwin-Katherine power system. The major transmission lines in this system are lines from Channel Island to Katherine and Channel Island to Hudson Creek. A double-circuit overhead 132 kV transmission line from Channel Island to Hudson Creek (Channel Island-Hudson Creek) serves the Darwin area, while a 300 km single circuit 132 kV transmission line (Channel Island-Katherine) runs south from Darwin to Manton, Batchelor, Pine Creek and Katherine.

2 Based on data from PWC System Control issued Northern Territory Regulated Power Systems biannual reports.

Figure 1: Darwin-Katherine power system[3]



Incidents

An incident, or reportable incident, is a power system event that had or could have had a significant adverse effect on security or reliability of electricity supply, and is determined by PWC System Control in accordance with the System Control Technical Code (SCTC). PWC System Control determines whether a reportable incident is classed as a major or minor incident, noting it has a level of discretion. Major incidents are subject to more detailed investigation and reporting requirements.

The Commission considers the purpose of incident reporting is to ensure power system events that would benefit from investigation are investigated to identify and address issues, and to improve the safe and reliable supply of electricity to customers.

This section considers the overall customer impact from major and minor incidents, provides an overview of major incidents, and discusses the tracking and implementation of PWC System Control recommendations following the investigation of major incidents.

3 Generation capacities relate to non-summer (dry season) capacities in accordance with the 2020 NTEOR. The 2021 NTEOR had not been published at the time of writing this review.

Overall customer impact

This section shows the overall impact of major and minor incidents on customers in the Darwin-Katherine region over the last five years (Table 2).

The number of customers impacted and total duration (minutes) of an incident is reported to the Commission by PWC System Control as part of its SCTC obligations, and is used to calculate indicators such as SAIDI. However, as customers are restored in stages not all customers are impacted for the full duration of the incident, which may lead to over reporting. To address this, starting from 2020-21, the Commission's reporting on SAIDI takes this sequential restoration into account, and therefore provides a better representation of the customers' overall experience. The Commission notes this change to reporting may impact the usefulness of historical comparisons.

Table 2: Overall customer impact from major and minor incidents in the Darwin-Katherine power system, and Darwin and Katherine subregions

	2016-17	2017-18[4]	2018-19	2019-20	2020-21
Darwin-Katherine					
Number of incidents	78	71	61	80	75
Customers impacted	131 976	111 368	81 105	97 880	161 960
Total duration (minutes)	10 853	10 939	8 823	12 170	12 551
SAIDI	169.3	194.3	115.0	158.56	196.6
SAIFI	1.95	1.55	1.16	1.38	2.27
Reliability (% of year)	99.97	99.97	99.98	99.97	99.96
System blacks					
Region wide	0	0	0	0	0
Katherine island blacks[5]	7	7	3	4	11
132 kV separation[6]			3	4	12
Darwin					
Number of incidents	68	61	51	66	63
Customers impacted	106 876	83 523	62 335	80 302	110 340
Total duration (minutes)	10 269	9 933	7 548	8 936	10 213
SAIDI	156.9	178.2	108.6	139.8	189.7
SAIFI	1.68	1.24	0.95	1.21	1.65
Reliability (% of year)	99.97	99.97	99.98	99.97	99.96
Katherine					
Number of incidents	10	10	10	14	12
Customers impacted	25 100	27 845	18 770	17 578	51 620
Total duration (minutes)	584	1 006	1 275	3 234	2 338
SAIDI	360.2	442.9	210.3	439.9	300.2
SAIFI	6.07	6.35	4.25	3.97	11.60
Reliability (% of year)	99.93	99.92	99.96	99.92	99.94

4 Excludes Tropical Cyclone Marcus, which resulted in a major incident on 17 March 2018. The major incident is attributable to 473,440,000 customer minutes without supply in the Darwin-Katherine power system, however has been removed from the data for the analysis in this review as it masks underlying power system performance.

5 A Katherine island black is a system black for the region south of the point where a disconnection occurs of the 132 kV line from Darwin to Katherine.

6 Data not reported prior to 2018-19.

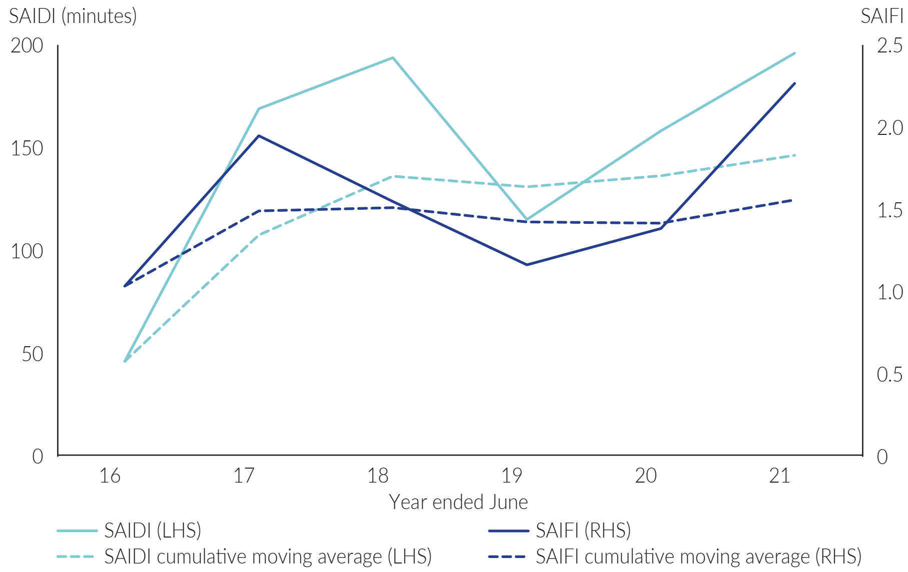
SAIDI is a measure in minutes of the average duration of an incident weighted by the number of customers affected by each event. That is, if 10 customers suffer a 10-minute interruption but there are 100 customers in the region in total, then this would lead to a SAIDI of 1 minute. Multiple incidents are added together so if a second incident of 15 minutes affected 10 customers then that would be added to the first incident and lead to a SAIDI of 2.5 minutes.

SAIFI is a measure of the average number of incidents weighted by the number of customers affected by each incident. Using the examples above, the SAIFI would be 0.1 after the first incident and 0.2 after the second.

Reliability (percentage of year) is calculated based on SAIDI and is the percentage of a year the average duration in minutes of incidents per customer represents, subtracted from the total number of minutes in a year. This is different from the unserved energy-based reliability standard[7] for generation of 0.002% applied in the National Electricity Market (NEM), which is also adopted by the Commission in its Northern Territory Electricity Outlook Report (NTEOR) reliability assessments in the absence of a formal Territory target.

The major and minor incident SAIDI and SAIFI performance for the Darwin-Katherine power system over the last six years is shown in Figure 2.

Figure 2: Major and minor incident SAIDI and SAIFI performance, Darwin-Katherine[8]



There was a large increase in SAIDI and SAIFI during 2020-21 compared with 2019-20. Based on the rolling average, both SAIDI and SAIFI are continuing to deteriorate. However, Entura notes an incident on 18 November 2020 resulting in the loss of gas supply to the Channel Island power station, and subsequent technical black[9], strongly impacted the result in 2020-21 and accounted for 82% of the SAIDI when considering major incidents (55% of the 2020-21 SAIDI when considering both major and minor incidents).

7 https://www.aemc.gov.au/sites/default/files/content/2f4045ef-9e8f-4e57-a79c-c4b7e9946b5d/Fact-sheet-reliability-standard.pdf.

8 Based on data from PWC System Control incident reporting ('customers impacted' and 'total duration (minutes)').

9 A technical black is not defined in the Territory's legislative instruments, including the SCTC, however it is understood to be used by PWC System Control where supply is lost to a significant portion but not all of the power system.

Comparing the performance between the Darwin and Katherine subregions, it is evident that customers in the Katherine region are experiencing a disproportionately higher impact from power system incidents than those in the Darwin region, with SAIFI nearly tripling in the Katherine region during 2020-21 compared with 2019-20 due to the high frequency of Katherine island blacks (based on major incidents). The data also shows an increase in SAIDI for Katherine by about 40 minutes (from 260 to 300 minutes).

The incidents noted in the following sections, and Entura's analysis as to the causes of these incidents, suggest a decline in performance. This decline is mainly due to unresolved issues in the Katherine region pertaining to synchronising issues at the Pine Creek substation and island management at the Katherine substation. Entura understands PWC Power Services and System Control are actively working to resolve the issues in the Katherine region of the Darwin-Katherine power system.

It is also apparent to Entura that the number of incidents caused by equipment failure significantly increased during 2020-21. These incidents were within the Darwin subregion.

Major incidents

There were 21 major incidents recorded in the Darwin-Katherine power system in 2020-21, which is a large increase from the nine major incidents in 2019-20. The incidents are summarised in Table 3.

Table 3: Darwin-Katherine major incident summary[10]

ID	Date of incident	Description	Category	Cause	UFLS/black	Incident duration (minutes)	Customers affected	Customer minutes without supply
1	31-Jul-20	132 kV Pine Creek-Katherine line tripped – Pine Creek	Networks	Transient	Katherine system black	33	4187	119062
2	22-Aug-20	132 kV Manton-Pine Creek (MT-PK) line tripped	Networks	Transient/ animals	Katherine system black/KAZSS 1, 2 and 3	35	4836	163539
3	24-Aug-20	132 kV Channel Island to Hudson Creek line tripped	Networks	Equipment failure		1826	0	0
4	02-Sep-20	Woolner zone substation – RAAF feeder (11WN26) – network disturbances	Networks	Equipment failure (at RAAF base)		58	0	0
5	20-Sep-20	132 kV Manton-Pine Creek line tripped – Pine Creek	Networks	Transient	Katherine system black/KAZSS 2 and 3	102	4814	23028
6	18-Nov-20	Technical system black – loss of gas supply to Channel Island power station	Generation	Equipment failure/third-party impacts	System black/ UFLS 1Y, 2Y, 3X, 4X, 5Y, 6X, KAZS 1 and 2	248	49089	7712225

continued

10 Based on data from PWC System Control incident reporting ('customers impacted' and 'total duration (minutes)').

ID	Date of incident	Description	Category	Cause	UFLS/black	Incident duration (minutes)	Customers affected	Customer minutes without supply
7	25-Nov-20	66 kV separation event, dual trip HC-AR/HC-PA	Networks	Weather/ transient		4	0	0
8	08-Dec-20	132 kV Pine Creek-Katherine (PK-KA) line tripped	Networks	Equipment failure	Katherine system black/UFLS KAZS 1	221	4762	535355
9	15-Dec-20	Channel Island power station C1/C7 node tripped	Generation	Equipment failure		298	0	0
10	06-Jan-21	132 kV Pine Creek-Katherine line tripped	Networks	Weather	Katherine system black /KAZSS 2 and 3	18	4762	68310
11	09-Jan-21	132 kV Manton-Pine Creek line tripped	Networks	Weather	Katherine system black/KAZSS 1	350	4880	16833
12	21-Jan-21	132 kV Manton-Pine Creek line tripped – Pine Creek	Networks	Weather	Katherine system black /KAZSS 1, 2 and 3	16	5123	61801
13	23-Jan-21	Weddell power station Units 1, 2 & 3 – unstable operation	Networks	Equipment failure		104	246	7732
14	08-Feb-21	Palmerston zone substation (PAZSS) – 66/11 kV transformer 5 (TF5) tripped	Networks	Equipment failure		375	982	5441
15	12-Feb-21	132 KV Manton-Pine Creek line tripped – Pine Creek	Networks	Weather	Katherine system black/KAZSS 1	171	5126	342169
16	13-Feb-21	132 KV Manton-Pine Creek line tripped – Pine Creek	Networks	Weather	Katherine system black/KAZSS 1	1107	5126	15984
17	27-Feb-21	Weddell unit 1 (W1) tripped – UFLS stage K1	Generation	Equipment failure	KAZSS 1	58	1528	9884711
18	17-Mar-21	132 kV Manton-Pine Creek line tripped	Networks	Weather/ operational error	Katherine system black/ KAZSS 1 and 2	224	5361	23882
19	23-Apr-21	66 kV PK-PC line and C8 tripped	Networks	Transient	1Y, KAZSS 1	34	5159	150766
20	07-May-21	Channel Island power station C2/C5 node tripped	Networks	Operational error		79	0	0
21	06-Jun-21	Operational issue during re-synchronising the 132 kV Manton-Pine Creek line	Generation	Operational error	Katherine system black/KAZSS 1	6	4689	13178

11 A minor inconsistency exists for incident 17 with the PWC System Control reported total customer minutes exceeding the 'number of affected customers multiplied by the event duration' by about 10%.

The incidents fall in four categories, namely operational error, weather, equipment failure and transient faults:

1. Operational error

Incidents 18, 20 and 21 fall into this category.

The 2018-19 NTPSPR made a recommendation relating to the need for more careful and deliberate planning and execution of outages. This is particularly important where other in-service generation units can be inadvertently impacted by a switching error. Entura is not satisfied that performance in this area is sufficiently consistent to consider this recommendation complete.

However, Entura appreciates that the power system, power stations and their related controls are complex, and often the errors that lead to these incidents are made in unusual circumstances. Entura expects that design, process and system improvements, in conjunction with better support, supervision and training of personnel, would all form part of a strategy to improve performance in this area.

2. Weather

Incidents 7, 10, 11, 12, 15, 16 and 18 fall into this category.

This category of incidents is unavoidable, however the impact may not always need to be as severe.

The common denominator with these events is the formation of islands. The management of islanding events is going to become more important as renewable energy penetration increases. Islands that form may or may not include sufficient synchronous sources to remain viable. It appears the management of the potential islands in the existing network is inadequate. Entura understands there is a project underway to address some of the issues arising from Katherine islanding events. Entura considers this will reduce the impact from this incident type (incidents 10, 11, 12, 15 and 16 in 2020-21).

Entura suggests further planning must be done to ensure islands form in a satisfactory manner for credible contingencies or protected events.

3. Equipment failure

Incidents 3, 4, 6, 8, 9, 13, 14 and 17 fall into this category.

While equipment failure is inevitable it is also good electricity industry practice to pre-empt this failure through condition monitoring and preventative maintenance regimes. The 2018-19 NTPSPR recommended practices relating to condition monitoring and routine testing be improved. Discussions with licensees during consultation suggest these practices are improving, however the number of incidents of this type remains too high.

Entura expects the improved practices will have a positive effect over time and will continue to monitor this category in subsequent reviews.

4. Transient faults

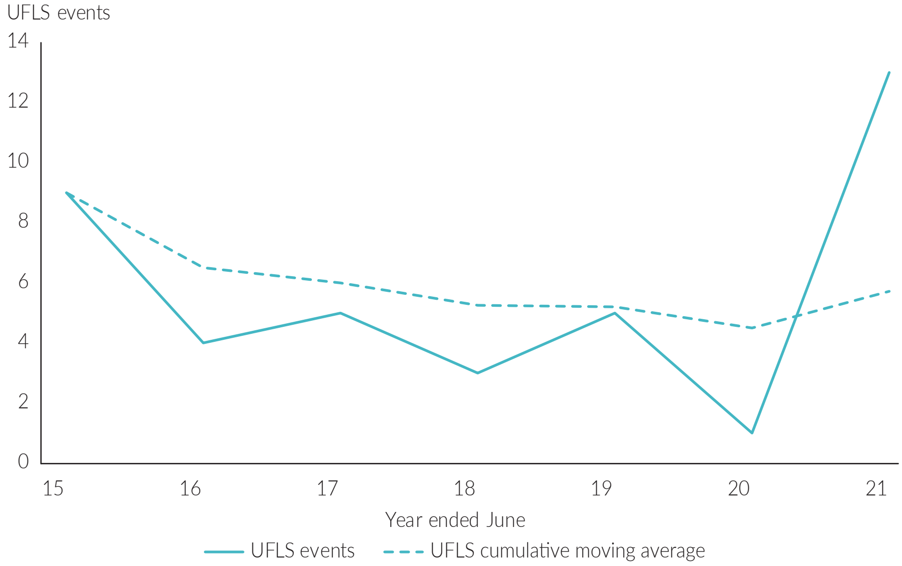
Incidents 1, 2, 5 and 19 fall into this category.

These incidents have a variety of causes (animals, transient faults), however the incidents have a common denominator, namely the opening of the Channel Island-Katherine 132 kV transmission line, resulting in the islanding of the Katherine region and ultimately loss of customer load in Katherine (often completely). The causes of the transient faults are almost totally unavoidable, however the robustness of the power system to deal with these faults while minimising customer impact can be improved. Entura discussed the management of islanding events above under the weather category.

Impact of major incidents

Figure 3 shows a substantial increase in the number of UFLS events during 2020-21, with the result being the highest in the last seven years. These events can be attributed to the Katherine island events. While the spinning reserve requirements were always met, most of the online generation tends to be in the Darwin subregion, which does not assist in recovering the system once a Katherine island is formed.

Figure 3: Number of UFLS incidents in Darwin-Katherine



Major incident report recommendations

Recommendations made by PWC System Control, as a result of its investigation of major reportable incidents, are consolidated in a recommendation tracking spreadsheet, which is periodically provided to the Commission.

In the Commission's independent investigation of a system black in Alice Springs on 13 October 2019, the Commission recommended placing a focus on determining if the recommendations of this report and other major event reports have been tracked and implemented during its annual power system reviews, which the Territory Government accepted. Accordingly, as part of the 2020-21 NTPSPR, Entura assessed PWC System Control's recommendation tracking spreadsheet (up to 30 June 2021), based on data provided by PWC System Control on 9 August 2021.

PWC System Control's recommendations are organised into eight categories: asset management, energy management system (EMS), modelling, power system studies, procedural, protection, training, and other. Table 4 shows the percentage of 'completed' and 'closed' recommendations for each category, and by the financial year in which they were raised (excluding obsolete and duplicate recommendations).

Table 4: Percentage of 'completed' and 'closed' recommendations by category and financial year raised, Darwin-Katherine

	Financial year raised			
	2020-21	2019-20	1 January 2015 to 30 June 2019	**All recommendations[12]**
	%	%	%	**%**
Asset management	57	67	69	**67**
EMS	7	0	23	**12**
Modelling	n/a	n/a	0	**0**
Power system studies	0	20	13	**10**
Procedural	12	59	38	**40**
Protection	22	21	56	**42**
Training	50	88	33	**67**
Other	89	n/a	n/a	**89**
All categories	**26**	**55**	**53**	**46**

Completing recommendations is not consistent across PWC System Control recommendation categories for the Darwin-Katherine power system. For instance, there has been a satisfactory level of progress made in completing other, asset management and training-related recommendations, while little progress has occurred with EMS, modelling and power system study-related recommendations.

Of the recommendations raised during 2020-21, 26% have been completed, while just over half of recommendations raised more than two years ago (at 30 June 2021) are complete. Overall, for recommendations made between January 2015 and 30 June 2020, 46% are complete.

12 From 1 January 2015 to 30 June 2021.

Generation

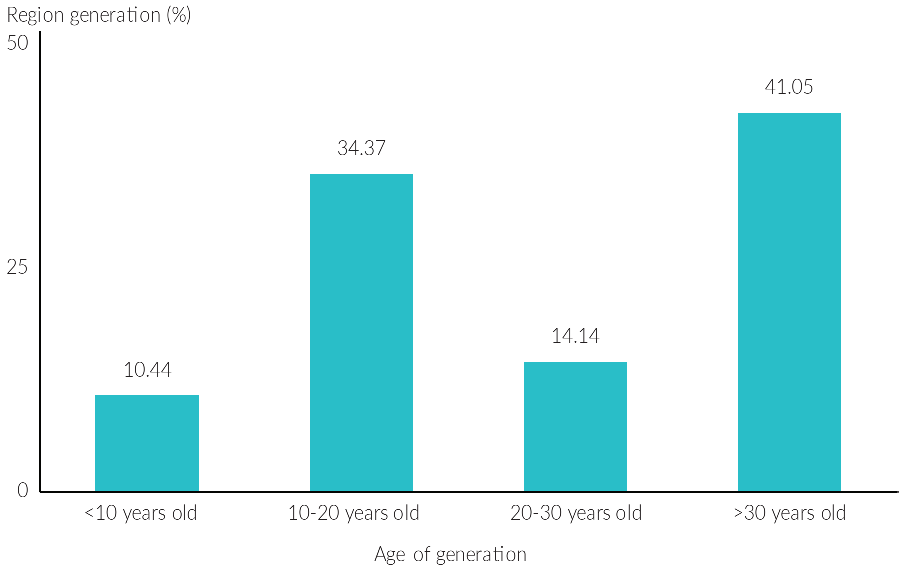
The total in-front-of-the-meter generation capacity in the system is over 444.1 megawatts (MW)[13]. This does not include behind-the-meter rooftop solar photovoltaic (PV) generation capacity, which totalled around 88 MW by the end of 2020-21. The fuel type of the generation is currently made up of dual fuel (gas/diesel), gas only, heat recovery steam and landfill gas. The operational maximum demand in 2020-21 was 284.8 MW.

Table 5: Maximum non-summer (dry season) network connected in-front-of-the-meter generation capacity in Darwin-Katherine[14]

Power station	Capacity (MW)
Channel Island	278.4
Weddell	102
Katherine	36.5
Pine Creek (EDL)	26.4
Shoal Bay landfill	1.1
Total generation	**444.1**

Figure 4 shows about 41% of Darwin-Katherine power system generation capacity is more than 30 years old.

Figure 4: Age of generators in Darwin-Katherine by percentage of maximum generation capacity[15]



13 Generation capacity relates to non-summer (dry season) network connected in-front-of-the-meter generation capacities. The generation capacity does not include generators that were built or partially built, but had not reached full commercial operations during 2020-21.

14 Generation capacities relate to non-summer (dry season) capacities in accordance with the 2020 NTEOR. The 2021 NTEOR had not been released at the time of writing this report.

15 Generation capacity relates to non-summer (dry season) network connected in-front-of-the-meter generation capacities.

The age of the generation fleet changed during 2020-21 as about 20% of the fleet moved from the less than 10 years old category to the 10-20 years old category. Additionally, 8% of the generation fleet moved from the 10-20 years old category to the 20-30 years old category. The percentage of generation fleet in the over 30 years old category has remained consistent with 2019-20. Entura notes this simple analysis ignores refurbishment and life extension works performed for many generators, and is intended to provide a general and high-level summary of the age of the generation fleet.

The following sections show generation within the region continues to perform within a satisfactory band but with room for improvement. Those necessary improvements relate to:

- design and commissioning processes for system protection and communications
- condition monitoring.

With an ageing generation fleet as shown in Figure 4, both these activities become more important. The reliability of an ageing plant will inevitably reduce and therefore prudent condition monitoring will highlight the need for maintenance or refurbishment prior to unplanned outages occurring. More unreliability and maintenance work leads to more times that generating units must be safely returned to service or recommissioned.

Entura notes that although the ageing generation fleet continues to be of concern, Territory Generation has adopted a new risk management process to proactively investigate generating unit failure and identify failure modes and possible trends, which then feeds into its preventative maintenance program. Entura considers this consistent with good electricity industry practice as it directs resources where they are most likely to have the greatest effect. Also consistent with good electricity industry practice, is to ensure ageing equipment remains fit for purpose and is sufficiently reliable to maintain compliance with the Network Technical Code and or Generator Performance Standards, as applicable. Entura notes in a later section (Generation availability) that forced outages increased during 2020-21, so the balance between reactive and proactive maintenance may not currently be optimal. This was the subject of recommendation three in the 2018-19 NTPSPR.

There is a significant capacity of large-scale solar PV under test or ready to be tested that will radically change the generation mix in the Darwin-Katherine power system. Entura considers these projects are taking comparably longer to bring online than those in the NEM jurisdictions. While Entura appreciates that the Darwin-Katherine power system is different to other power systems around Australia, discussions during consultation with the licensees and other stakeholders involved in bringing these plants online suggest there may not be sufficient capacity for PWC Power Services and System Control to accept such a large change in generation in a short period. Entura notes this issue is a problem for generators, network service providers and regulators across Australia. A combination of strict and changed regulatory requirements, lack of experience with new generating technologies and lack of capacity in the industry more broadly is hampering efforts to connect new generation across Australia.

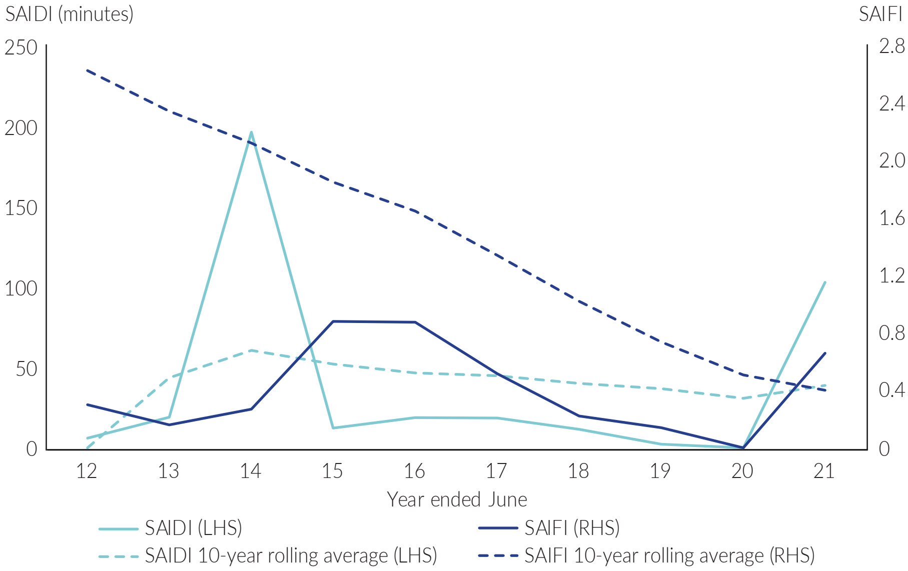
Generator performance

The EIP Code does not set targets for generation SAIDI and SAIFI performance indicators. Historical performance is used to provide commentary on generator performance in 2020-21.

Darwin region

Generation performance for the Darwin region is shown using the SAIDI and SAIFI indices (see Figure 5).

Figure 5: SAIDI and SAIFI performance for generation, Darwin



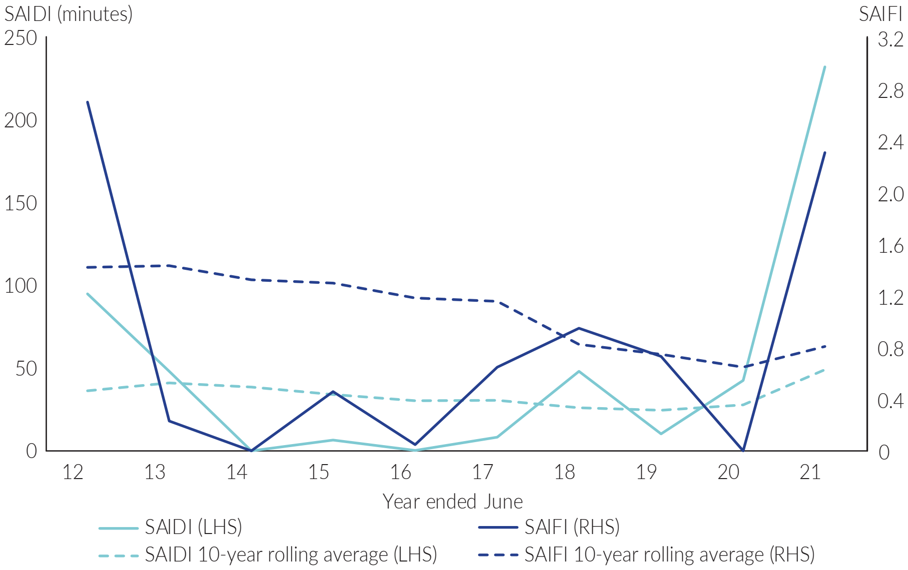
SAIDI and SAIFI have considerably increased in 2020-21, with SAIDI and SAIFI levels rising to the highest levels in the last five years. Despite this, the 10-year rolling average for SAIFI continues to decline, while for SAIDI, the 10-year rolling average slightly increased. Entura notes a single technical black event, caused by gas supply interruption to the Channel Island power station, contributed about 55% of the 2020-21 SAIDI result. Given that Territory Generation reported a SAIDI of zero in the Darwin region during 2019-20, Entura considers that had the technical black not occurred, performance of generation in the Darwin region would still have declined during 2020-21. This is despite a decrease in the number of single unit trips in comparison to 2019-20. The number of single generator unit trips is discussed in the following section.

Katherine region

SAIDI and SAIFI are compiled for the generating units in the Katherine region separately (Figure 6).

EDL, which operates the Pine Creek power station in the Katherine region, reported SAIDI and SAIFI indices of zero in 2020-21. This result indicates that no incidents were initiated by EDL and therefore generation performance in the Katherine region during 2020-21 is influenced solely by Territory Generation.

Figure 6: SAIDI and SAIFI performance for generation, Katherine



SAIDI and SAIFI show a significant deterioration from 2019-20. SAIFI has increased to levels comparable to those of 2011-12, while SAIDI in 2020-21 is the worst result over the last 10 years and is above the 10-year average by a substantial level, as shown in Figure 6. The trend for both indices changed trajectory in 2020-21 with the 10-year rolling average starting to increase.

The data shows that the events in 2020-21 were more severe and widespread than those for the previous 10 years. The majority of the increase in SAIDI during 2020-21 comes from the gas event at the Channel Island power station and therefore the result does not necessarily represent worse performance from the generation fleet. Gas events can have a large impact on the perceived reliability of the Darwin-Katherine generation. Entura notes planning to minimise common modes of failure is ongoing.

In its issues paper[16] in relation to a review of the EIP Code (published 16 September 2020), the Commission raised generation performance indicators as an issue it is considering, including whether the reporting of SAIDI and SAIFI by generation licensees is appropriate.

It has been suggested that with the introduction of additional generation licensees, which is particularly relevant to the Katherine region, other than a whole of system measure, SAIDI and SAIFI may no longer be sensible or useful.

On one hand, the allocation of incidents between generation and networks is generally clear cut and therefore calculating a generation SAIDI and SAIFI seems to be reasonable. Further, each generating unit can have a proportion of that SAIDI and SAIFI allocated to it based on causality.

However, the severity of an event can be influenced by external factors to the generating unit. Specifically, where single unit trips cause UFLS when the system constraints should stop that from occurring, the customer minutes without supply should be allocated to the systems and other units that may not have performed as expected, rather than the initial generating unit that tripped.

16 https://utilicom.nt.gov.au/publications/approvals-decisions-and-determinations/issues-paper-electricity-industry-performance-code-review.

Therefore on balance, SAIDI and SAIFI remain valid indices of overall generation performance for now, however detailed analysis of system incidents is required to understand where the performance is being adversely affected. Entura considers the level of analysis undertaken by PWC System Control in incident reports is adequate for this purpose, however calculating SAIDI and SAIFI and apportioning these indices across licensees should be more explicit in these reports. In the absence of this explicit apportioning, Entura considers SAIDI and SAIFI for generators should be reported on a regional basis only.

The reporting requirements within the schedules of the EIP Code are being considered by the Commission as part of a review of the EIP Code, which commenced with publishing an issues paper on 16 September 2020. The review remains in the consultation phase at the time of writing.

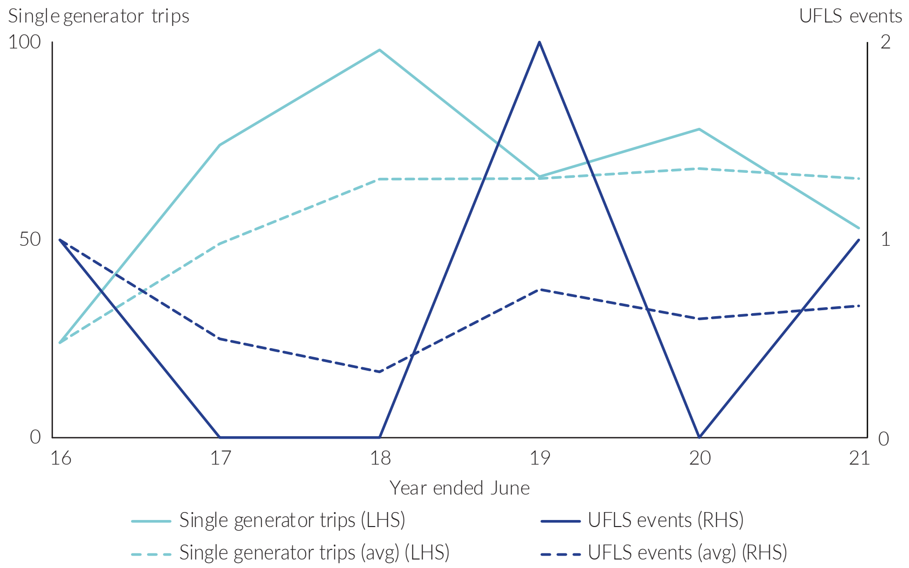
Observed UFLS and single generator trips

This review has focused on single unit trips and their impact on customers for a number of years. The focus is due to the high incidence of single unit trips (relative to other power systems) and the challenge smaller power systems, such as Darwin-Katherine, have in managing these incidents without loss of load due to the relatively large size of the generating units.

Historically, the Darwin-Katherine power system was dispatched in such a way that UFLS was required to stop frequency fall for most large single generating unit incidents. This practice was discontinued in an attempt to improve power system performance. Since that time, the power system has seen a steady increase in single unit trips but a stark reduction in corresponding UFLS incidents. The Commission notes this improvement has been achieved in part through PWC System Control changes to spinning reserve, which may increase costs, particularly for Territory Generation. Further, given there is no competitive process for and transparency around providing spinning reserve, or ancillary services more broadly, there is little incentive for the associated increased costs to be minimised.

PWC System Control biannual reports[17] to the Commission show a decline in unit trips during 2020-21, as shown in Figure 7.

Figure 7: Darwin-Katherine single generator trips versus UFLS (due to single generator trips)



17 As required by the SCTC.

In 2020-21, the number of single unit trips decreased from 2019-20, with only one leading to a UFLS incident. Entura considers the change in trajectory of the trend in generator trips to be a good result. Regardless, the number of single unit trips may represent an unacceptable lack of robustness in the generation fleet, as observed in previous reviews.

Intuitively, SAIDI and SAIFI for generating units in a multiple power station power system should be very low. Power stations should have few common modes of failure and the power system should be run so the loss of a single unit does not lead to load shedding. As discussed in previous sections, Territory Generation has adopted a new risk management process for its generating units, which should result in continuing improvement in the future years.

Entura has observed an increase in the number of days between trips during 2020-21, with the number of trips occurring within five days of a previous trip halving. In 2020-21, the number of single unit trips relating to failed restoration attempts has also significantly improved.

Territory Generation has made improvements associated with a previous recommendation relating to tracking the causes of single generation trips to determine if there are trends and possible remedial actions (recommendation 4 from the 2017-18 NTPSPR, reporting of causes for single unit trips).

A higher proportion of unit trips at the Pine Creek and Katherine power stations during 2020-21 are mostly related to the Darwin and Katherine regions of the Darwin-Katherine power system being isolated from each other. The current islanding scheme is considered by Entura to be quite slow and unreliable, which is the main contributor to these tripping events. Entura notes plans to upgrade the islanding scheme, which have been ongoing for a few years, should lead to improvements in the southern region of the Darwin-Katherine power system.

Generation availability

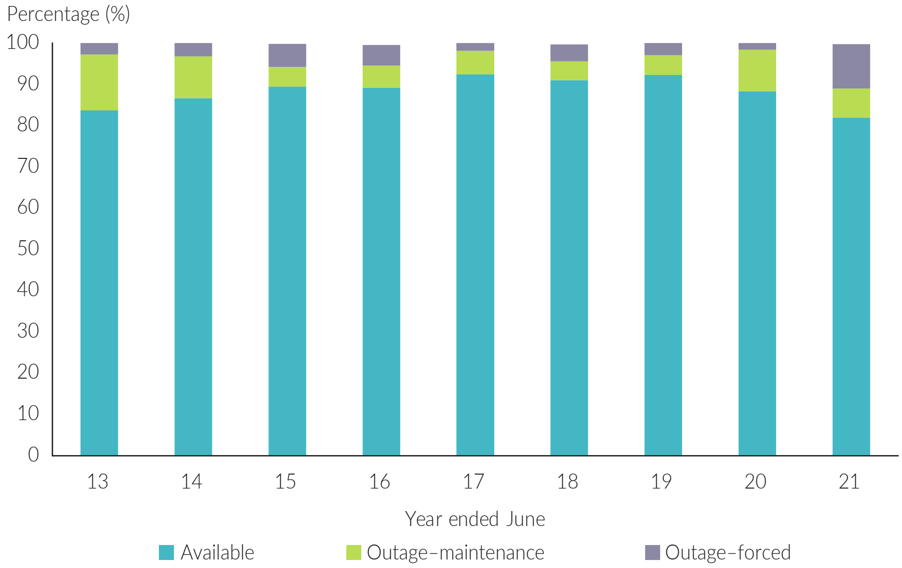
A number of indices are calculated as per the EIP Code to provide some insight into the availability of the generating units and allow an assessment to be made of the adequacy of condition monitoring and preventative maintenance. These include:

- availability factor
- unplanned availability factor
- equivalent availability factor
- forced outage factor
- equivalent forced outage factor.

Ideally planned maintenance should be to a level and adequacy that minimises the level of unplanned maintenance or forced outages resulting from faults as much as reasonably practicable, noting it is unreasonable to expect zero unplanned maintenance or forced outage events. Planned maintenance activities can be planned for by generators and PWC System Control, whereas unplanned maintenance or forced outages can lead to risks to system reliability and security, with limited or no notice.

Figure 8 combines the indices reported by generators in the Darwin-Katherine power system to show the capacity weighted generation availability in the region over the last nine years, including the level of both planned maintenance and forced outages.

Figure 8: Capacity weighted Darwin-Katherine generation availability



In 2020-21, the availability of generators in the Darwin-Katherine power system decreased to the lowest levels during the last nine years, as shown in Figure 8. This is a concern as the number of forced outages has increased substantially, which is a discouraging change following an improving trend in the level of forced outages over the past few years.

Forced outages have largely increased due to the Katherine power station and to a lesser degree the Channel Island power station. The performance of the Pine Creek power station and the Weddell power station has been satisfactory and similar to 2019-20.

It can be observed that planned maintenance activities reduced in the region due to Territory Generation concentrating its efforts and resources on resolving forced outages. This is evident as the 'outage – forced' percentage is significantly higher during 2020-21.

Due to machine failures, there were two major engine replacements at the Katherine power station during the reporting period. This should lead to a reduction in the forced outage factor in subsequent years.

There have also been significant maintenance activities at the Channel Island power station. This was highlighted in last year's review as the generating units at the Channel Island power station are ageing with some nearing end of life (starting in 2026-27), hence the probability of extended outages may increase. This is evident from the forced outage factor for 2020-21.

As highlighted in previous sections, Territory Generation has adopted a new risk management system for its units that is expected to lead to less forced outages. This is in line with good electricity industry practice, which is essential for proper management of generating units.

Comparison with similar Australian regions

Table 6 compares the forced and planned outage rates from the Darwin-Katherine power system with those from the Western Australian South West Interconnected System (SWIS). The SWIS is a larger power system, but has similar generating unit types to select as points of comparison. Entura has used a selection of 18 units ranging in size from 26 to 342 MW.

Table 6: Capacity weighted average outage and unavailability rates for Darwin-Katherine generating units compared with equivalent units in the Western Australian SWIS[18, 19]

	Darwin-Katherine 2020-21 (%)	Darwin-Katherine 10-year average (%)	SWIS WA average 2016-19 (%)[20]
Forced outage rate	10.8	4.1	1.3
Planned outage rate	7.1	7.2	7.5
Equivalent availability	81.9	86.1	91.0

The planned outage rates for generating units in the Darwin-Katherine power system compares well with the average performance of similar open cycle gas turbine type generating units in the SWIS. Entura would have expected a slightly higher planned outage rate in the Darwin-Katherine power system based on two main factors. The first of these factors is the surplus of generation in the region, owned predominantly by a single owner, and the second being the age of the units (that is, the units are closer to end-of-life).

The forced outage rate is higher for the Darwin-Katherine generating units, which may be due to two factors, the advanced age of the units in the Darwin-Katherine power system and the lower incentive to return to service or minimise outage duration compared with the capacity based Wholesale Electricity Market that applies in the SWIS. It remains clear that equivalent availability for the Darwin generating units is lower than for those in the SWIS and NEM.

Entura's previous recommendations in relation to condition-monitoring and maintenance planning relates to this performance gap relative to other jurisdictions.

Non-reliable periods

Non-reliable periods are a forward-looking assessment rather than in response to system incidents, and are declared when PWC System Control identifies that power system reliability cannot be maintained. There are a number of causes, including:

- planned, unplanned or forced outages that reduce reliability for all or part of the power system
- lack of generation to meet demand and or requirements for spinning reserve.

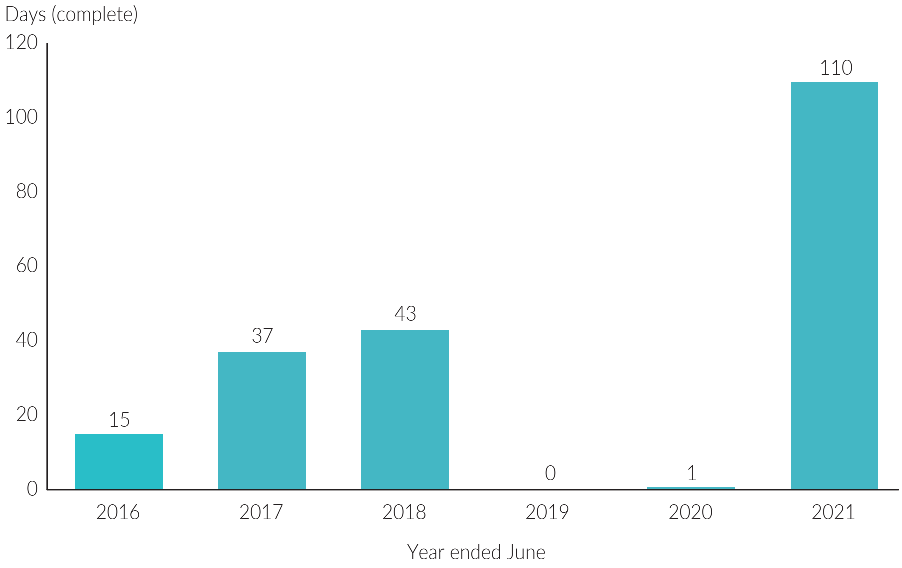
There were five non-reliable periods in the Darwin-Katherine system, with two relating specifically to the Katherine and or Pine Creek regions. The total duration of the non-reliable periods in 2020-21 is shown in Figure 9.

18 Report on the effectiveness of the Wholesale Electricity Market 2020 (28 August 2020) Microsoft Word – WEM Report – Final – 2020 (v4.1 Redacted)(rev 9) (erawa.com.au) pages 73 and 74.

19 GHD report on Generator Availability Analysis for the Economic Regulation Authority (13 July 2020).

20 Generating units < 150 MW.

Figure 9: Non-reliable periods for generators in Darwin-Katherine



One non-reliable period during 2020-21 lasted 102 days and was due to multiple Katherine generating units being subject to forced outages. This highlights the criticality of the Katherine power station generating units for supply in the Katherine region. With only a single circuit link back to Darwin, the N-1 capacity in the Katherine region relies on the availability of sufficient generation in the region to meet demand. This means improving the availability of these units may be more effective at avoiding non-reliable periods than a similar improvement of other generators.

PWC System Control will need to carefully consider the security of supply across the Darwin-Katherine power system as renewable energy penetration increases and synchronous units are displaced. The power system cannot be treated as a homogeneous network, and there are local peculiarities that may need to be managed through constraints, ancillary service support agreements or other mechanisms to ensure power system standards are maintained across the range of likely operating scenarios.

Generation constraints

Table 7 summarises the generation constraints in the Darwin-Katherine power system.

Table 7: Darwin-Katherine system constraints

	Constraint description	Applied to	Limit	System condition	Open/ closed	Comments
1	C1 dispatch and maximum output constraint	Channel Island unit C1	30 MW	Ongoing	Open	Due to additional cracks in stage 1 Nozzle Block
2	C8/C9 maximum output constraint	Channel Island units C8 and C9	35 MW each	System demand above 180 MW	Closed[21]	Prevents UFLS operation from a C8 or C9 trip
3	C8/C9 maximum output constraint	Channel Island units C8 and C9	30 MW each	System demand below 180 MW	Closed	

continued

21 Closed: present in July to December 2020 PWC System Control half-yearly report but not in January to July 2021 edition.

	Constraint description	Applied to	Limit	System condition	Open/ closed	Comments
4	C4/C5/C6 maximum output constraint	Channel Island units C4, C5 and C6	Combined output less than 75% of system demand	In practice this limit applies at low demand times	Open	Controls rate of change of frequency to within the technical envelope of the UFLS scheme such that simultaneous loss of C4/C5/C6 does not lead to system black
5	C1/C7 dispatch	Channel Island units C1 and C7	-	Ongoing	Closed	Only one unit of C1 or C7 can be dispatched online at all times
6	C2 Start-up restriction	Channel Island unit C2	Higher than 20 MW	First 40 minutes after starting	Open	To avoid vibration issues occurring during start-up of machine
7	C7 dispatch	Channel Island unit C7	When online, run between from 25 MW to 32 MW	Ongoing	Open	Due to long-running rotor vibration issues
8	C5 output	Channel Island unit C5	30 MW/22 MW to be considered as one of the online frame 6 units	Ongoing	Open	Due to limitation of the gas valve stroke and potential combustion issue/due to spinning reserve policy
9	K1, K2, K3, K4 runtime	Katherine power station units	Minimum runtime of 6 hours Minimum downtime of 12 hours between stopping and starting	Ongoing	Open	Due to operational restrictions
10	Weddell power station output	Generating units of Weddell power station	Spray intercooling system restricted. To be used only in the event of: • machine fail to start • unexpected step load increase • unexpected generation step decrease	Ongoing	Open	Due to system security reasons

The number of constraints in 2020-21 increased in comparison with 2019-20, with the addition of constraints 7 to 10. With the exception of constraint 9, the additional constraints relate to issues with individual generating unit stability.

Constraint 9 relates to the efficient use of generating unit operational life with a minimum runtime and downtime constraint ensuring thermal cycling of units is not outside their design parameters.

In general, the constraints shown in Table 7 lead to inefficiency in the dispatch of generation in the Darwin-Katherine power system, noting the low level of inertia on units other than the older frame 6 generators at the Channel Island power station and the limited governor response of some of the remaining generation fleet make frequency management in the power system difficult.

PWC System Control has put in place these constraints (specifically 4, 5 and 10) to limit the contingency size of the largest credible generation event in order to minimise the rate of change of frequency (RoCoF). RoCoF is proportional to the event size and inversely proportional to the system inertia. That is, a large event on a light system has a higher level of RoCoF than a smaller event on the same inertia or the same event on a 'heavier' inertia. RoCoF must be managed to ensure secondary controls such as UFLS can operate fast enough to maintain frequency within the frequency standard.

In Entura's opinion, larger spinning reserve margins or faster governor response may allow constraints 2 and 3 to be lifted. However, there would be a cost of supply implication to this course of action.

Constraints 1, 6 and 8 demonstrate how the ageing frame 6 generation units at the Channel Island power station are impacting the power system leading to more operational restrictions.

Network

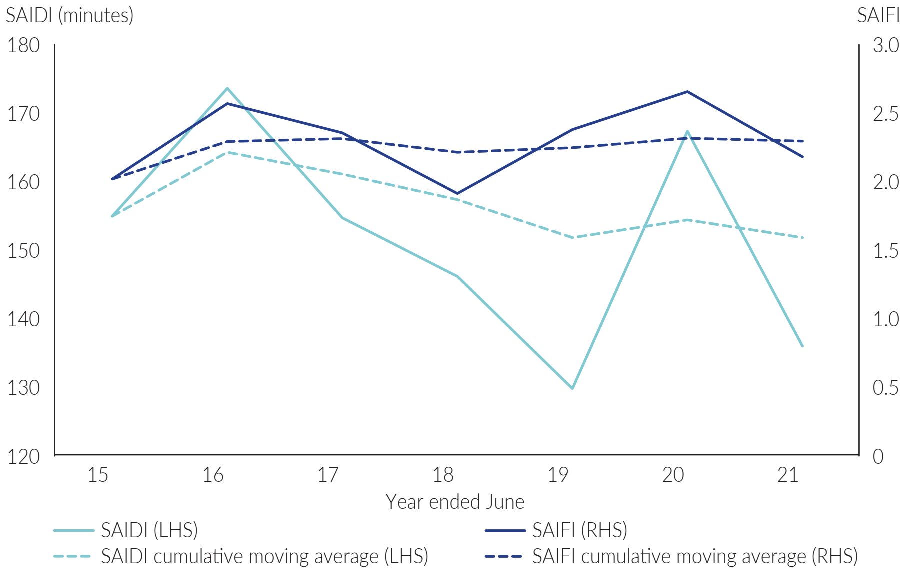
The Darwin-Katherine network covers the Darwin and Katherine regions with a corridor between Darwin and Katherine to the south. The highest transmission voltage is 132 kV. The network in Darwin is relatively robust with the 66 kV network forming a series of loops. The 132 kV and 66 kV networks are strongly interconnected, albeit at a single point at Hudson Creek.

The southern extremities of the network are supported by EDL's Pine Creek and Territory Generation's Katherine power stations. The long single circuit provides challenges from a system robustness perspective.

Network performance

Network performance is measured and reported by PWC Power Services as part of the EIP Code requirements. The SAIDI and SAIFI performance for the Darwin-Katherine network is presented in Figure 10.

Figure 10: Adjusted SAIDI and SAIFI performance for the Darwin-Katherine network[22]



22 The EIP Code allows licensees to adjust SAIDI and SAIFI values by excluding incidents that meet an exclusion criteria included in the code, with the list of the excluded incidents required to be included in the reporting. The SAIDI and SAIFI values are derived from PWC Power Services' EIP Code reporting by combining data reported for Darwin and Katherine, weighted by the number of customers in each region.

The SAIDI and SAIFI reported by PWC Power Services shows an improvement in performance in 2020-21 when compared with 2019-20. There is no standard stipulated for overall network SAIDI or SAIFI, but it is worth considering how this performance relates to the customer experience. On average in 2020-21, a customer was likely to be impacted by a total of 135 minutes (SAIDI) of interruption and each customer was likely have two interruptions (SAIFI) from network-related outages.

The SAIDI and SAIFI numbers discussed above are designated as adjusted. The EIP Code allows adjustment based on a range of criteria (excluded events) to identify underlying network performance. PWC Power Services' reporting includes a list of the permitted excluded events and the number of exclusions per exclusion category.

Network utilisation

Transmission network

The maximum demand transmission network utilisation during 2020-21 is shown in Figure 11.

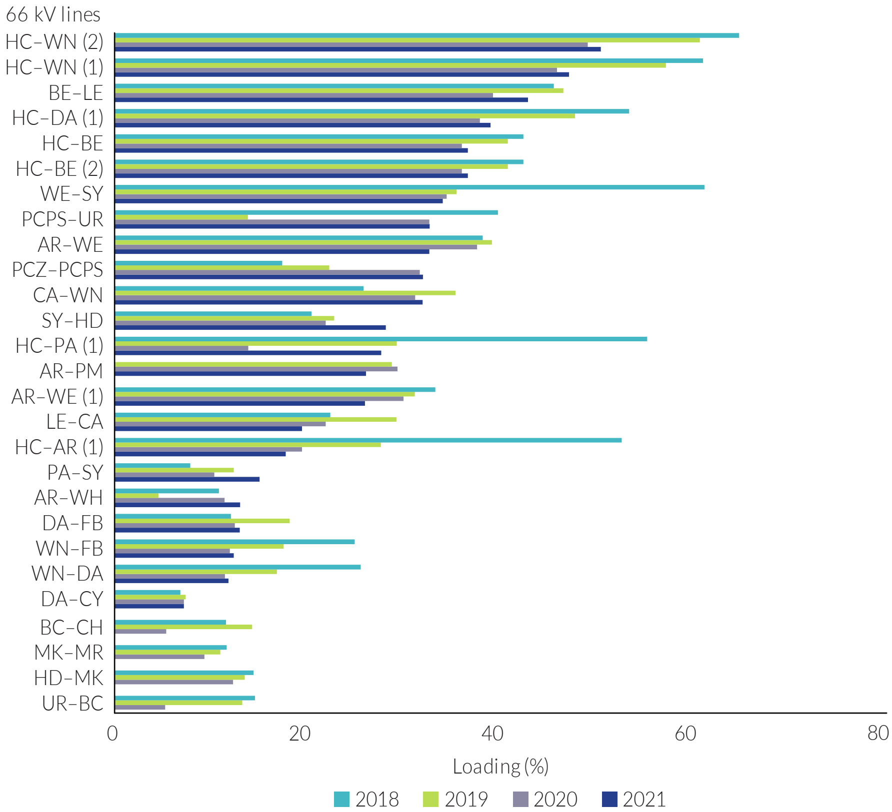
Figure 11: Transmission network utilisation Darwin-Katherine (132 kV)

132 kV line loadings remain well within rating. Entura make this assessment on the following basis:

- parallel lines such as the CI-HC lines do not exceed 50% of their rating and so can be considered to run firm. This means that in normal operation, one of the lines could trip due to a fault and full flow could be maintained on the other line
- other lines are below their rating. The remaining lines are essentially radial and run from Channel Island through Manton, Bachelor and Pine Creek to Katherine. Therefore, they must operate at or below their rating but are not required to provide increased flow in the event of a contingency.
- The addition of new solar PV generation south of Channel Island is likely to lead to higher flows on the CI-MA and MA-BA lines in coming years. There is currently spare thermal capacity on those lines to allow for some additional generation in that region.

The maximum demand loadings of 66 kV lines during 2020-21 are shown in Figure 12.

Figure 12: Transmission network utilisation Darwin-Katherine (66 kV)



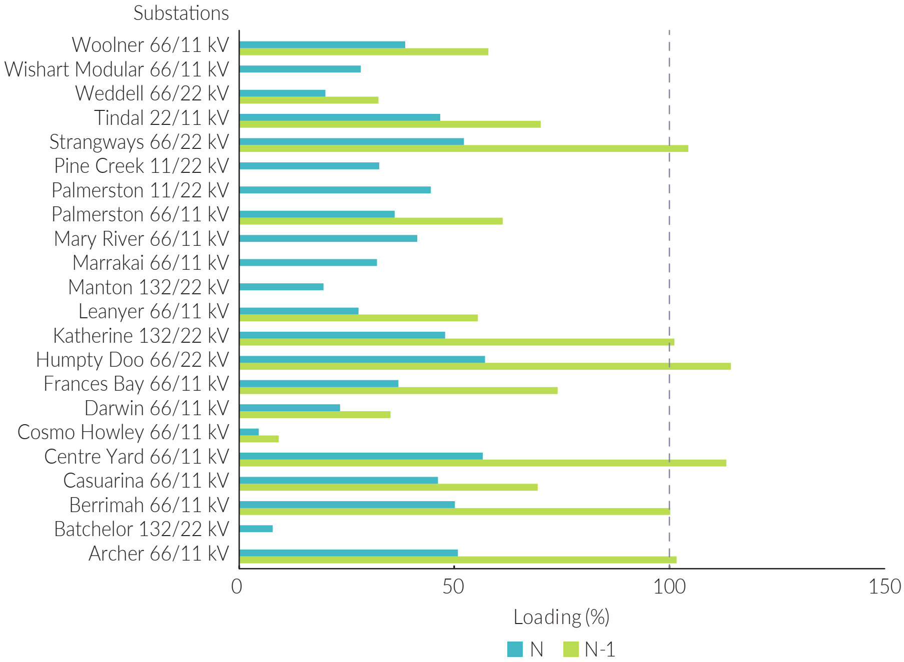
In general, flows on the 66 kV lines in 2020-21 were somewhat higher than 2019-20, due to demand increases, but still below 2018-19 and 2017-18 levels, leading to N-1 contingency capacity for all double circuit lines.

Zone substations

The zone substation transformer loading under N and N-1 conditions for 2020-21 is shown in Figure 13. The zone substations of concern in the figure are those where either the N (for substations with single and multiple power transformers) or N-1 (for substations with multiple power transformers) loading exceeds 100%.

Generally, where a zone substation has multiple transformers, it is expected a substation can supply the full zone substation load with one transformer out of service (N-1). Where a substation is a single power transformer zone substation, it can supply the full zone substation load under normal conditions (N), however supply would be lost should the single power transformer fail. Should a power transformer fail at a single power transformer zone substation, such as Marrakai or Mary River substations, PWC Power Services indicate in its 2021 Transmission Distribution Annual Planning Report (TDAPR) that a spare 8/12 megavolt ampere (MVA) Nomad power transformer may be able to be transported to the substation to expedite the restoration of supply.

Figure 13: Substation utilisation for N and N-1 conditions Darwin-Katherine



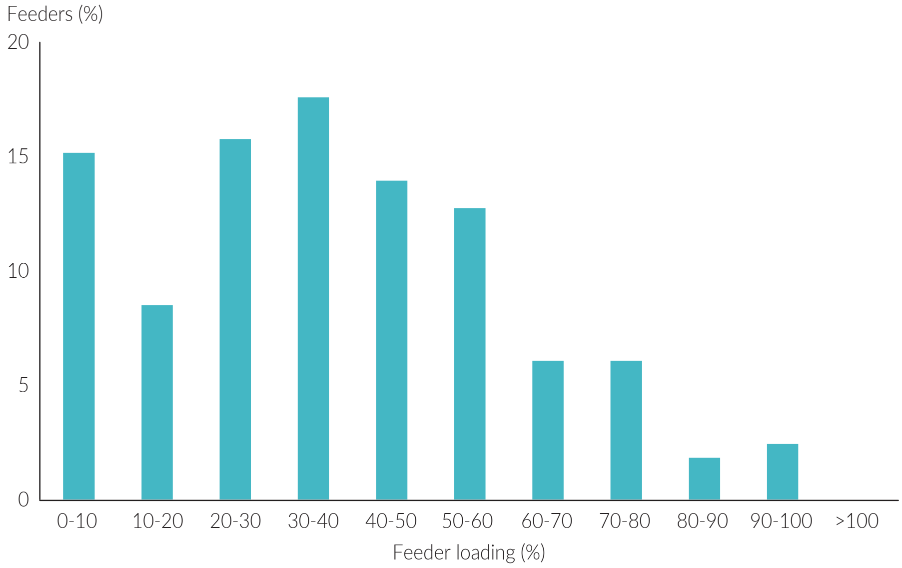
The figure above shows actual zone substation loading in 2020-21. On the basis that substation loading on either N or N-1 should not exceed 100%, in 2020-21 Strangways, Katherine, Humpty Doo, Centre Yard and Archer zone substations were at risk of not fully supplying the substation load had one transformer gone out of service (N-1). Strangways and Archer zone substations were just below 100% capacity for N-1 operation in 2019-20, however due to an increase in demand this has now been exceeded. Berrimah is expected to exceed N-1 capacity in 2021-22. PWC Power Services indicated the assets at Berrimah are approaching end of life and are in the process of being replaced. According to the 2021 TDAPR this replacement will be completed by 2023-24.

PWC Power Services' 2021 TDAPR states it has a generator in place with 1 MW capacity in case of an emergency event at the Centre Yard zone substation. At the Humpty Doo zone substation, PWC Power Services states it can install a spare 8/12 MVA Nomad power transformer in an emergency as load transfers to adjacent zone substations cannot address the N-1 limitation from 2027-28 onwards. The existing assets at Humpty Doo zone substation are in poor condition and PWC Power Services is currently exploring options to replace the existing power transformers. As for the Katherine zone substation, PWC Power Services is currently exploring options to procure generators that can directly connect to the 22 kV bus at the zone substation, which would allow load to be supplied for a short period of time if an overload event occurs under N-1 conditions.

Feeders

The distribution of feeder loadings for the Darwin-Katherine network is shown in Figure 14.

Figure 14: Feeder utilisation for Darwin-Katherine



Based on data provided directly from PWC Power Services in late 2021, no feeders exceeded their nominal capacity during 2020-21. However, 2% of feeders are loaded between 90 and 100% and may be overloaded in the coming years. These include two Archer feeders, one Strangways feeder and one Leanyer feeder.

PWC Power Services is currently looking into load transfers from the two Archer feeders to adjacent feeders.

Network constraints

Table 8 summarises the network constraints in the Darwin-Katherine region, which have remained unchanged since 2018-19.

Table 8: Darwin-Katherine normal system constraints

	Constraint description	Applied to	Limit	System condition	Comments
1	Weddell power station generation constraint	Total Weddell output	64 MVA line flow: constraint to generation calculated based on demand	A two-part formula as a function of load determines the limit. The limit is implemented in the supervisory control and data acquisition system	Prevents post-contingency line overloads. The constraint was updated based on network changes on 24/01/2019
2	132 kV Channel Island – Katherine	Pine Creek and Katherine power stations	Minimises load flow on the transmission section that may trip due to storm activity	Localised storm activity leading to risk of islanding	

Constraint 1 can be understood as a permanent reduction in generation from the Weddell power station under certain demand conditions in case of the loss of transmission. PWC Power Services has been working to reduce the impact of this constraint by reviewing the line ratings. The introduction of the Palmerston-Archer line has also acted to relieve the impact of this constraint. Entura considers that an automated run-back could be used to manage this flow limit, which would free the Weddell power station generating units to be operated at higher power output levels as long as the amount of load reduction can be managed within the spinning reserve allowances. Accordingly, Entura previously recommended investigating the benefits of using a run-back scheme to manage this constraint if the other actions do not completely mitigate it. The constraint could have a long-term impact on the efficiency of dispatch. The constraint has largely evolved due to a line rating adjustment in about 2017.

Constraint 2 requires generation to be dispatched in the Katherine region, when it may not have been ordinarily required, in order to limit the amount of electricity transmission across the 132 kV line where there is storm activity that may lead to a disconnection. This constraint highlights the system security implications of the single circuit line to Katherine.

While the Commission notes that PWC System Control's obligations include ensuring the system operates reliably, safely and securely, the Commission considers this constraint may not be the most efficient solution and encourages licensees more broadly to appropriately consider the costs and benefits of generator dispatch and network solutions as part of addressing system security issues. This constraint may become more of an issue once a number of solar power stations are commissioned in the region and electricity transmission across the 132 kV line increases.

Entura notes the introduction of minimum run-time constraints on the Katherine generating units has led to a reduction in the application of constraint 2.

Power system wide constraints

Table 9 summarises the power system wide constraints in the Darwin-Katherine power system.

Table 9: Darwin-Katherine power system wide constraints

	Constraint description	Applied to	Limit	System Condition	Comments
1	Additional instructions for low load conditions	All generators in the Darwin-Katherine power system	Additional instructions to controllers to assist in meeting dispatch and system security requirements during low loads	Customer demand in the range 60 MW – 150 MW during the dry season	
2	Spinning reserve policy	All generators in the Darwin-Katherine power system	Spinning reserve policy increased to a minimum of 30 MW during daylight hours where cloud cover is forecast, and to a minimum of 37 MW if widespread cloud cover is forecast	Daylight hours where cloud cover is forecast/ widespread cloud cover is forecasted	

Constraints 1 and 2 were added during 2020-21. The constraints relate to the changing operational conditions in the Darwin-Katherine power system. Constraint 1 provides for low demand instructions and constraint 2 allows for the variability of solar generation during cloudy conditions. Entura understands work is being undertaken by PWC Power Services and System Control to ensure both of these constraints can be reasonably applied and adjusted once more operational experience of both of these scenarios is obtained.

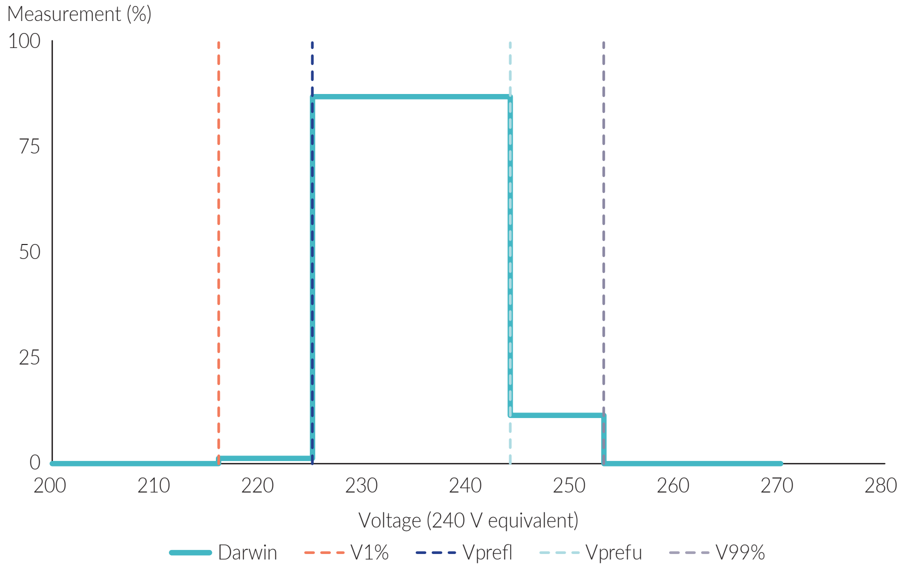
The level of spinning reserve under constraint 2 level has a degree of discretion to the System Controller on duty. There is currently no mechanism in place for PWC System Control to record and report on how and when these decisions are made, which results in a lack of transparency and potentially accountability, for decisions that may have a significant financial impacts on generators.

Network power quality

Low voltage quality

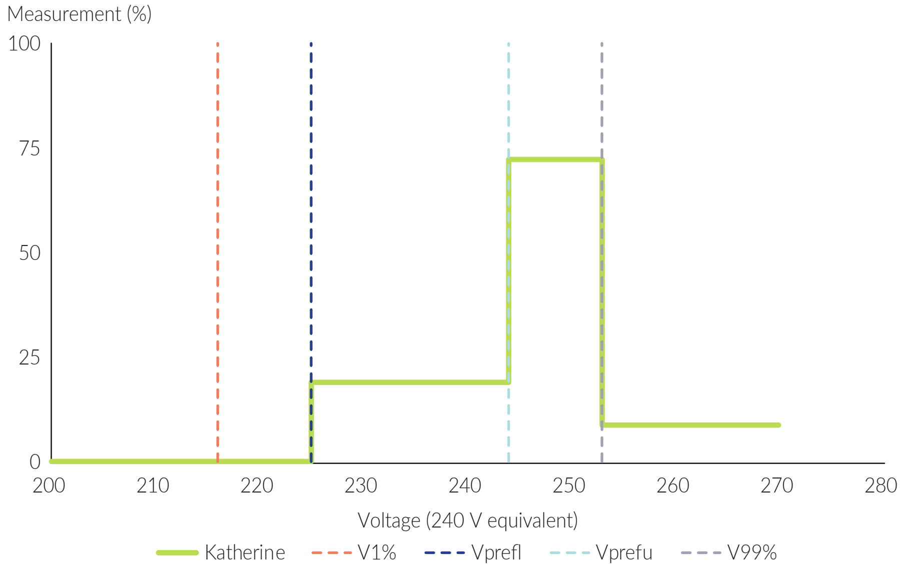
Figures 15 and 16 show the steady state voltage performance for the Darwin and Katherine regions in 2020-21, respectively.

Figure 15: Steady-state voltage performance, Darwin



The measurement and reporting against this criterion is important in modern power systems where voltage can no longer be reliably regulated by the distribution transformers alone and where the configuration of rooftop solar PV inverters is not always consistent with mitigating voltage rise during high solar power production. In 2020-21, voltage regulation in Darwin has remained relatively stable as the voltage in the preferred zone (that is, between Vprefl and Vprefu) is about 87% in comparison with 86% in 2019-20. However, high voltage periods have increased from 0.7% to 11% while low voltage periods have reduced from 13% to 1%.

Figure 16: Steady-state voltage performance, Katherine



In contrast to the Darwin region, in the Katherine region PWC Power Services reported a lack of buck (voltage reducing) taps on the transformers, in conjunction with the long line to Darwin leads to some high and extremely high voltage periods. In 2020-21, the voltage in the preferred zone (that is, between Vprefl and Vprefu) has decreased from 27% to 19% compared with 2019-20, and high voltage periods have increased from 70% to 72% while extremely high voltage periods have increased from 3% to 8%. Entura therefore concludes the voltage in the Katherine region is higher during 2020-21. This continues to be a concern. PWC Power Services has advised that the Darwin-Katherine power system voltage management strategy is currently being reviewed in conjunction with plans to install inductive compensation to lower voltages in zone substations, with the development stage of this project expected to be completed by the end of 2021. Additionally, PWC Power Services has introduced new technical specifications for connection of embedded generation that requires solar PV and batteries to assist in mitigating voltage rise.

Network complaints

PWC Power Services is required by the EIP Code to report on the percentage and total number of complaints it receives that are associated with network quality of supply issues and network-related activities.

Complaints associated with network quality of supply issues in Darwin-Katherine substantially decreased from 2,900 in 2019-20 to 1,535 in 2020-21, which continued a downward trend over the last six years, to the lowest level during that period in 2020-21. Complaints are mostly made in relation to the Darwin region of the network, which is to be expected given the larger number of customers in the region compared with the Katherine region. However, the substantial reduction in 2020-21 was mainly attributed to complaints in the Darwin region more than halving.

Generally, complaints have been mostly in relation to no power rather than partial and low power, or fluctuations in power. However, complaints in relation to no power markedly decreased in 2020-21, while complaints regarding partial and low power, or fluctuations in power remained fairly consistent.

Complaints associated with network-related activities are categorised as administration process and customer service, connections, reliability of supply, technical quality of supply or other. There were a small number of complaints regarding the Darwin-Katherine network in 2020-21 compared with the total number of customers in the region. About 40% of the complaints were categorised as administration process and customer-service related.

2 Alice Springs power system

This chapter focuses on the 2020-21 generation and network performance of the Alice Springs power system. Where possible it compares 2020-21 performance with historical data to identify trends. Specifically, this chapter considers:

- incidents
- generator performance, observed UFLS and single generator trips, generation availability, non-reliable periods and generation constraints
- network performance, utilisation, constraints, power quality and complaints.

Power system description

The Alice Springs power system is the second largest power system in the Territory. It supplies the township of Alice Springs and surrounding rural areas from the Ron Goodin, Owen Springs and Uterne (solar) power stations.

The energy sent out by licensed generators over the last four years is shown in Table 10.

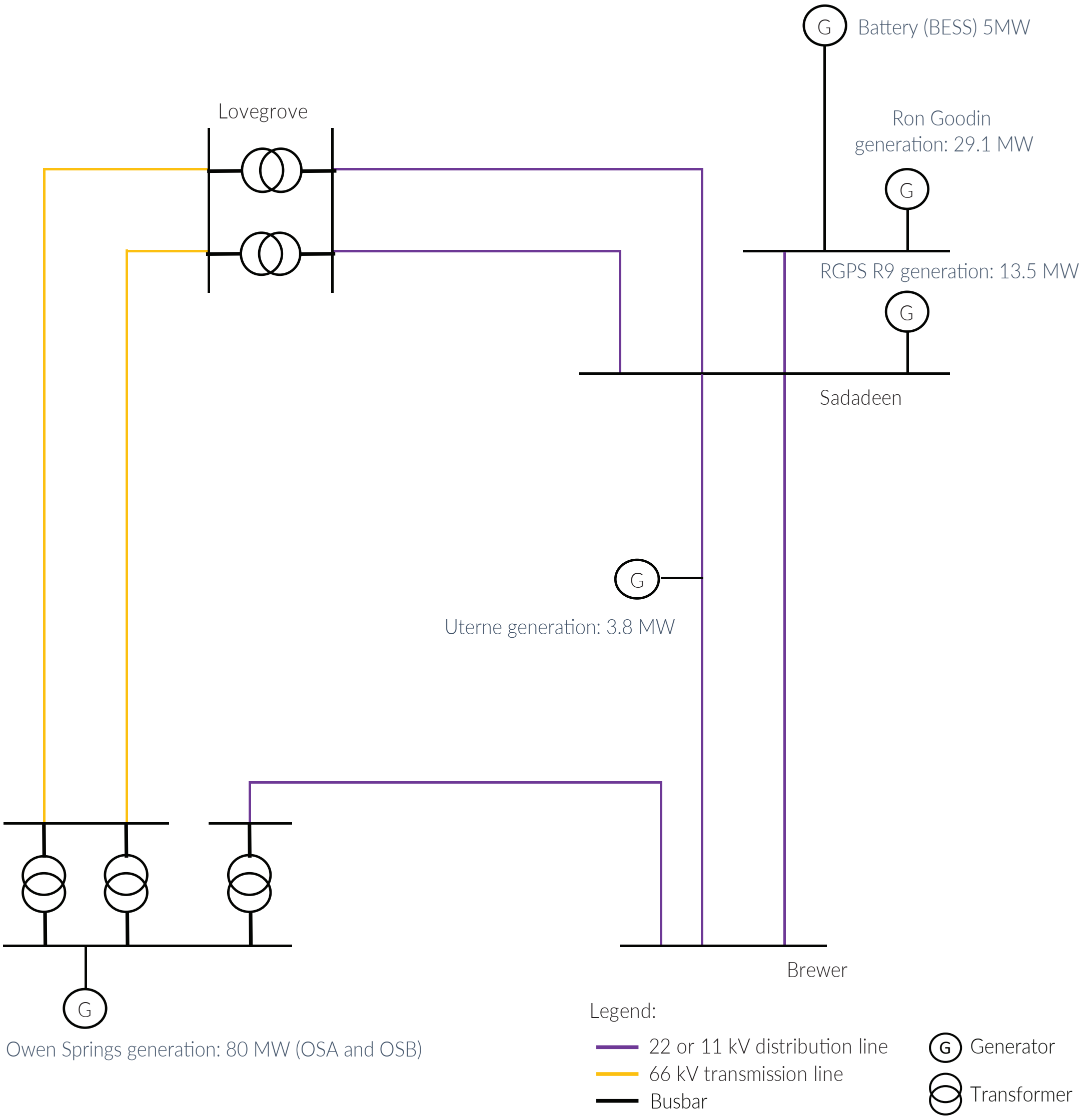
Table 10: Alice Springs energy sent out[23]

	Energy sent out (GWh)			
	2017-18	2018-19	2019-20	2020-21
Alice Springs	214	221	211	202

Figure 17 shows a simplified representation of the Alice Springs power system. The highest voltage of the network is 66 kV.

23 Based on data issued from PWC System Control Northern Territory Regulated Power Systems biannual reports.

Figure 17: Alice Springs power system[24]



Incidents

An incident, or reportable incident, is a power system event that had or could have had a significant adverse effect on security or reliability of electricity supply, and is determined by PWC System Control in accordance with the SCTC. PWC System Control determines whether a reportable incident is classed as a major or minor incident, noting it has a level of discretion. Major incidents are subject to more detailed investigation and reporting requirements.

The Commission considers the purpose of incident reporting is to ensure power system events that would benefit from investigation are investigated to identify and address issues, and to improve the safe and reliable supply of electricity to customers.

This section considers the overall customer impact from major and minor incidents, provides an overview of major incidents, and discusses the tracking and implementation of PWC System Control recommendations following the investigation of major incidents.

24 Generation capacities relate to non-summer capacities in accordance with the 2020 NTEOR. The 2021 NTEOR had not been published at the time of writing this review.

Overall customer impact

This section shows the overall impact of major and minor incidents on customers in the Alice Springs region over the last five years (Table 11).

The number of customers impacted and total duration (minutes) of an incident is reported to the Commission by PWC System Control as part of its SCTC obligations, and is used to calculate indicators such as SAIDI. However, as customers are restored in stages, not all customers are impacted for the full duration of the incident, which may lead to over reporting. To address this, starting from 2020-21, the Commission's reporting on SAIDI takes this sequential restoration into account, and therefore provides a better representation of the customers' overall experience. The Commission notes this change to reporting may impact the usefulness of historical comparisons.

Table 11: Overall customer impact from major and minor incidents in the Alice Springs power system

	2016-17	2017-18	2018-19	2019-20	2020-21
Number of incidents	10	14	14	8	10
Customers impacted	33 730	43 270	18 691	31 205	16 188
Total duration (minutes)	415	1 247	1 867	2 157	1 510
SAIDI	152.9	570.3	223.0	719.3	72.4
SAIFI	2.77	3.45	1.53	2.52	1.30
Reliability (% of year)	99.97	99.89	99.96	99.86	99.99
System blacks					
Number	0	2	0	1	0

SAIDI is a measure in minutes of the average duration of an incident weighted by the number of customers affected by each incident. That is, if 10 customers suffer a 10-minute interruption but there are 100 customers in the region in total, then this would lead to a SAIDI of 1 minute. Multiple incidents are added together so if a second incident of 15 minutes affected 10 customers then this would be added to the first incident and lead to a SAIDI of 2.5 minutes.

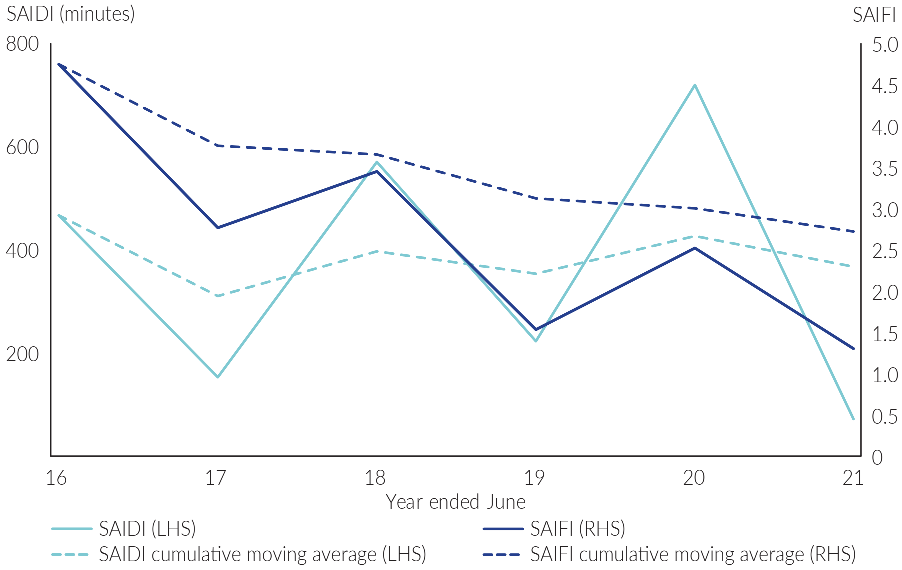
SAIFI is a measure of the average number of incidents weighted by the number of customers affected by each incident. Using the examples above, the SAIFI would be 0.1 after the first incident and 0.2 after the second.

Reliability (percentage of year) is calculated based on SAIDI and is the percentage of a year the average duration in minutes of incidents per customer represents subtracted from the total number of minutes in a year. This is different from the unserved energy-based reliability standard[25] for generation of 0.002% applied in the NEM, which is also adopted by the Commission in its NTEOR reliability assessments in the absence of a formal Territory target.

The major and minor incident SAIDI and SAIFI performance for the Alice Springs power system over the last six years is shown in Figure 18.

25 https://www.aemc.gov.au/sites/default/files/content/2f4045ef-9e8f-4e57-a79c-c4b7e9946b5d/Fact-sheet-reliability-standard.pdf.

Figure 18: Major and minor incident SAIDI and SAIFI performance, Alice Springs[26]



There was a decrease in SAIDI and SAIFI during 2020-21 compared with 2019-20, and to the lowest levels calculated since 2015-16.

The long-term view of the SAIDI and SAIFI for the Alice Springs power system is quite interesting. The SAIFI trend is generally downwards with some year-on-year variation, however the SAIDI is more variable and peaks are becoming more pronounced over time. Therefore, incidents are getting less frequent per customer but marginally longer on average. Entura knows from past experience that peaks in SAIDI occur in years where there were system blacks or more severe incidents than the average. Therefore, the performance data leads Entura to conclude that if the causes of large, prolonged events could be controlled or the incident recovery became shorter, then the customer impact would be reduced somewhat.

Power Systems are not typically planned, designed or operated in such a way as to control multiple contingency events except through eliminating common modes of failure with redundancy. This means it is unlikely that all the causes of severe incidents can be eliminated while operating the power system in a cost-effective manner. Therefore, focus should be brought to the recovery from incidents, and some of this thinking was embedded in the recommendations stemming from the System Black report from 2019. That report was targeted at the events and shortcomings for a particular incident. During consultation for the 2020-21 NTPSPR, Entura has heard that Territory Generation is extending this philosophy to look at other common mode failures and investigating controller and other plant enhancements to eliminate these modes where practical.

Entura considers the missing piece of the puzzle remains the recovery phase after an incident. Some of the System Black recommendations from 2019 related to this phase of the incident. Unfortunately, the details relating to rates of customer load recovery are not consistent through PWC System Control's major incident reporting and so tracking improvements in this space, given the variety of system incidents, would be difficult with the available data. Entura recommends PWC System Control review its reporting guidelines in relation to how incident recovery is reported so the speed and accuracy of system recovery can be tracked and a continuous improvement methodology applied going forward. Entura understands amendments to SCTC reporting requirements are under development.

26 Based on data from PWC System Control incident reporting ('customers impacted' and 'total duration (minutes)').

Major incidents

Table 12 shows a summary of the major incidents in the Alice Springs power system during 2020-21.

Table 12: Alice Springs major incident summary[27]

ID	Date of incident	Description	Category	Cause	UFLS/black	Incident duration (minutes)	Customers affected	Customer minutes without supply
1	22-Jul-20	LG-SD separation	Networks	Operational error		12	0	0
2	17-Oct-20	Loss of gas to Owen Springs power station	Generation	Equipment failure	A4, 1A, 1B, 2B, 3A, 3B	41	6 340	107 007
3	12-Feb-21	Multiple generation trip	Generation	Equipment failure	1A, 1B	26	4 412	80 157
4	03-Apr-21	Owen Springs generating units 1 and 3 (O1 and O3)	Generation	Transient/ unknown		28	0	0

The incidents fall into three broad categories, namely operational error, equipment failure and transients:

1. Operational error (incident 1)

In general, sensitive earth fault (SEF) protection is disabled before transformer energisation as this tends to trigger protection operation. However, as part of this incident, the SEF protection was not disabled and therefore energisation of transformer 2 at the Lovegrove substation caused a trip at the Sadadeen switching station. This led to a separation between the Owen Springs and Ron Goodin power stations. No customer load was impacted during this incident.

2. Equipment failure (incidents 2 and 3)

As part of incident 2, a faulty level transmitter interrupted gas supply to six generating units at the Owen Springs power station. As a result, the frequency of the power system declined and triggered UFLS operation.

Incident 3 involved two lightning strikes on the 66 kV transmission lines between the Owen Springs and Lovegrove zone substations. Following the event, two Owen Springs generating units tripped on injection control major alarms and three additional generating units tripped leading to the operation of UFLS stage 1.

3. Transients (incident 4)

A lightning strike on an 11 kV distribution line led to two generating units at the Owen Springs power station to trip on injection control major alarms. This has been an ongoing issue since November 2017. No customer loads were impacted. Entura notes recommendations in the incident report were made to System Control, Territory Generation and PWC Power Services. The recommendations to Territory Generation are mostly repeat recommendations from previous incidents.

Impact of major incidents

The number of generation incidents have remained consistent with 2019-20. Similar to 2019-20, multiple generating unit failures continued to occur.

27 Based on data from PWC System Control incident reporting ('customers impacted' and 'total duration (minutes)').

Due to the increase in the minimum spinning reserve, following the Alice Springs system black on 13 October 2019, only two of the four major events led to customer interruption, which resulted in a lower SAIDI and SAIFI for the region during 2020-21.

Consistent with the previous three years, there was only one network incident during 2020-21, however the incident did not impact any customer load.

Major incident report recommendations

Recommendations made by PWC System Control, as a result of its investigation of major reportable incidents, are consolidated in a recommendation tracking spreadsheet, which is periodically provided to the Commission.

In the Commission's independent investigation of a system black in Alice Springs on 13 October 2019, the Commission recommended placing a focus on determining if the recommendations of this report and other major event reports have been tracked and implemented during its annual power system reviews, which the Territory Government accepted. Accordingly, as part of the 2020-21 NTPSPR, Entura assessed PWC System Control's recommendation tracking spreadsheet (up to 30 June 2021), based on data provided by PWC System Control on 9 August 2021.

PWC System Control's recommendations are organised into eight categories: asset management, EMS, modelling, power system studies, procedural, protection, training, and other. Table 13 shows the percentage of 'completed' and 'closed' recommendations for each category, and by the financial year in which they were raised (excluding obsolete and duplicate recommendations).

Table 13: Percentage of 'completed' and 'closed' recommendations by category and financial year raised, Alice Springs

	Financial year raised			
	2020-21	2019-20	1 January 2015 to 30 June 2019	**All recommendations**[28]
	%	%	%	**%**
Asset management	40	20	75	**62**
EMS	10	50	67	**33**
Modelling	n/a	n/a	0	**0**
Power System studies	0	100	25	**30**
Procedural	50	67	63	**62**
Protection	0	0	50	**32**
Training	0	100	33	**40**
Other	0	n/a	n/a	**0**
All categories	**25**	**46**	**62**	**51**

28 From 1 January 2015 to 30 June 2021.

Completing recommendations is not consistent across PWC System Control recommendation categories for the Alice Springs power system. For instance, there has been a satisfactory level of progress made in completing asset management and procedural-related recommendations, while less progress has occurred with EMS, modelling and power system study-related recommendations.

Of the recommendations raised during 2020-21, 25% have been completed, while 62% raised more than two years ago (at 30 June 2021) are complete. Overall, for recommendations made between January 2015 and 30 June 2020, 51% are complete.

Generation

The total in-front-of-the-meter generation capacity in the Alice Springs power system is 126.4 MW[29] and the fuel type of the generation units is currently made up of dual fuel (gas and diesel), diesel only, gas only and solar PV. This capacity does not include behindthemeter rooftop solar PV generation capacity, which totalled about 15 MW by the end of 2020-21. The operational maximum demand in 2020-21 was 52.6 MW.

Table 14: Maximum non-summer network connected in-front-of-the-meter generation capacity in Alice Springs[29]

Power station	Capacity (MW)
Ron Goodin	42.6
Uterne	3.8
Owen Springs	80
Total generation	**126.4**

The Ron Goodin power station was expected to be decommissioned in late 2019, however the full retirement of the power station is now dependent on a number of technical capability milestones being met post a system black incident in late 2019. The new Jenbacher generators at the Owen Springs power station are now considered to be fully commissioned, although there are lingering performance issues associated with these units. Further, these performance issues are exacerbated by the failure of the BESS to perform as required.

The following sections show generation in Alice Springs continues to present reliability and availability challenges.

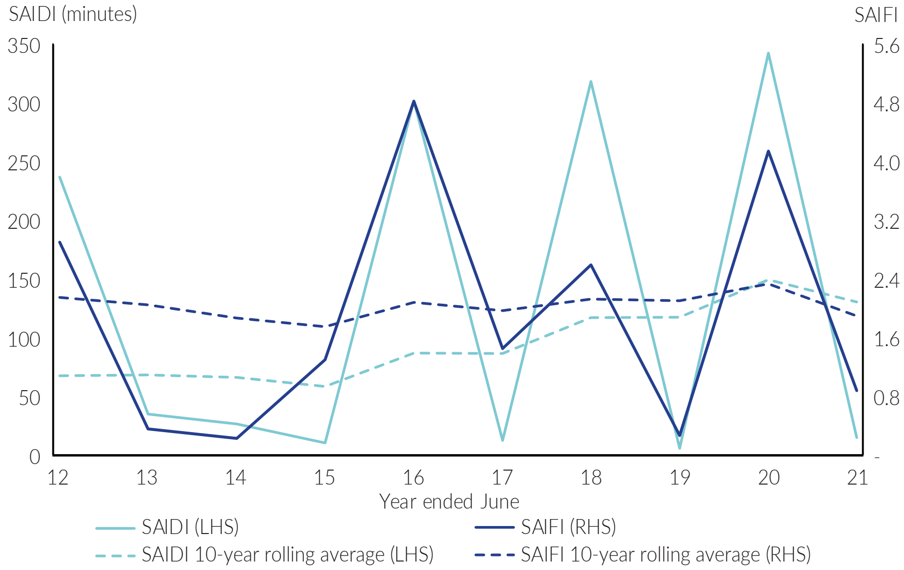
Generator performance

The EIP Code does not set targets for generation SAIDI and SAIFI performance indicators. Historical performance is used to provide commentary on generator performance in 2020-21.

Generation performance for the Alice Springs power system is shown using the SAIDI and SAIFI indices (see Figure 19).

29 Generation capacities relate to non-summer (winter) capacities in accordance with the 2020 NTEOR. The 2021 NTEOR had not been released at the time of writing this report.

Figure 19: SAIDI and SAIFI performance for generation, Alice Springs



The two indices demonstrate the number of issues that have beset the Alice Springs power system over the last 10 years. It can be observed that the generation SAIDI and SAIFI improved in 2020-21, however the indices have been extremely volatile over the last 10 years.

Entura has been expecting the generation upgrades at the Owen Springs power station and the full commercial operation of the BESS to improve the performance. Unfortunately, these upgrades are yet to meet this expectation in a consistent manner.

Entura notes, regardless of these upgrades, the generation mix and high penetration of solar PV, resulting in a reducing minimum demand, leads to a challenging system control problem, particularly in a small system such as Alice Springs. Therefore, careful planning in relation to how the power system is operated and coordination between relevant stakeholders is necessary.

The BESS operation at the Ron Goodin power system continues to give inconsistent performance in relation to frequency regulation, which indirectly leads to higher SAIDI by making it harder than necessary for the synchronous generators to stay online.

As Entura has observed in the major incident section above, it considers that more focus must be applied to the recovery phase of system incidents to try to control the upwards SAIDI trend. This is generally a PWC System Control responsibility, however for generators, having good knowledge of generating unit capability in isolated load scenarios and understanding the power station controls under system black conditions can facilitate system restart and recovery.

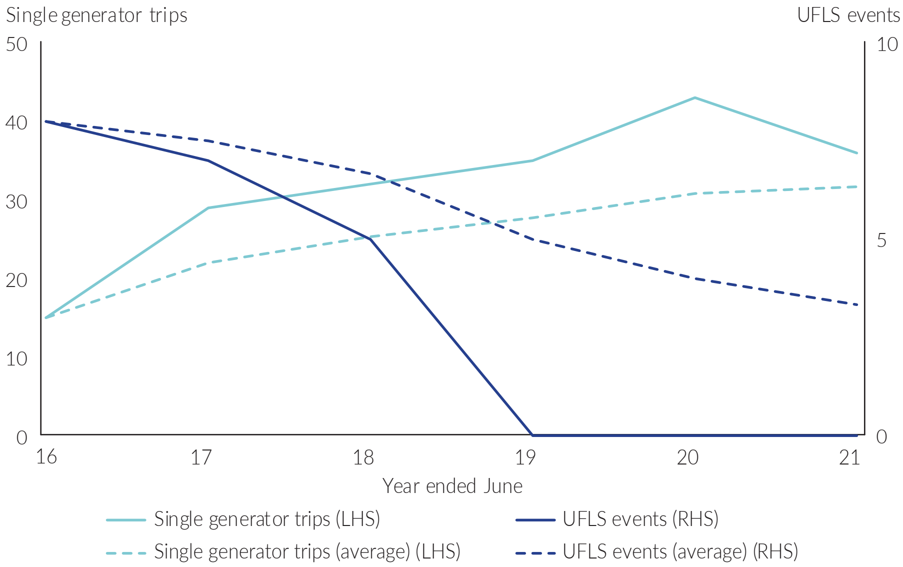
Observed UFLS and single generator trips

This review has focused on single unit trips and their impact on customers for a number of years. The focus is due to the high incidence of single unit trips (relative to other power systems) and the challenge smaller power systems, such as Alice Springs, have in managing these incidents without loss of load due to the relatively large size of the generating units.

Historically, the Alice Springs power system was dispatched in a way that required UFLS to arrest frequency fall for most large single generating unit incidents. This practice was ended in an attempt to improve power system performance. Since that time the power system has seen a steady increase in single unit trips but a stark reduction in coincident UFLS incidents. The Commission notes this improvement has been achieved in part through PWC System Control changes to spinning reserve, which may increase costs, particularly for Territory Generation. Further, given there is no competitive process for and transparency around the provision of spinning reserve, or ancillary services more broadly, there is little incentive for the associated increased costs to be minimised.

Following on from 2019-20, the Alice Springs power system continues to eliminate UFLS events from single generator trips in 2020-21, as shown in Figure 20.

Figure 20: Alice Springs single generator trips versus UFLS (due to single generator trips)



Maintaining zero UFLS operations three years in a row is a great result from the customer's perspective. Despite the number of single generator unit trips decreasing in comparison with 2019-20, the number of trips remains relatively high for a small power system.

It is evident from PWC System Control biannual reports[30] that performance in relation to generator trips has improved in comparison with 2019-20, with the number of days between trips increasing.

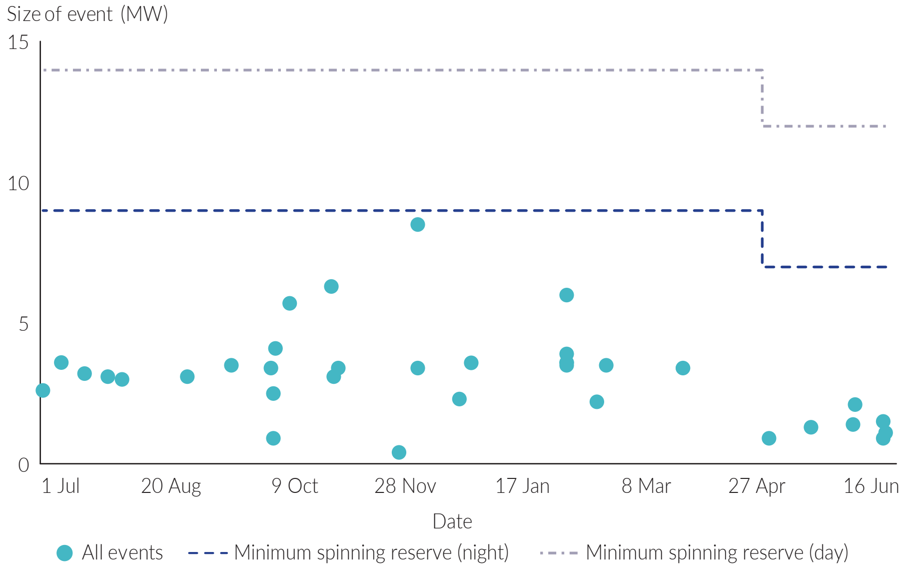
As noted earlier, the number of single generator unit trips remains relatively high for a power system of this size, however Entura has not observed a trend for any particular units. The MAN units 01-03 appear to have tripped more frequently, but this is more due to high utilisation of these units lower in their operational range.

The combination of running aged generators at the Ron Goodin power station and running the Jenbacher generators, for which Territory Generation is still overcoming installation issues, has led to a decline in power system performance. Entura notes that Territory Generation is actively working to resolve and or manage the issues with both the Ron Goodin and Owen Springs power stations, respectively.

The size of single generator trips compared with the day and night minimum spinning reserves in Alice Springs, which changed during 2020-21, is shown in Figure 21.

30 As required by the SCTC.

Figure 21: Alice Springs single generator trip by size



The spinning reserve at the beginning of 2020-21 was nominated at 14 MW for day time operation and 9 MW for night time operation. In May 2021, the minimum spinning reserve was reduced by PWC System Control to 12 MW and 7 MW for day and night time operation, respectively. The margin between an event size and the minimum spinning reserve can be misleading as there may have been a generating unit dispatched at a higher power output that did not trip, however Entura considers the minimum spinning reserve to be adequate for the events that occurred during 2020-21.

The level of spinning reserve limits the ability of the power system to be dispatched with a high percentage of the newer Jenbacher generators, which are high efficiency reciprocating engines. This is due to engines of this type, regardless of equipment supplier, not being able to rapidly accept or reject load, such as during a contingency event. This makes this type of generator generally inappropriate for the provision of large amounts of spinning reserve from a single machine. The result is that a higher spinning reserve amount is required to ensure sufficient governor response to meet the contingency requirement, in the absence of other solutions.

In summary, even though the number of trips is high, the management of spinning reserve is reducing the customer impact, however this is likely to come with increased costs, in particular Territory Generation's costs.

Generation availability

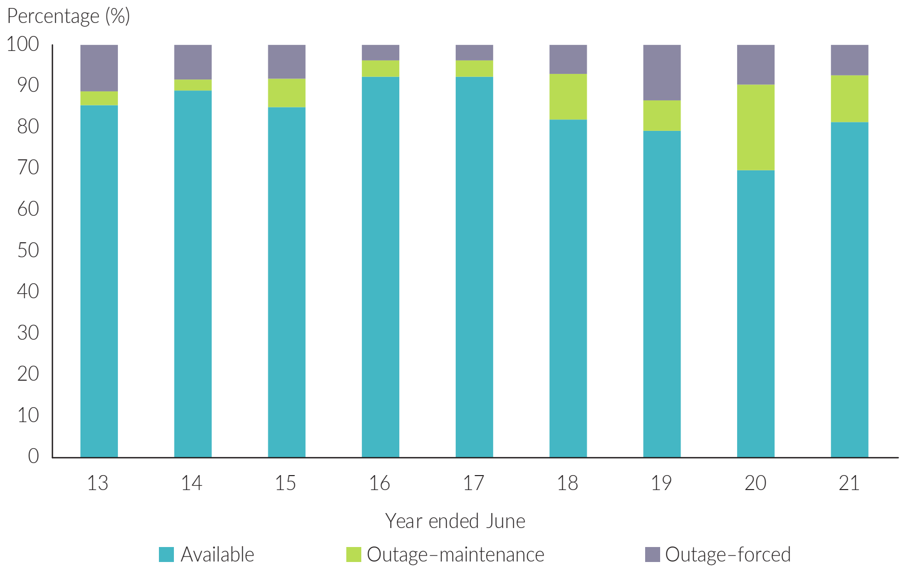
A number of indices are calculated as per the EIP Code to provide some insight into the availability of the generating units and allow an assessment to be made of the adequacy of condition monitoring and preventative maintenance. These include:

- availability factor
- unplanned availability factor
- equivalent availability factor
- forced outage factor
- equivalent forced outage factor.

Ideally planned maintenance should be to a level and adequacy that minimises the level of unplanned maintenance or forced outages resulting from faults as much as reasonably practicable, noting it is unreasonable to expect zero unplanned maintenance or forced outage events. Planned maintenance activities can be scheduled by generators and PWC System Control, whereas unplanned maintenance or forced outages can lead to risks to system reliability and security, with limited or no notice.

Figure 22 combines the indices reported by generators in the Alice Springs power system to show the capacity weighted generation availability in the region over the last nine years, including the level of both planned maintenance and forced outages.

Figure 22: Capacity weighted Alice Springs generation availability



Generation availability improved in 2020-21 compared with 2019-20, however, although not shown, the rolling average continued to fall due to inconsistent generation availability over the last nine years.

Generation forced outages in the Alice Springs power system dropped in 2020-21, however still remained at a high level compared with the previous years and, although not shown, was still higher than the rolling average. It appears generation forced outages are still on the upward trend. Forced outages vary considerably year on year and it is more appropriate to consider the rolling average, which suggests a decline in performance.

The Owen Springs power station performance improved in 2020-21 compared with the previous year. The discovery of technical issues associated with the Jenbacher generators continued to detract from the power station's performance in 2020-21. This is a combination of contractual obstacles between Territory Generation and the original equipment manufacturers, and lack of local Jenbacher expertise, which continues to impede the performance of the power station. Territory Generation has noted the effects of COVID-19 significantly increased the time it takes to return a generator to service.

Although forced outages at the Ron Goodin power station have decreased in 2020-21, the outages still remain at a high level. Territory Generation understands the challenges associated with the Ron Goodin power station, in particular where no pattern of failures are evident, and are currently exploring new ways to increase reliability of the generators by combining two generators to make one reliable machine. This also has an impact on the level of forced outages as the donor generator will become a long-term forced outage.

Ongoing issues at the Owen Springs power station and prolonged use of the Ron Goodin power station have resulted in higher levels of unplanned maintenance and forced outages across the Alice Springs power system. Territory Generation describes this as having a power station at each end of the bathtub curve. That is, one power station at the beginning and one at the end of its service life.

This can be understood as continued ageing effects at the Ron Goodin power station and continued teething problems at the Owen Springs power station. Plants suffer 'annoying' and 'niggling' unreliability as commissioning and equipment 'running in' occurs, and then operates at a reliable level of performance across the life of the plant. It is not until the end-of-life stage, where the Ron Goodin power station is now, that the frequency of failures starts to increase again due to wear and tear on all components. Accordingly, the observed performance decline is almost inevitable. Entura considers it important that work at both power stations stabilises the outage rates in the short term. Further, once the Ron Goodin power station is decommissioned, the units at the Owen Springs power station will operate at a sustainably higher level of availability.

As highlighted in previous sections, Territory Generation has adopted a new risk management system for its units that is expected to lead to less forced outages. This is in line with good electricity industry practice.

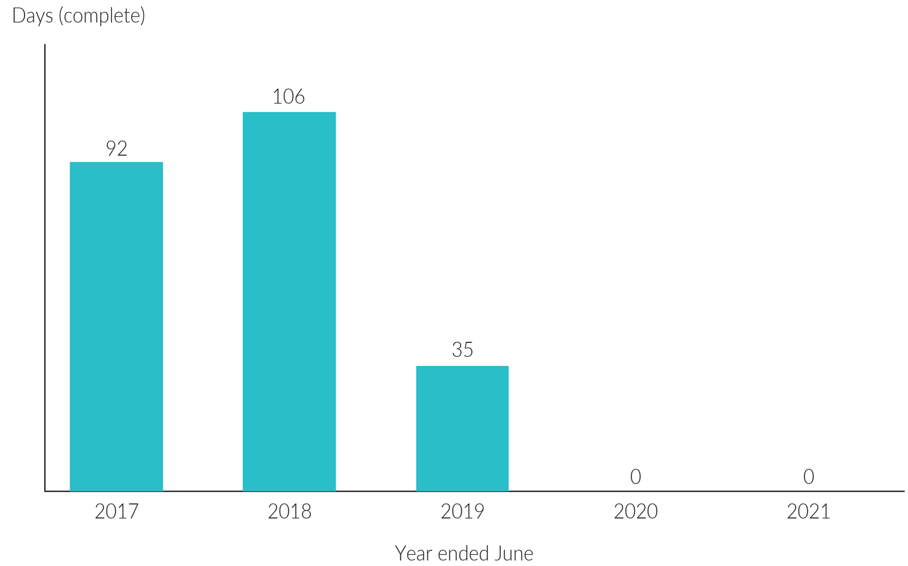
Non-reliable periods

Non-reliable periods are a forward-looking assessment rather than in response to system incidents, and are declared when PWC System Control identifies that power system reliability cannot be maintained. There are a number of causes, including:

- planned, unplanned or forced outages that reduce reliability for all or part of the power system
- lack of generation to meet demand and or requirements for spinning reserve.

There were no recorded non-reliable periods in the Alice Springs power system during 2020-21 (see Figure 23).

Figure 23: Non-reliable periods for generation in Alice Springs



2020-21 is the second year that zero non-reliable periods were declared, which suggests a more diligent operation of the power system. This is currently made easier due to the large number of generators available between the Owen Springs and Ron Goodin power stations.

Generation constraints

Table 15 summarises the generation constraints in the Alice Springs power system.

Table 15: Alice Springs System constraints

	Constraint description	Applied to	Limit	System condition	Open/ closed	Comments
1	Dispatch level management	Ron Goodin power station	17 MVA	All	Closed	Manages power flow through Ron Goodin/Sadadeen 11/22 kV transformers
2	Dispatch level management	Jenbacher generators		All while Territory Generation is working with PWC System Control on implementing recommendations from the system black event	Open	Ron Goodin power station decommissioning to continue at the discretion of Territory Generation with approval of PWC System Control upon completion of closing the system black root cause rectifications
3	Dispatch level management	Owen Springs power station	Dynamic minimum figure real time calculated and displayed in Areva EMS	All	Open	Prevents overloading of Lovegrove Sadadeen ties 1 or 2 in the event of a contingency

Constraint 1 was a network constraint. The constraint curtailed (or preferentially dispatched) generation to manage loading on a network element. Constraint 1 was only valid during the first half of 2020-21.

Constraints 2 and 3 were introduced during 2020-21.

It is expected that constraint 2 will be removed once Territory Generation completes the root cause rectifications following a system black in Alice Springs on 13 October 2019. This will be a significant step for the system as it will allow the efficient Jenbacher generators to supply more of the customer demand.

Constraint 3 should also be more easily managed once the load balance between Owen Springs and Ron Goodin power stations swings more towards the Owen Springs power station.

Network

The Alice Springs power system supplies Alice Springs and the surrounding areas through a network of 66 kV sub-transmission and lower voltage distribution feeders. The network forms a ring with Lovegrove zone substation and the Ron Goodin power station at one end, and Owen Springs power station at the other.

Network performance

Network performance is measured and reported by PWC Power Services as part of the EIP Code requirements. The SAIDI and SAIFI performance for the Darwin-Katherine network is presented in Figure 24.

Figure 24: Adjusted SAIDI and SAIFI performance indices for the Alice Springs network[31]

Both indices have risen in 2020-21 to levels comparable with the cumulative moving average from 2012-13, with SAIDI more than doubling during 2020-21 in comparison with 2019-20. Using the rural short feeder category target of 190 for SAIDI and 3 for SAIFI, both indices are well within that benchmark. Further, both the SAIDI and SAIFI results also achieve the higher urban feeder category target of 150 and 2, respectively.

Entura notes there were no transmission level (66 kV lines) outages in Alice Springs across the last six financial years. This is an excellent result, however Entura is concerned the change in operation in the network associated with the eventual decommissioning of the Ron Goodin power station, and introduction of a large load at Joint Defence Facility Pine Gap, may lead to some unexpected network incidents in the future. Entura expects PWC System Control (in consultation with PWC Power Services) to work to preempt these issues where possible.

Network utilisation

Transmission network

The 66 kV lines between Owen Springs and Lovegrove continue to be lightly loaded due to the continued load sharing between the Ron Goodin and Owen Springs power stations. This loading will change as the Ron Goodin power station is decommissioned and as more load is connected. The 66 kV lines will become very important for the Alice Springs supply and management of the ring (normally open) will need to be carefully considered. The utilisation of these lines will be driven by Alice Springs demand, the operation of the BESS and capacity of the 66/22 kV power transformers at Lovegrove zone substation.

Zone substations

The zone substation transformer loading under N and N-1 conditions in 2020-21 is shown in Figure 25.

31 The EIP Code allows licensees to adjust SAIDI and SAIFI values by excluding incidents that meet an exclusion criteria included in the code, with the list of the excluded incidents required to be included in the reporting.

Generally, where a zone substation has multiple transformers, it is expected a substation can supply the full substation load with one transformer out of service (N-1). The substations of concern in the figure are those where either the N or N-1 loading exceeds 100%.

Figure 25: Substation utilisation for N and N-1 conditions, Alice Springs

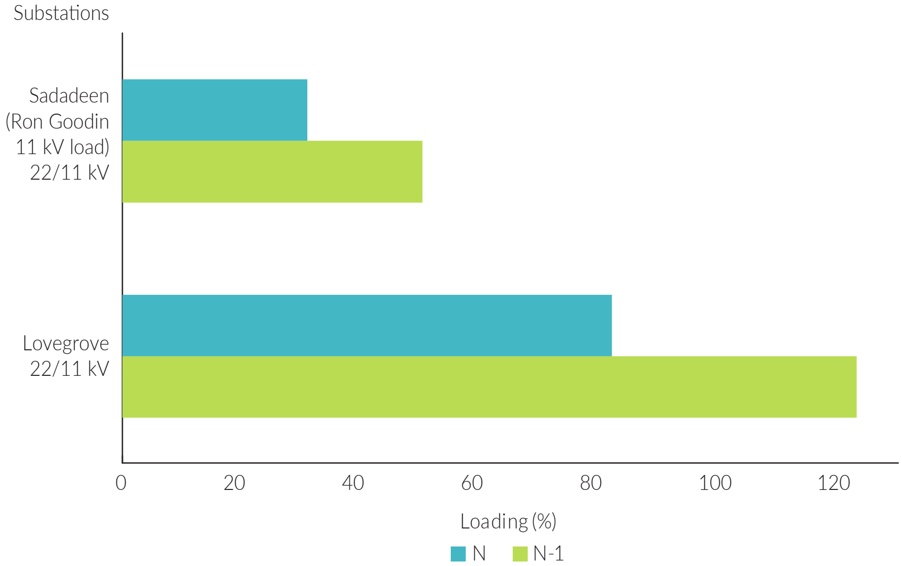
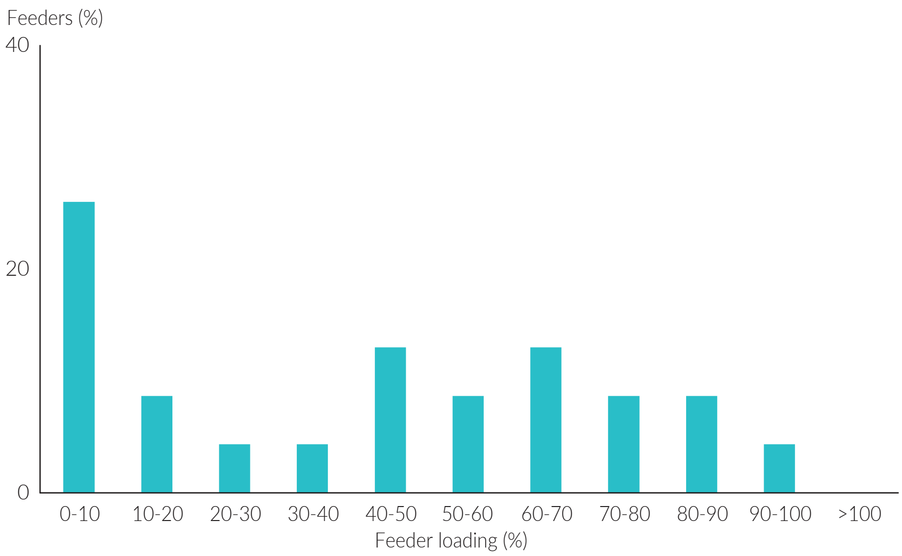


Figure 25 shows actual zone substation loading in 2020-21. On the basis that substation loading should not exceed 100%, in 2019-20 the Sadadeen 22/11 kV substation was at risk of not fully supplying the substation load if one transformer went out of service (N-1). However, this switched to the Lovegrove 22/11 kV substation in 2020-21. Entura understands that load can be transferred between these two zone substations following a failure of one of the Lovegrove transformers. However, upgrades are required at Lovegrove to improve the cyclic rating so customers can be supplied during the transfer process.

Feeders

The distribution of feeder loadings for Alice Springs is shown in Figure 26.

Figure 26: Feeder utilisation for Alice Springs



In 2020-21, no feeders exceeded their nominal capacity. This demonstrates that feeder loadings are well managed in the Alice Springs network with all feeders operating below their capacity. Loading on feeder 11RG02 (GOLF) is approaching capacity (loading of 93% in 2020-21). Entura understands PWC Power Services is currently looking into transferring load to adjacent feeders to reduce the utilisation on feeder 11RG02.

Network constraints

Table 16 summarises the network constraints in the Alice Springs region.

Table 16: Alice Springs network constraints

	Constraint description	Applied to	Limit	System condition	Open/closed	Comments
1	22/11 kV transformers	Sadadeen	17 MVA	All	Closed (during 2020-21)	

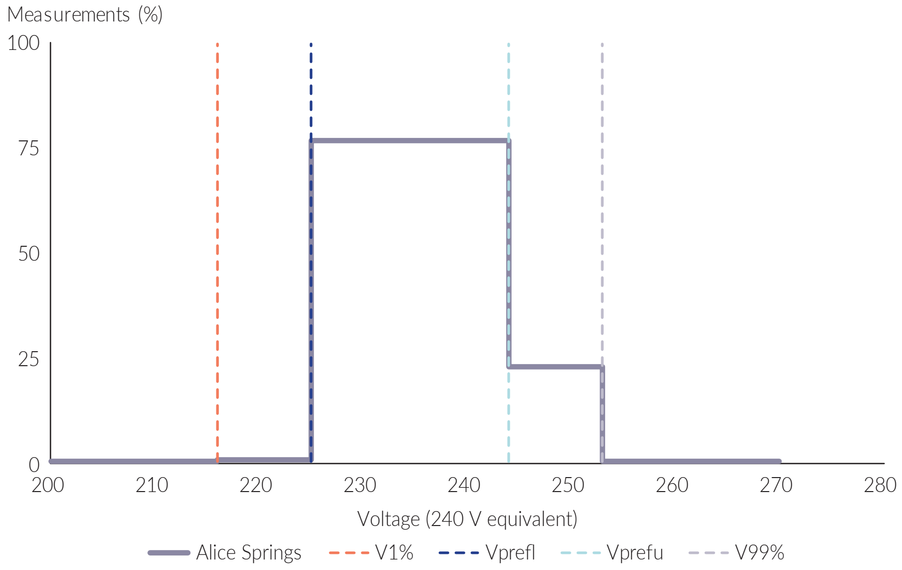
Constraint 1 was a simple thermal limit that represents a limit to the flexibility of the Alice Springs network topography. Constraint 1 was removed during 2020-21.

Network power quality

Low voltage quality

Figure 27 shows the steady state voltage performance for the Alice Springs region in 2020-21.

Figure 27: Steady-state voltage performance, Alice Springs



Voltage regulation has improved in 2020-21 in comparison to 2019-20, with voltages in the preferred zone rising from 55% to 77%. The high voltage periods have also decreased from 44% to 23%.

The improvement appears to mostly relate to commissioning a third transformer at the Sadadeen zone substation that has decreased the impedance in the network and therefore enhanced voltage control. The voltage remains above the preferred range for about a quarter of the time. Entura understands PWC Power Services is considering the management of voltage in the Alice Springs region carefully and will consider further augmentations as required.

Network complaints

PWC Power Services is required by the EIP Code to report on the percentage and total number of complaints it receives that are associated with network quality of supply issues and network-related activities.

Complaints associated with network quality of supply issues in Alice Springs slightly decreased from 397 in 2019-20 to 390 in 2020-21, and continued a downward trend over the last six years. Complaints are mostly made in relation to no power rather than partial and low power, or fluctuations in power, which is consistent with the last six years, however the percentage of no power complaints has slightly increased over the same period.

Complaints associated with network-related activities are categorised as administration process and customer service, connections, reliability of supply, technical quality of supply or other. There were a small number of complaints regarding the Alice Springs network in 2020-21 compared with the number of customers in the region. Just under 40% of the complaints were categorised as administration process and customer-service related.

3 Tennant Creek power system

This chapter focuses on the 2020-21 generation and network performance of the Tennant Creek power system. Where possible it compares 2020-21 performance with historical data to identify trends. Specifically, this chapter considers:

- incidents
- generator performance, observed UFLS and single generator trips, generation availability, non-reliable periods and generation constraints
- network performance, utilisation, constraints, power quality and complaints.

Power system description

The Tennant Creek power system is the smallest power system covered in the NTPSPR. The power system supplies the township of Tennant Creek and surrounding rural areas from its centrally located power station. The energy sent out by licensed generators over the last four years is shown in Table 17.

Table 17: Tennant Creek energy sent out[32]

	Energy sent out (GWh)			
	2017-18	2018-19	2019-20	2020-21
Tennant Creek	29	30	30	28

The total in-front-of-the-meter generation capacity in the Tennant Creek power system is 19.75 MW[33] in accordance with the 2020 NTEOR. This does not include behind-the-meter rooftop solar PV generation capacity, which totalled around 0.4 MW by the end of 2020-21.

The power station at Tennant Creek has undergone a significant transformation with the commissioning of new generating units and retirement of a large number of existing units.

Incidents

An incident, or reportable incident, is a power system event that had or could have had a significant adverse effect on security or reliability of electricity supply, and is determined by PWC System Control in accordance with the SCTC. PWC System Control determines whether a reportable incident is classed as a major or minor incident, noting it has a level of discretion. Major incidents are subject to more detailed investigation and reporting requirements.

The Commission considers the purpose of incident reporting is to ensure power system events that would benefit from investigation are investigated to identify and address issues, and improve the safe and reliable supply of electricity to customers.

This section considers the overall customer impact from major and minor incidents, provides an overview of major incidents, and discusses the tracking and implementation of PWC System Control recommendations following the investigation of major incidents.

32 Based on data issued from PWC System Control Northern Territory Regulated Power Systems biannual reports.

33 Generation capacity relates to non-summer (dry season) network connected in-front-of-the-meter generation capacities in accordance with the 2020 NTEOR. The 2021 NTEOR had not been released at the time writing this report.

Overall customer impact

This section shows the overall impact of major and minor incidents on customers in the Tennant Creek region over the last five years (Table 18).

The number of customers impacted and total duration (minutes) of an incident is reported to the Commission by PWC System Control as part of its SCTC obligations, and is used to calculate indicators such as SAIDI. However, as customers are restored in stages, not all customers are impacted for the full duration of the incident, which may lead to over reporting. To address this, starting from 2020-21, the Commission's reporting on SAIDI takes this sequential restoration into account and therefore provides a better representation of the customers' overall experience. The Commission notes this change to reporting may impact the usefulness of historical comparisons.

Table 18: Overall customer impact from major and minor incidents in the Tennant Creek power system

	2016-17	2017-18	2018-19	2019-20	2020-21
Number of incidents	7	11	19	10	10
Customers impacted	3 780	6 435	16 825	9 232	4 885
Total duration (minutes)	225	1 784	667	182	230
SAIDI	93.7	363.2	587.0	153.7	52.9
SAIFI	2.47	4.00	10.82	5.97	3.13
Reliability (% of year)	99.98	99.93	99.89	99.97	99.99
System blacks					
Number	2	2	3	2	1

SAIDI is a measure in minutes of the average duration of an incident weighted by the number of customers affected by each incident. That is, if 10 customers suffer a 10-minute interruption but there are 100 customers in the region in total, then this would lead to a SAIDI of 1 minute. Multiple incidents are added together so if a second incident of 15 minutes affected 10 customers then this would be added to the first incident and lead to a SAIDI of 2.5 minutes.

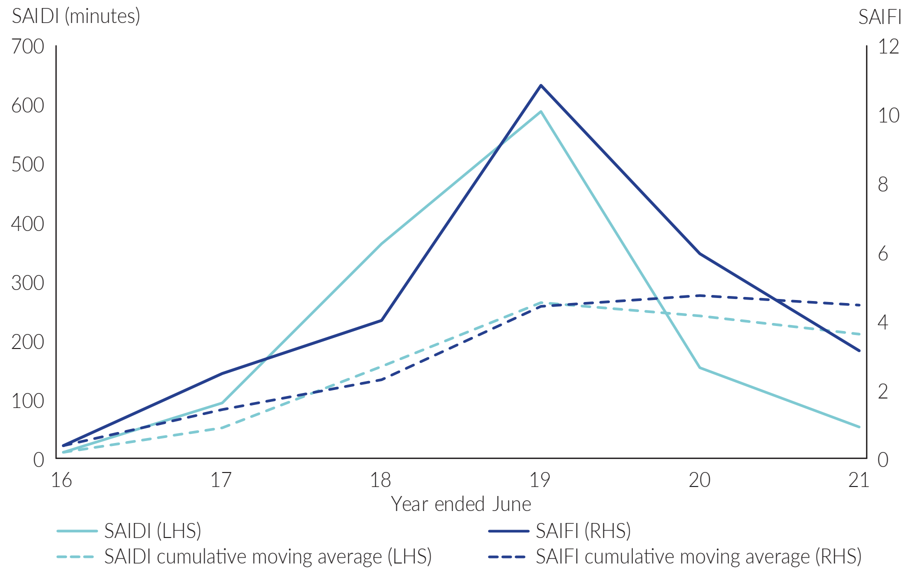
SAIFI is a measure of the average number of incidents weighted by the number of customers affected by each incident. Using the examples above, the SAIFI would be 0.1 after the first incident and 0.2 after the second.

Reliability (percentage of year) is calculated based on SAIDI and is the percentage of a year the average duration in minutes of incidents per customer represents subtracted from the total number of minutes in a year. This is different from the unserved energy-based reliability standard[34] for generation of 0.002% applied in the NEM, which is also adopted by the Commission in its NTEOR reliability assessments in the absence of a formal Territory target.

The major and minor incident SAIDI and SAIFI performance for the Tennant Creek power system over the last six years is shown in Figure 28.

34 https://www.aemc.gov.au/sites/default/files/content/2f4045ef-9e8f-4e57-a79c-c4b7e9946b5d/Fact-sheet-reliability-standard.pdf.

Figure 28: Major and minor incident SAIDI and SAIFI performance, Tennant Creek[35]



SAIDI and SAIFI has improved in the Tennant Creek power system during 2020-21 compared with 2019-20, with both indices below the cumulative moving average from 2015-16. Performance has improved with fewer customers impacted by outages. The number of major incidents in 2020-21 was consistent with 2019-20, however the average duration of these events was around half.

Major incidents

There were 10 major incidents in the Tennant Creek power system in 2020-21. This is an increase of one from the nine incidents that occurred in the 2019-20. The incidents are summarised in Table 19.

Table 19: Tennant Creek major incident summary[36]

ID	Date of incident	Description	Category	Cause	UFLS/black	Incident duration (minutes)	Customers affected	Customer minutes without supply
1	08-Jul-20	Tennant Creek power station unit T16 trip	Generation	Equipment failure and operational error[37]	1 and 3A	11	596	4 337
2	09-Aug-20	22TC01 (Ali Curung) and 22TC09 (Warrego) feeders tripped	Networks	Transient/unknown	1	16	634	879
3	19-Aug-20	22TC07 (Three Ways) feeder tripped	Networks	Transient/unknown	1	8	55	436
4	12-Sep-20	22TC02 (Tennant Creek East) feeder tripped	Networks	Transient/unknown	1	20	54	1 008
5	27-Oct-20	22TC07 (Three Ways) feeder tripped	Networks	Transient/unknown	1	28	55	1 564

continued

35 Based on data from PWC System Control incident reporting ('customers impacted' and 'total duration (minutes)').
36 Based on data from PWC System Control incident reporting ('customers impacted' and 'total duration (minutes)').
37 As designated by the PWC System Control incident report.

ID	Date of incident	Description	Category	Cause	UFLS/black	Incident duration (minutes)	Customers affected	Customer minutes without supply
6	17-Nov-20	22TC07 (Three Ways) feeder fault	Networks	Transient/unknown	System black/1, 3A, 4A, BU	88	1 812	55 369
7	18-Nov-20	22TC02 (Tennant Creek East) feeder tripped	Networks	Transient/unknown	1	18	673	9 640
8	19-Nov-20	22TC01 (Ali Curung) feeder tripped	Networks	Transient/unknown	1 and 3A	9	852	7 217
9	25-Jan-21	22TC07 (Three Ways) feeder reclose	Networks	Transient/unknown	1	18	52	927
10	12-Jun-21	22TC01 (Ali Curung) feeder transient fault	Networks	Transient/unknown	1	14	102	1 342

Most of the incidents during 2020-21 fall into the transients category with the exception of incident 1, which is categorised as equipment failure and operational error.

1. Equipment failure and operational error (incident 1)

In relation to this incident, in discussions with Territory Generation during consultation, Entura concludes the operational error component of this incident is not the root cause. The plant was in an abnormal state (a cable had been disconnected for maintenance) and this led to an operator reacting to incorrect data in a correct way. Entura considers that had the data been correct and the operator done nothing, the generating unit may have been damaged.

2. Transients (incidents 2-10)

These are the typical major incidents in the Tennant Creek power system, where a line fault or the reclose after a line fault leads to a generating unit tripping, followed by the operation of UFLS. Entura understands these faults, and the management of them, are under investigation by both PWC Power Services and Territory Generation.

In a small power system such as Tennant Creek it is difficult to determine the cause of incidents such as these. There is often shared responsibility for maintaining supply and so Entura considers it good that both PWC Power Services and Territory Generation are working to address the performance during these incidents.

Impact of major incidents

The majority of the incidents that occurred in 2020-21 were related to UFLS events, triggered by re-energisation of 22 kV feeders. This issue has been ongoing for a number of years in the Tennant Creek power system. Entura understands PWC Power Services has a project in place to install additional sectionalisers on 22 kV feeders that would limit the impact of feeder energisation (feeder energisation to be carried out in stages), which should reduce the occurrence of UFLS events.

Major incident report recommendations

Recommendations made by PWC System Control as a result of its investigation of major reportable incidents are consolidated in a recommendation tracking spreadsheet, which is periodically provided to the Commission.

In the Commission's independent investigation of a system black in Alice Springs on 13 October 2019, the Commission recommended placing a focus on determining if the recommendations of this report and other major event reports have been tracked and implemented during its annual power system reviews, which the Territory Government accepted. Accordingly, as part of the 2020-21 NTPSPR, Entura assessed PWC System Control's recommendation tracking spreadsheet (up to 30 June 2021), based on data provided by PWC System Control on 9 August 2021.

PWC System Control's recommendations are organised into eight categories: asset management, EMS, modelling, power system studies, procedural, protection, training and other. Table 20 shows the percentage of 'completed' and 'closed' recommendations for each category, and by the financial year in which they were raised (excluding obsolete and duplicate recommendations).

Table 20: Percentage of 'completed' and 'closed' recommendations by category and financial year raised, Tennant Creek

	Financial year raised			
	2020-21	2019-20	1 January 2015 to 30 June 2019	**All recommendations[38]**
	%	%	%	**%**
Asset management	100	88	60	**80**
EMS	0	27	20	**20**
Modelling	n/a	n/a	33	**33**
Power System studies	n/a	60	22	**46**
Procedural	14	78	50	**61**
Protection	56	50	77	**62**
Training	67	n/a	n/a	**67**
Other	43	n/a	n/a	**43**
All categories	**45**	**70**	**51**	**59**

Completing recommendations is not consistent across PWC System Control recommendation categories for the Tennant Creek power system. For instance, there has been a satisfactory level of progress made in completing asset management, training, protection and procedural-related recommendations, while less progress has occurred with EMS and modelling-related recommendations.

Of the recommendations raised during 2020-21, 45% have been completed, while just over half raised more than two years ago (at 30 June 2021) are complete. Overall, for recommendations made between January 2015 and 30 June 2020, 59% are complete.

38 From 1 January 2015 to 30 June 2021.

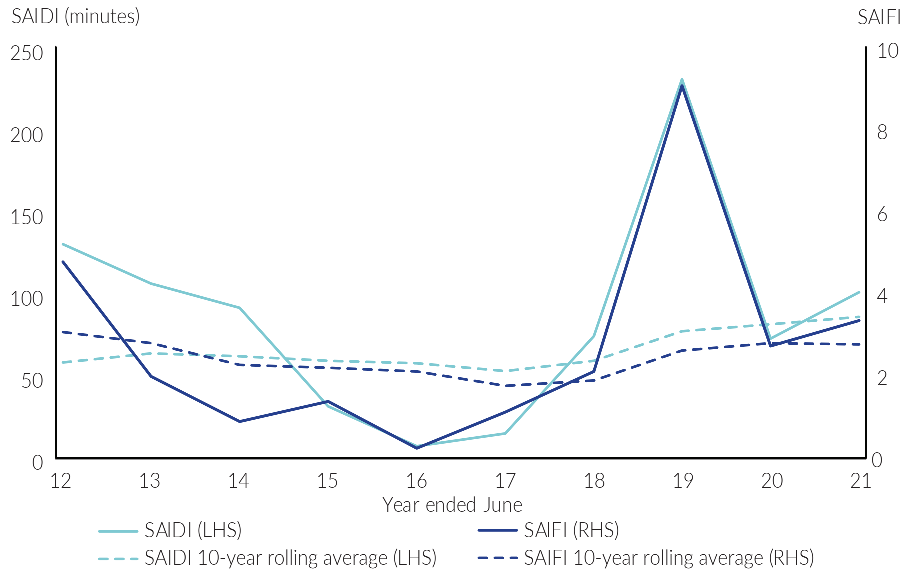
Generation

The generation performance in Tennant Creek has slightly worsened during 2020-21 compared with 2019-20.

Generator performance

Generation performance for the Tennant Creek power system is shown using the SAIDI and SAIFI indices (see Figure 29).

Figure 29: SAIDI and SAIFI performance indices for generation, Tennant Creek



The performance in 2020-21 has seen a slight decline from 2019-20 as indicated by a small increase in both SAIDI and SAIFI. The 10-year rolling average for SAIDI and SAIFI appears to be stable and consistent with 2019-20. The number of generator trips during 2020-21 was more frequent than 2019-20 (increased from 7 to 9), which explains why SAIDI and SAIFI increased despite only one of the trips being classified as a major incident.

Observed UFLS and single generator trips

It is rare for a single unit trip to not result in UFLS in the Tennant Creek power system due to the minimum spinning reserve approach taken in this power system. Generation trips were more common in Tennant Creek in 2020-21, as noted in the previous section.

Sourcing spinning reserve can be difficult in small power systems such as Tennant Creek. It is made particularly difficult with high efficiency reciprocating engines like the Jenbachers. Engines of this type, from any equipment supplier, are not able to rapidly accept or reject load. This makes them generally inappropriate in providing large amounts of spinning reserve from a single machine. The result is a higher spinning reserve amount is required to ensure sufficient governor response to meet the contingency requirement.

In Entura's opinion, with current technologies, the only options to break the link between single machine trips and UFLS in the Tennant Creek power system are to carry an unreasonable amount of spinning reserve, purchase low-efficiency generators or install a BESS. Entura considers advances in battery technology as recent as the last 24 months mean a BESS should be seriously considered to supply the spinning reserve in the Tennant Creek power system, subject to a cost-benefit analysis.

Generation availability

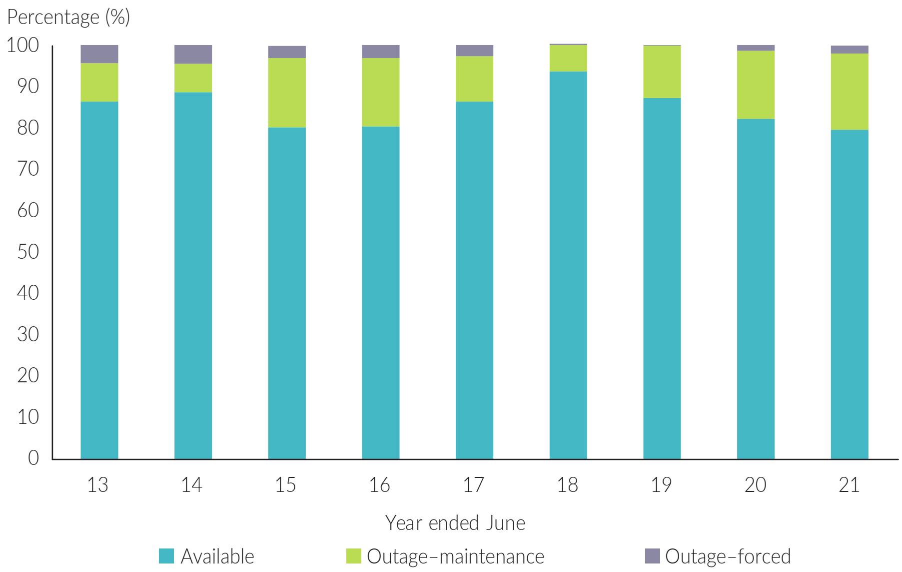
A number of indices are calculated as per the EIP Code to provide some insight into availability of the generating units, and allow an assessment of condition monitoring adequacy and preventative maintenance to be made. These include:

- availability factor
- unplanned availability factor
- equivalent availability factor
- forced outage factor
- equivalent forced outage factor.

Ideally, planned maintenance should be to a level and adequacy that minimises the level of unplanned maintenance or forced outages resulting from faults as much as reasonably practicable, noting it is unreasonable to expect zero unplanned maintenance or forced outage events. Planned maintenance activities can be planned for by generators and PWC System Control, whereas unplanned maintenance or forced outages can lead to risks to system reliability and security, with limited or no notice.

Figure 30 combines the indices reported by generators in the Tennant Creek power system to show the capacity weighted generation availability in the region over the last nine years, including the level of both planned maintenance and forced outages.

Figure 30: Tennant Creek generation availability



The availability of generators in the Tennant Creek power system has continued to decrease in 2020-21, however the main contributing factor to this reduction is an increase in planned maintenance, and to a lesser extent, a slight increase in forced outages. While the increase in planned maintenance is positive in terms of showing a higher level of preventative maintenance and or withdrawal from service of units that are of questionable reliability, it does reduce the amount of capacity available to support PWC System Control in managing a reliable and secure system. This is likely mitigated by the large amount of installed capacity in Tennant Creek compared with the level of system demand.

Generator forced outages have continued to rise in 2020-21, however, while not shown, still remain under the rolling average. Tennant Creek is a challenging power system to operate, and these challenges are significantly reduced when the generating units are reliable or managed so unreliability does not lead to unplanned outages.

Non-reliable periods

Non-reliable periods are a forward-looking assessment rather than in response to system incidents, and are declared when PWC System Control identifies that power system reliability cannot be maintained. There are a number of causes, including:

- planned, unplanned or forced outages that reduce reliability for all or part of the power system
- lack of generation to meet demand and or requirements for spinning reserve.

There were no instances of non-reliable periods during 2020-21 in the Tennant Creek power system. The system is simple and the abundance of generation options should lead to this level of reliability.

Generation constraints

Table 21 summarises the generation constraints in the Tennant Creek power system.

Table 21: Tennant Creek system constraints

	Constraint description	Applied to	Limit	System condition	Open/ closed	Comments
1	Minimum MW spinning reserve	Tennant Creek power station	1.8 MW	All	Open	Develop constraints based on review of historical events
2	Regulation down reserve	Tennant Creek power station	0.5 MW for 1st half of 2020-21, 0.4 MW from Jan 2021 onwards	All	Open	Develop constraints based on review of historical events

The constraints shown in Table 21 were introduced in the second half of 2019-20 to ensure minimum spinning reserve is achieved at all times and are still open. The move to impose constraints for spinning reserve should reduce reliance on UFLS and in turn increase the reliability for customers.

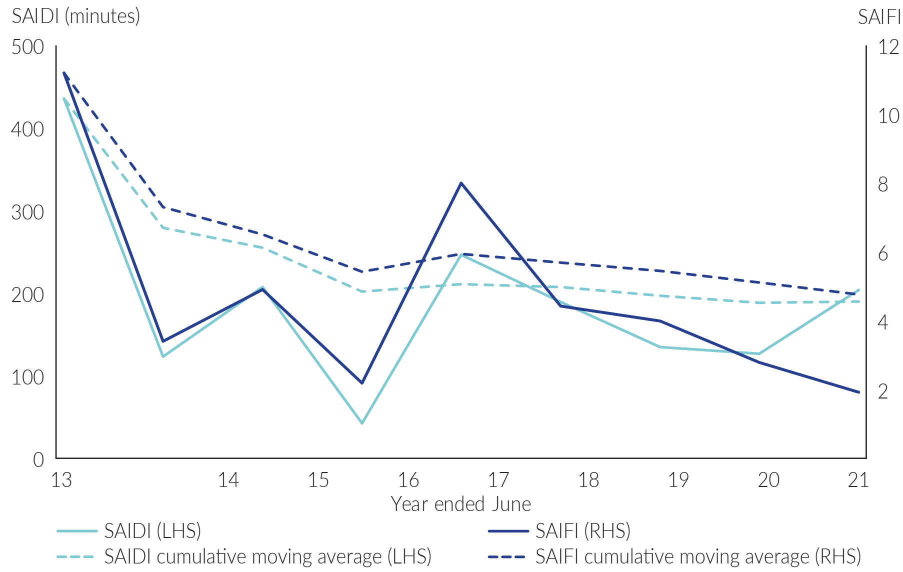
Network

The Tennant Creek network has a single zone substation and a maximum rated system voltage of 22 kV.

Network performance

Network performance is measured and reported by PWC Power Services as part of the EIP Code requirements. The SAIDI and SAIFI performance for the Darwin-Katherine network is presented in Figure 31.

Figure 31: Adjusted SAIDI and SAIFI performance indices for the Tennant Creek network



SAIDI in the Tennant Creek network has increased and is higher than the rural short feeder category target. This is due to the increased number of network-related major incidents that led to UFLS operation in 2020-21 compared with 2019-20.

SAIFI continued to decrease under the rolling average and rural short feeder category target. This is a very good result considering the nature of the network.

Network utilisation

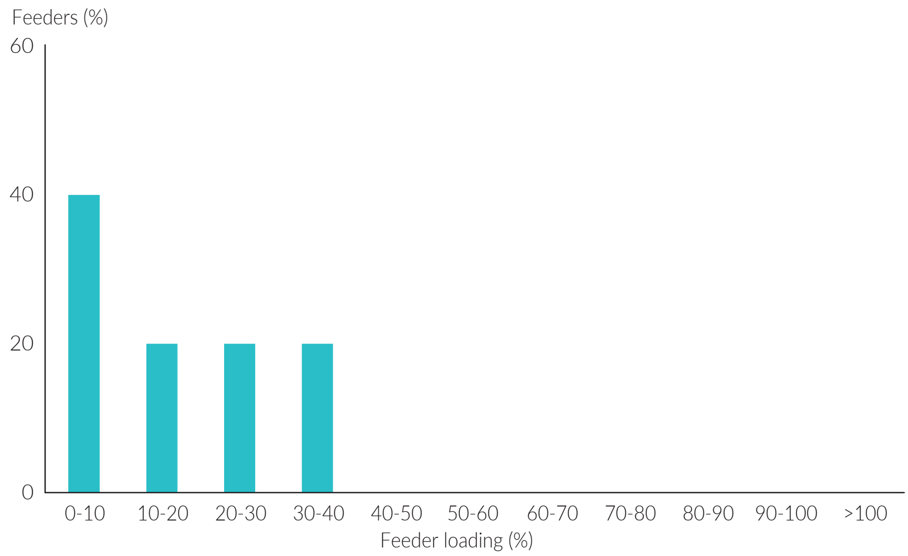
Zone substation

The zone substation remains below capacity under N-1 conditions during 2020-21.

Feeders

The feeder loading distribution for Tennant Creek is shown in Figure 32.

Figure 32: Feeder loading distribution, Tennant Creek



The low level of feeder loading in Tennant Creek is typical of lightly loaded distribution networks. Cost-effective distribution design relies on standard designs and stock holdings, and so often distribution networks utilise assets built with a higher level of capacity than the expected loads.

Network constraints

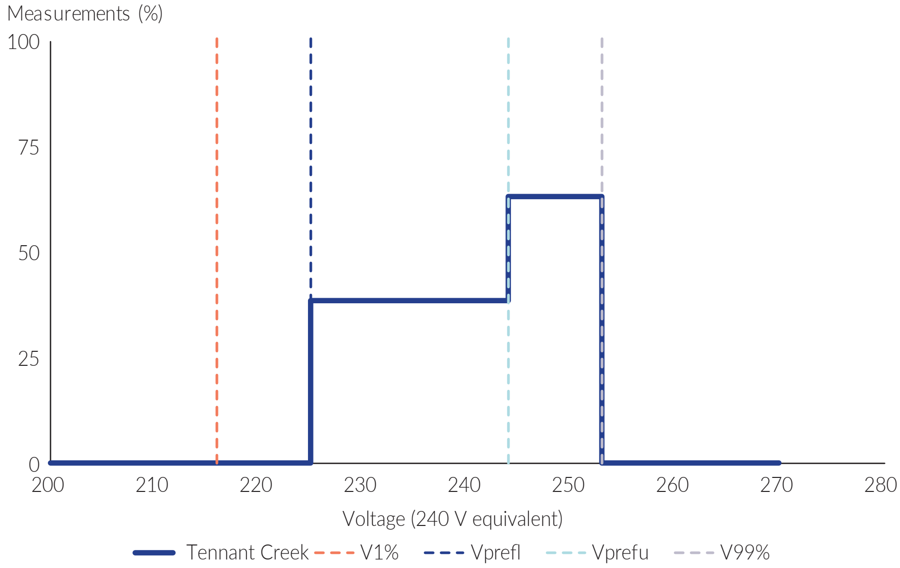
There are no network constraints applied to the Tennant Creek network.

Network power quality

Low voltage quality

Figure 33 shows the steady state voltage performance for the Tennant Creek region in 2020-21.

Figure 33: Steady-state voltage performance, Tennant Creek



This is the first year low voltage quality data has been reported by PWC Power Services in relation to the Tennant Creek network.

During 2020-21, data indicates voltage was in the preferred zone for about 38% of the time and high voltage periods accounted for 62%. Similar to the Alice Springs network, voltage regulation is an ongoing challenge in the Tennant Creek network given the long lightly loaded distribution feeders.

Network complaints

PWC Power Services is required by the EIP Code to report on the percentage and total number of complaints it receives that are associated with network quality of supply issues and network-related activities.

Complaints associated with network quality of supply issues in Tennant Creek decreased from 87 in 2019-20 to 67 in 2020-21 and is the lowest level reported in the last six years. Complaints are mostly made in relation to no power rather than partial and low power, or fluctuations in power, which is consistent across the last six years.

Complaints associated with network-related activities are categorised as administration process and customer service, connections, reliability of supply, technical quality of supply or other. There were a very small number of complaints regarding the Tennant Creek network in 2020-21 compared with the number of customers in the region. Complaints were evenly distributed between administration process and customer service, technical quality of supply, and other.

4 | Territory electricity industry performance

This chapter focuses on the 2020-21 performance data from PWC Power Services' EIP Code reporting that is not region specific. Where possible it compares 2020-21 performance to historical data to identify trends. Specifically this chapter considers:

- distribution feeders (including overall Territory SAIDI and SAIFI, and worst performing feeders)
- guaranteed service level payments
- phone answering
- new connections.

Distribution feeders

PWC Power Services reports its distribution feeder performance against four feeder categories as per the EIP Code:

- CBD
- urban
- rural short
- rural long.
- The results for 2020-21 are shown in Table 22.

Table 22: SAIDI and SAIFI performance by feeder type

	Adjusted SAIDI (minutes)			Adjusted SAIFI (interruptions)		
Feeder category	Target standard[39]	Actual performance	Result	Target standard[40]	Actual performance	Result
CBD	4.0	4.0[40]	Target not met	0.1	0.1[41]	Target met
Urban	140.0	117.7	Target met	2.0	1.5	Target met
Rural short	190.0	149.2	Target met	3.0	2.5	Target met
Rural long	1 500.0	1 701.1	Target not met	19.0	29.1	Target not met
Whole of network	175.8	136.5	Target met	2.6	2.1	Target met

The results show mixed performance across the feeder categories. Entura is satisfied that appropriate actions are planned to improve any unsatisfactory aspects of this performance.

The results are shown graphically in Figure 34.

39 Target standards for a regulatory control period are submitted by PWC Power Services to the Commission for approval in accordance with the EIP Code, except for the 'whole of network' target, which is a derived target and not required to be approved by the Commission. The EIP Code states a network entity must use its best endeavours to meet the target standards.

40 Actual performance 4.005, rounded to 4.0.

41 Actual performance 0.081, rounded to 0.1.

Figure 34: Feeder performance by feeder type

The Figure 34 shows that generally the SAIFI and SAIDI targets are met for the rural long and urban feeders, however, in 2020-21 the SAIFI and SAIDI targets were not met for rural long feeders. The CBD performance has varied across the last seven years, with 2020-21 SAIDI marginally under target. The rural short feeder performance has improved with both SAIDI and SAIFI targets met for the first time in seven years.

A range of actions are being undertaken across the three rural long feeders to address the performance shortfall, which did not meet the target approved by the Commission. These actions include installation of animal (bat) guards on feeders.

These actions are in line with the EIP Code best endeavors approach to these targets. However, failure to meet these targets on an ongoing basis will draw closer inspection by the Commission.

In addition to reporting on feeder category performance, PWC Power Services is required to report on the five worst performing feeders at the Territory level for each feeder category for the reporting period based on a feeder's SAIDI performance, as per the EIP Code. In previous years, PWC Power Services has determined the worst performing feeders for each category by using what it calls SAIDI contribution, which is the contribution each feeder made to the relevant feeder category SAIDI (shown in Table 22). However, PWC Power Services revised its methodology in 2020-21 to align with the EIP Code requirements.

Due to the change in methodology, historical comparisons are not possible, which is important for identifying performance issues. The Commission is concerned with feeders that have performed poorly over a number of years, rather than in one particular year, which may be a result of an isolated issue or event, rather than systemic issues or being overlooked by PWC Power Services. Accordingly, in future reviews the Commission will concentrate on identifying feeders that have performed poorly and are above the relevant feeder category SAIDI target standard for successive years.

Of the top five worst performing feeders reported by PWC Power Services in 2020-21, those above the Commission's feeder category target standard in each feeder category are shown in Table 23.

Table 23: Worst-performing distribution feeders

CBD		Urban		Rural short		Rural long	
Feeder name	SAIDI	Feeder name	SAIDI	Feeder name	SAIDI	Feeder name	SAIDI
11MS04 PEEL	50.5	11BE04 MCMILLANS	1 066.2	22BR102 BOREFIELDS	6 293.9	22SY04 DUNDEE	1 980.3
		11RG02 GOLF	688.0	22TC09 WARREGO	2 294.5	22TC01 ALI CURUNG	1 875.2
		11BE03 TDZ	559.0	22HD403 MIDDLE POINT	716.2		
		11WN24 PARAP	309.2	11PA25 PINELANDS	616.1		
		11WN22 LUDMILLA	243.8	22WD102 WICKHAM	613.6		

One CBD feeder (11MS04 PEEL) was above the CBD category SAIDI target standard of 4 minutes, however PWC Power Services advised that this was due to an isolated event. All five of the worst performing urban feeders were above the urban category SAIDI target standard of 140 minutes, and while three feeders were at least four times above this level in 2020-21, Entura considers where relevant, appropriate actions have been completed by PWC Power Services or are underway.

All five of the worst performing rural short feeders were above the rural short category SAIDI target standard of 190 minutes, and notably the 22BR102 BOREFIELDS and 22TC09 WARREGO feeders were 33 and 12 times higher during 2020-21, respectively. In relation to the 22BR102 BOREFIELDS feeder, PWC Power Services reported the poor SAIDI performance was a result of asset failures and transient events, with improvement activities planned for 2022-23, which include installing additional fuse savers to reduce the impact of transient events, and installing animal protection along the backbone of the feeder. The poor performance of the 22TC09 WARREGO feeder was caused by an equipment failure and other unknown non-weather-related outages. PWC Power Services advised that the regulated area of this feeder serves one customer, which has the capability to use onsite backup generation during interruptions and, given the length of the feeder, the level of investment required to improve performance is not justifiable.

Two of the three rural long feeders in the power systems covered by this review performed worse than the rural long category SAIDI target standard of 1500 minutes in 2020-21, being the 22SY04 DUNDEE and 22TC01 ALI CURUNG feeders. PWC Power Services advised that the majority of the SAIDI on the 22SY04 DUNDEE feeder was driven by animals, with some contribution from equipment failures and weather-related events. In relation to improving the performance of the feeder, during 2021-22 planned activities, include installing remote-controlled switches to enable faster restoration of supply after an outage and additional animal protection in areas not already addressed during 2020-21. In relation to the 22TC01 ALI CURUNG feeder, PWC Power Services advised that the poor performance was due to unknown non-weather-related factors, which are typically animal related. Activities planned for 2021-22 to improve performance of the feeder include installing re-closers in two locations, and animal guards and improved animal protection on problem poles.

Further, PWC Power Services notes in its EIP Code reporting that due to the length of rural feeders, it is challenging to identify specific areas to target for upgrades. Animals and weather-related interruptions can affect different parts of the feeder from year to year, however recently installed diagnostics now reveal locations of the highest contribution to unreliability, which can then be targeted, resulting in more efficient and effective mitigation.

Guaranteed service level payments

PWC make payments to customers where it does not meet guaranteed service levels (GSL) as set out in the EIP Code. These payments are shown in Table 25.

Table 25: Guaranteed service level payments

		2017-18[42]		2018-19		2019-20		2020-21	
GSL measure	Performance indicator	Total	Amount $	Total	Amount $	Total	Amount $	Total	Amount $
Duration of a single interruption	Between 12 and 20 hours	139	11 120	5	400	65	5 850	4	370
	More than 20 hours	0	0	1	125	4	565	0	0
Frequency of interruptions	> 12 interruptions in a financial year	1 225	98 000	2 734	218 720	3 988	358 920	1 594	147 445
Cumulative duration of interruptions	> 20 hours in a financial year	578	72 250	633	79 125	1 068	150 588	762	110 109
Time for establishing a connection	Reconnection > 24 hours[43]	17	1 700	12	2 900	13	2 278	5	745
	New connection > 5 business days[44]	27	5 400	2	250	5	1 278	20	4 600
Time for giving notice of planned interruptions	< 2 business days	472	23 600	159	7 950	178	10 005	18	1 035
Keeping appointments	> 30 minutes outside agreed time[45]	1	20	0	0	0	0	0	0
Total payments			**212 090**		**309 470**		**529 484**		**264 304**

The bulk of the GSL payments are due to the frequency of interruptions and cumulative duration of interruptions (about 97% in 2020-21). The frequency of these payments has decreased during 2020-21, which is likely a result of the feeder improvement works carried out by PWC Power Services, such as introducing distribution fault anticipation technology, animal protection and increased targeted vegetation management.

Entura is satisfied that PWC Power Services appears to be changing asset management approaches to improve the customer experience.

42 Start of new regulatory period.
43 Small customers.
44 Excluding connections requiring network extension or augmentation.
45 With small customers.

Phone answering

The EIP Code (section S.3.6.3) requires licensees providing network services in the Darwin-Katherine, Alice Springs and Tennant Creek power systems to report on customer service performance indicators, which includes performance related to telephone answering. Accordingly, as the only licensee providing network services in the relevant power systems, Table 26 shows PWC Power Services' telephone answering performance during business hours over the last three years, at a Territory level. Entura notes that PWC Power Services reports on calls received outside of business hours (after hours), however due to after-hour calls going directly to the control room at PWC System Control and not through a telephone answering system, the level of performance is not able to be measured.

Table 26: Telephone answering performance (business hours)

	2018-19	2019-20	2020-21
Number of calls received	11 344	11 037	5 847
Average waiting time before a call is answered (seconds)	6	6	5 546
Percentage of calls answered within 30 seconds (%)	67	64	79
Percentage of calls abandoned before being answered (%)	8	11	35

Changes in the total number of calls to a network provider may be an indicator of the level of customer satisfaction. The percentage of calls answered within 30 seconds, the average waiting time before a call is answered, and the percentage of calls abandoned before being answered provide an indication of how long a customer has to wait to speak to the network operator, and whether this wait is considered reasonable by a customer. While the Commission considers it is not always reasonable for a customer to expect to speak to an operator within 30 seconds, especially during spikes in call volumes, it is reasonable to expect a customer's call to be answered before the point where a customer feels the need to abandon their attempt to speak to the network operator, potentially leading to issues going unresolved, which may cause distress. Accordingly, the Commission is particularly concerned with the level of performance regarding the percentage of calls being abandoned before being answered.

PWC Power Services reported a large reduction in the total number of calls it received in 2020-21 in comparison with 2019-20, down from 11,037 to 5,847. The level of performance in terms of calls answered within 30 seconds improved in 2020-21 while the percentage of calls abandoned before being answered tripled. The average waiting time before a call is answered substantially increased from 5.9 seconds in 2019-20 to 55 seconds in 2020-21, noting the data provided is only for the second half of 2020-21.

As a useful benchmark, the Australian Energy Regulator (AER) used a traffic light system in its 2020-21 Annual Retail Markets report[47] to allow an at-a-glance overview of retailers' performance in relation to phone answering, with the highest 'green' category assigned to a retailer with 80% or more calls taken within 30 seconds. PWC Power Services' 2020-21 performance regarding calls answered within 30 seconds during business hours of 79% shows improvement, however just misses out on the 'green' category and remains in the middle 'amber' category, which includes retailers that achieved 51 to 79% of calls taken within 30 seconds.

46 Data only reported for the 2021 calendar year due to limitations in the reporting systems.

47 https://www.aer.gov.au/retail-markets/performance-reporting/annual-retail-markets-report-2020-21.

In relation to PWC Power Services' performance of 35% of calls abandoned before being answered during business hours, when compared with the AER's traffic light system, PWC Power Services remains in the lowest 'red' category, which includes retailers that achieve 10% or more of calls abandoned before being answered.

New connections

Table 27 shows the average time taken to provide network access to new subdivisions where minor extensions or augmentation is required.

Table 27: New connections in urban areas to new subdivisions

	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
Total	83	53	60	58	255	279
Average weeks	11.1	10.8	11.45	9.96	3.51	2.4

The average time taken to complete new connections has continued to reduce in 2020-21 compared with the previous five years despite a larger increase in new connections over the same period.

Appendix A: 2018-19 PSPR recommendations

Table 28 summarises Entura's assessment of the status of the recommendations from the 2018-19 NTPSPR, noting the recommendations are those of the Commission and where they do not relate to non-compliance, such with licence conditions or relevant legislation, are not enforceable.

Table 28: Recommendations from the 2018-19 NTPSPR

Recommendation	Comments on observed progress	Overall assessment
1 **Generation and demand change planning:** Detailed planning work is required to understand the operability of the three power systems with increased variable renewable energy penetration. This should include consideration of frequency and voltage control and regulation.	Entura considers some work has begun in relation to the Darwin-Katherine and Alice Springs power systems.	In progress
2 **Balance pro-active and reactive system improvement strategies:** Improved condition monitoring Better visibility of plant limits in real time.	Unplanned outage rates remain changeable across the three regions. Discussions with Territory Generation during consultation suggest a more deliberate approach to reducing single unit faults. Entura considers this may lead to better reliability, however the current trends do not suggest reliability is improving consistently. Entura considers this issue still requires improvement.	In progress
3 **Manage testing and abnormal plant conditions:** Outage protocols including switching sheets, isolations and workspace delineation need greater focus from plant owners to ensure the number of inadvertent trips and faults are minimised.	Incident reports for 2020-21 still show inadvertent switching of equipment often leading to large interruptions for customers. Entura considers this issue still requires improvement.	In progress
4 **Operation of the Katherine/Pine Creek Island:** Accurate and reliable islanding identification and clear and robustly implemented protocols are required.	Entura understands PWC Power Services is undertaking a review of the islanding schemes operating on the Channel Island to Katherine 132 kV transmission line. This will include considering each of the islands that may form once additional generation is connected to the line. Entura considers this work is progressing slowly.	Slow progress
5 **Knowledge of Jenbacher units:** The system black in Alice Springs on 13 October 2019 demonstrated the level of knowledge Territory Generation has of the original equipment manufacturer's controls of the Jenbacher generators is insufficient to ensure correct operation while operating near or at the generators' expected capacity.	There remain difficulties in getting proper support for these units. These difficulties appear to be contractual as well as logistical. The COVID-19 border restrictions hampered efforts to address this issue in 2020 and 2021. Territory Generation is working to overcome these issues in a pragmatic manner, however Entura considers progress to be slow.	In progress
6 **Management of low voltage supply voltages:** The voltage quality statistics for the Darwin-Katherine network, particularly in the Katherine region, show supply voltages are trending towards the high end of the allowable spectrum.	Entura understands PWC Power Services is working to address these issues in the short term, with long-term solutions also being contemplated.	In progress

Appendix B: 2017-18 PSPR recommendations

Table 29 summarises Entura's assessment of the status of recommendations from the 2017-18 NTPSPR, noting the recommendations are those of the Commission and where they do not relate to non-compliance, such with licence conditions or relevant legislation, are not enforceable.

Table 29: Recommendations from the 2017-18 NTPSPR

Recommendation	Comments on observed progress	Overall assessment
1 **Condition monitoring and preventative maintenance** The Commission will seek input from generation licence holders as to an appropriate level of reporting regarding condition monitoring.	The Commission has included consideration of condition monitoring and preventative maintenance reporting by generators in its review of the EIP Code, which commenced on 16 September 2020 with the publication of an Issues Paper. Further, interviews with EDL and Territory Generation reveal that some thought is given to this, however Entura considers little formal effort or reporting is evident.	Closed as also recommended in the 2018-19 NTPSPR
2 **Coordination and cooperation between licence holders** Administrative procedures in terms of coordination and cooperation between licence holders to be developed to ensure better customer outcomes.	Entura considers some progress is evident in regular coordination meetings. However, some improvements in the coordination and agreement around recommendations stemming from incidents reports may be required. Entura is satisfied sufficient progress has been made to allow this action to be marked complete.	Completed in 2019-20
3 **Planning and modelling** Better planning, including modelling of system changes and associated operations, by PWC Power Services in consultation with PWC System Control and licensees.	Entura considers some improvements in modelling approaches are evident, with modelling guidelines being released by PWC Power Services. Further, some proactive work is being done in the Darwin-Katherine power system to use the models to look ahead to changed operation with higher renewable penetration. Entura notes there is a focus on modelling accuracy, and models for the BESS and Jenbacher generating units in the Alice Springs power system are attracting focus due to the criticality of their future roles. Entura considers limited progress has been made on this issue in 2020-21.	In progress
4 **Reporting of causes for single unit trips** The cause of these trips should also be reported to enable better scrutiny of the plant performance.	Entura understands that only an informal process is place in Territory Generation. PWC System Control is now including the generating unit for each trip (and its output at the time of the event) in its bi-annual reports to the Commission.	In progress

continued

Recommendation	Comments on observed progress	Overall assessment
5 Design and commissioning process control and quality assurance Processes to be developed to ensure intra and inter-company interfaces are managed so system operation and robustness is not undermined by implementation being inconsistent with design. These processes must cover primary and secondary electrical systems and the interface between network, generation and system control.	Entura understands PWC Power Services is working on process improvements on a project by project basis.	Completed in 2019-20
6 Tracking of major incident report recommendations A register should be made and coordinated between relevant parties so the recommendations and progress can be tracked.	As a result of implementing recommendations from the Alice Springs system black investigation, a register is now managed by PWC System Control. However, Entura considers an agreement on the incident report recommendations would facilitate a more streamlined approach to completion and clearing this register. While there remain issues around the agreement of report recommendations, Entura considers the processes between licensees are greatly improved.	Completed in 2019-20
7 Risk assessment and management The reduction of risk during outages should be to the extent that is reasonable, not to the extent it is easy or readily achieved. PWC System Control should implement cross-checking of appropriate risk exposure for outages, particularly over-lapping outages.	System incidents in 2018-19 suggested this issue had improved. None of the major system incidents stem from accumulation of risk due to overlapping outages.	Completed in 2019-20
Darwin-Katherine power system		
8 Pine Creek and Katherine island management: Existing protocols are not sufficiently robust to ensure correct operation of this island.	Entura considers there was further evidence in 2018-19 and 2019-20 to support the original recommendation. Entura understands there is a project underway to address this issue, however it is likely to take until 2022 to fully resolve.	Closed as also recommended in the 2018-19 NTPSPR
9 Outage coordination: Coordination of network and generation outages to ensure adequate reliability for customers is maintained	Entura considers the communication of outages and coordination between licensees to be much more effective.	Completed in 2019-20
Alice Springs power system		
10 Managing Ron Goodin power station retirement: Care to be taken to ensure a robust set of operating protocols is developed to allow for safe and secure operation of the Alice Springs network without the support the Ron Goodin power station.	Entura considers this issue remains unresolved with no set deadline for the retirement of the Ron Goodin power station. Discussions with licensees during consultation for the 2020-21 NTPSPR indicate this issue is under consideration, however there are other changes to the region that must also be considered and are taking precedence. Entura considers there has been limited progress on this recommendation during 2020-21.	In progress

Appendix C: Glossary

AER	Australian Energy Regulator
BESS	battery energy storage system
EIP Code	Electricity Industry Performance Code
Customer minutes without supply	Number of minutes customers are without supply, calculated by multiplying the number of customers impacted by the duration of the incident
EDL	EDL NGD (NT) Pty Ltd
EMS	energy management system
GSL	guaranteed service level
GWh	gigawatt hours
kV	kilovolt, 1 kV = 1 thousand volts
major incident	Defined by section 7.3.2 of the System Control Technical Code version 6
minor incident	Defined by section 7.3.3 of the System Control Technical Code version 6
MVA	megavolt ampere
MW	megawatt, 1MW = 1 million watts
NEM	National Electricity Market
NTEOR	Northern Territory Electricity Outlook Report
NTPSPR	Northern Territory Power System Performance Review
N-X	Planning criteria allowing for full supply to be maintained to an area supplied by the installed capacity of N independent supply sources, with X number of those sources out of service (with X usually being the units with the largest installed capacity)
PWC	Power and Water Corporation
PV	photovoltaic
RoCoF	rate of change of frequency
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index
SCTC	System Control Technical Code
SEF	sensitive earth fault
SWIS	South West Interconnected System
TDAPR	Transmission and Distribution Annual Planning Report
UFLS	under frequency load shedding
ZSS	zone substation