UTILITIES COMMISSION
OF THE NORTHERN TERRITORY

Northern Territory Power System Performance Review

2018-19

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Disclaimer

The Northern Territory Power System Performance Review (NTPSPR) is prepared using information sourced from participants of 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 2019. The commission understands the information received to be current as at December 2019.

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. Where possible, to enable comparison with other jurisdictions, the commission has sought to align its reporting of the data with the other Australian jurisdictions. However, there are some differences and any comparisons should only be considered indicative.

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

About this review

Since 2001, the Utilities Commission of the Northern Territory had published an annual Power System Review (PSR) as a single document providing a review of past and current generation, network and retail performance, forecasts of system demand and supply reliability, and an assessment of the adequacy of the fuel supply.

Following publication of the 2016-17 PSR, the commission undertook a stakeholder survey to gauge its usability and usefulness. Accordingly, to improve the commission's annual reporting, the PSR was split into three separate publications, namely:

- Northern Territory Electricity Retail Review
- Northern Territory Electricity Outlook Report (NTEOR)
- Northern Territory Power System Performance Review (NTPSPR, this review).

The NTPSPR focuses on the 2018-19 generation and network performance of the regulated power systems. Where possible, it compares 2018-19 performance to historical data to identify trends.

The review's main purpose is to inform the Minister for Renewables, Energy and Essential Services (as regulatory minister), government, licence holders and stakeholders on the 2018-19 generation and network performance of the Territory's regulated power systems, and highlight any areas of concern.

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

The content of this review was largely produced by Entura on behalf and with the assistance of the Utilities Commission, and with input from licensees (Power and Water Corporation (PWC) Power Services (Power Services), PWC System Control (System Control), EDL NGD (NT) Pty Ltd (EDL) and Territory Generation). The commission supports the analysis, conclusions and recommendations made on its behalf by Entura.

The 2018-19 NTPSPR is prepared in accordance with section 45 of the *Electricity Reform Act 2000*. The review is restricted to the Northern Territory's regulated power systems, namely Darwin-Katherine, Alice Springs and Tennant Creek.

Key findings and recommendations

Overall performance

Overall the review found the performance of the Territory's power systems in 2018-19 to be satisfactory, and in general the standards of service and adequacy of the network and generating units are being maintained. However, performance is inconsistent across the power systems. Alice Springs and Tennant Creek continue to be of concern where, in particular, poor generation performance is leading to low levels of overall system performance.

The 2018-19 period saw continued change in each of the three regions. Tennant Creek and Alice Springs are undergoing a large-scale change in their generation mix with older units being phased out of service. The Darwin-Katherine and Alice Springs regions are seeing increased behind-the-meter solar connections and Darwin-Katherine is preparing to connect its first large-scale solar photovoltaic (PV) power station.

While there are obvious differences across the three regions in terms of scale, network topology and generation mix, there are some common issues. Consistent with the 2017-18 NTPSPR, these common issues again relate to inter-operability of controls, adherence to good electricity industry practices and robustness of design and operation protocols.

Many of the recommendations from the 2017-18 NTPSPR remain in progress. The performance of the power systems in 2018-19 demonstrates that these recommendations remain valid or are not completed to a satisfactory extent. There are notable exceptions including the management of system risk, particularly in the Darwin-Katherine region.

The commission is now explicitly monitoring progress with the 2017-18 and future recommendations made in NTPSPRs. An assessment of progress against the recommendations is included after the individual system performance summaries in this section of the review.

The commission is aware of the recent renewed focus and monitoring of power system performance, and the subsequent system changes, by licensees and government, particularly in the Alice Springs power system, following the Alice Springs system black on 13 October 2019, noting this occurred early in the next reporting period. Further, the commission notes licensees are addressing the deteriorating performance in the Tennant Creek power system following the commission's proactive performance monitoring and identification of issues. Therefore, the commission has endeavoured to limit its focus and, where possible, not highlight or make recommendations in this review in relation to issues the commission considers are already being addressed.

Summary of recommendations

The following recommendations result from the investigations and analysis undertaken as part of the review:

1. Ensure generation and demand changes are planned for with a view to efficiency and robustness

The uptake of variable renewable energy is already showing signs of having significant impact on the Darwin-Katherine and Alice Springs systems. This impact will only increase. The commission is pleased to see some initiatives in this area, however does not think this goes far enough.

The challenge of increased renewable (inverter-based) generation penetration is the displacement of synchronous machines that leads to less system strength both in terms of voltage and frequency resilience. In smaller systems with proportionally large generating units, as is the case in the three Territory-regulated power systems, if renewables are used without other supporting technologies, this can lead to inefficient dispatch of synchronous generating units in order to maintain voltage and frequency stability.

The commission considers that additional planning is required in coordination between the relevant stakeholders, such as government, System Control and Power Services, to better understand how the systems will be operated with increased variable renewable energy penetration and the impact this will have on the robustness and efficiency of power generation and transmission. This should include consideration of frequency and voltage control and regulation.

2. Balance proactive and reactive system improvement strategies

Further to the previous recommendation, the commission observes that while it now appears licensees are starting to place sufficient emphasis on the outcomes of system incidents following increased scrutiny from the commission and the Alice Springs system black investigation, there are additional actions that could be taken to prevent incidents occurring in the first place. A raft of good electricity industry practices should be adopted with more formal auditing. These practices could include:

- Improved condition monitoring and preventative maintenance practices – generator performance data indicates an inconsistency in managing generating units, which is having an impact on their usefulness in ensuring supply adequacy. While there remains significant margin for generator-forced outages within the requirements of peak demand, the unreliability and increased system risk from high forced outage rates will affect the efficiency of supply and customer experience. Entura considers inspection and condition monitoring in accordance with good electricity industry practice can be useful in predicting failure of large electrical machines. The future reduction of the number of synchronous machines dispatched at any one time due to increased renewable penetration will place greater onus on individual unit's reliability.
- Better visibility and knowledge of plant limits, in particular where these plant limits vary – ambient conditions have always caused variations in the peak capacity of generating units in the three power systems. These variations have been shown to reduce System Control's ability to ensure the Secure System Guidelines can be met. Further work must be undertaken between the generators and System Control to ensure real time capacities are understood and communicated.

The Territory's power systems will become more heavily reliant on a diverse set of generating unit controls as the variable renewable energy penetration increases. Generation and system controllers must have greater confidence in their controls and ability to dispatch than they do now.

3. Manage testing and abnormal plant conditions

Several incidents across multiple regions involved commissioning or testing errors, often by third-party contractors. Power stations are complex environments and as such, contractors and testing personnel require specialised training or supervision while working around live equipment. There is evidence to suggest this is not well managed at present. The commission recommends that generation licensees review their commissioning and testing procedures and training to ensure the number of inadvertent trips and faults are minimised. The review should consider, among others, outage protocols including switching sheets, isolations and workspace delineation.

4. Review and improve the operation of the Katherine/Pine Creek island

The long, single-circuit 132 kilovolt (kV) transmission line from Darwin to Katherine is prone to faults, mostly due to storm activity. These faults lead to a disconnection along the line and an island forming at the remote end that includes Pine Creek and Katherine.

Entura has observed a number of incidents that show human and electronic communications paths are not effectively managing the operation of the Katherine/Pine Creek island under all circumstances. Entura surmises this is mostly due to ineffective supervisory control and data acquisition (SCADA) signalling and recommend the operation and control of this island is investigated thoroughly in terms of fitness for purpose. Specifically, while it is understood there has already been work and changes made in this area in the last two years, Entura is not convinced that even if the existing systems worked as intended, there is enough redundancy in the controls to ensure correct operation.

5. Ensure learnings from the Owen Springs Jenbacher project are embedded in the Tennant Creek Jenbacher project

The recent system black in Alice Springs[1] demonstrated that the level of knowledge Territory Generation has of the original equipment manufacturer (OEM) controls of the Jenbacher generators is insufficient to be able to assure correct operation while operating near or at the generators' expected capacity. While this appears to be mainly due to contractual difficulties between Territory Generation and the OEM or its Australian agent, there are unacceptable impacts. The commission recommends incorporating improvements in this knowledge and changes to the control settings in Tennant Creek, where appropriate.

6. Management of low voltage supply voltages in Darwin-Katherine

The voltage quality data for Darwin-Katherine, particularly in Katherine, shows supply voltages are trending towards the high end of the allowable spectrum. This should be addressed now and proactively managed into the future. There is likely to be a need for constant adjustment across the distribution networks as behind-the-meter solar PV installations increase. It is a positive that PWC is making use of existing metering resources to gain an insight into this issue and expects to see progress in this area.

1 The Alice Springs system black on the 13 October 2019 is outside the scope of this review, however at the time of writing the 2018-19 NTPSPR, the investigation into the incident had been finalised. Therefore this review references the incident and subsequent investigation findings in various locations, albeit in limited detail.

Darwin-Katherine

A review of 2018-19 generation and network performance in the Darwin-Katherine power system found satisfactory performance. While the performance trend is flat or improving, there are warning signs that indicate significant issues, which must be addressed to maintain or improve performance into the future. Table i summarises performance highlights and issues or concerns.

Detail on the performance of the Darwin-Katherine power system in 2018-19, including comparisons to historical data, comprehensive discussion in relation to the identified issues and concerns, and highlights is provided in Chapter 1 of this review.

Customers were without power for	Customers were impacted by
115 minutes	**1.16** interruptions
↓ 79 minutes	↓ 0.39 interruptions

Table i: Generation and network performance in the Darwin-Katherine power system in 2018-19

	Performance	Trend	Issue/concern	Highlights
Generation	Satisfactory	Flat	• Generator trips that do not lead to under frequency load shedding (UFLS) may not be fully investigated and subsequent code breaches identified, noting a number of generating units are subject to grandfathering arrangements • Single unit reliability • Over-reliance on Channel Island • Advanced age of generation fleet • System Control IT systems are not adequate for the connection of new large-scale solar PV power stations • Single generator trip UFLS incidents occurring where spinning reserve margins are outside of guidelines • Katherine/Pine Creek island operation is not robust • Testing and abnormal plant condition management	• Shorter less frequent incidents affecting customers • Channel Island reliability • Strong reporting culture for non-reliable notices • No Darwin-Katherine system blacks • Constraints increasing customer reliability • Control room visibility of behind-the-meter generation improved • Management procedures and reporting is improved in relation to overlapping outages and system risk
Network	Satisfactory	Improving	• Transmission interruptions cascaded to generation • Katherine frequency of incidents high • Katherine voltage regulation is not managing over-voltages • Network limitations resulting in constrained generation	• Darwin frequency of distribution incidents low • Network adequacy managed well • Operational protocols for the connection of large-scale solar PV power stations • Improvements in outage coordination

Alice Springs

A review of 2018-19 generation and network performance in the Alice Springs power system found network performance is satisfactory, however the generating units are not performing adequately, as summarised in Table ii.

Entura expected that once the commissioning of Territory Generation's new Jenbacher generators at the Owen Springs power station was complete and the project 'bedded down', the performance of the generators and system as a whole would improve. However, even though the project is now complete, Entura is still seeing performance issues relating to these generators. The system black of 13 October 2019 (three months into the next reporting period) further highlighted the critical importance of the Owen Springs generators and in particular the Jenbacher generators.

Detail on the performance of the Alice Springs power system in 2018 19, including comparisons to historical data, comprehensive discussion in relation to the identified issues and concerns, and highlights is provided in Chapter 2 of this review.

Customers were without power for	Customers were impacted by
223 **minutes** ↓ 347 minutes	**1.53** **interruptions** ↓ 1.92 interruptions

Table ii: Generation and network performance in the Alice Springs power system in 2018-19

	Performance	Trend	Issue/concern	Highlights
Generation	Poor	Flat	• Robustness of generating plant • Reliability and availability of Owen Springs is not improving • Testing and abnormal plant condition management • Uterne fault ride through and anti-islanding • Visibility of real time plant capability	• Reduced customer impact from generation incidents • Better spinning reserve approach by System Control, through risk notifications
Network	Satisfactory	Flat	• Operational flexibility to ensure reliability of supply to Lovegrove from Owen Springs • Change in generation focus needs to be addressed through operational planning • Distribution network faults leading to loss of generation and UFLS operation	• Visibility of network issues and appropriate action to maintain security • Four years with no major incidents caused by the transmission network • All feeder types within system average interruption duration index global target • Planned upgrades appear to be well timed

Tennant Creek

A review of 2018-19 generation and network performance in the Tennant Creek power system found neither generation nor the network is performing adequately, as summarised in Table iii.

Prior to writing the 2018-19 NTPSPR, through the monitoring of incidents and System Control biannual reports, the commission identified a deterioration in the performance of the Tennant Creek power system during 2018-19. The commission wrote to PWC and Territory Generation on 30 September 2019 to highlight its concerns and requested a response to explain the poor performance in the system from their perspective, along with advice on how the two licensees may address the issues to improve the level of service to customers. This matter is discussed further in Chapter 3 of this review.

Detail on the performance of the Tennant Creek power system in 2018-19, 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.

Customers were without power for	Customers were impacted by
587 minutes	**10.82** interruptions
↑ 224 minutes	↑ 6.82 interruptions

Table iii: Generation and network performance in the Tennant Creek power system in 2018-19

	Performance	Trend	Issue/concern	Highlights
Generation	Poor	Deteriorating	• High number of generation incidents that take longer to recover from • Testing and abnormal plant condition management • Communications protocol between System Control operators and Territory Generation station operators needs to be improved • Too many network incidents lead to generation incidents and UFLS operation	• Low level of unplanned outage and high availability
Network	Poor	Flat	• Large increase in incident duration • Too many network incidents lead to generation incidents and UFLS operation	• Less frequent incidents leading to load-shedding • Completion of SCADA upgrade

Review of progress on previous recommendations

The following summarises the status of the recommendations from the 2017-18 NTPSPR.

	Page no.	Comments on observed progress	Overall assessment
General recommendations from 2017-18 NTPSPR			
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.	iv, 12	The commission intends to complete this recommendation as part of a review of the Electricity Industry Performance Code (EIP Code), which is scheduled to commence in 2020. As part of the review, the commission will seek feedback from stakeholders. Through interviews with EDL and Territory Generation, it was indicated condition monitoring and preventative maintenance is managed internally by licensees.	Not started
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.	iv	Some progress is evident with regular coordination meetings. Some improvements in the coordination and agreement regarding recommendations stemming from incident reports may be required.	Partially complete
3 **Planning and modelling** Better planning, including modelling of system changes and associated operations, by Power Services in consultation with System Control and licensees.	iv	PowerFactory models are under development by System Control and Power Services in coordination with licensees to improve system modelling capacity. However, this recommendation will continue to be monitored in future reviews to determine whether it is resulting in better planning outcomes. While the Alice Springs system black occurred three months into the next reporting period, the response to the incident will be monitored as it may provide a useful insight into the progress with this recommendation in relation to the planning and modelling of system changes.	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.	9	System Control is now including the generating unit, loading and a brief description of the cause for each trip in the biannual reports. However, while Territory Generation has a process in place, it has stated not all causes of single unit trips are fully investigated.	In progress

continued

	Page no.	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.	18	Power Services is working on process improvements on a project by project basis.	In progress
6 **Tracking of major incident report recommendations** A register should be made and coordinated between relevant parties so recommendations and progress can be tracked.	25	As a result of implementing recommendations from the Alice Springs system black investigation (which occurred early in 2019-20), a register is now managed by System Control. However, agreement on the incident report recommendations would facilitate a more streamlined approach to completion and clearing this register.	Partially complete
7 **Risk assessment and management** The reduction of risk during outages should be to a reasonable extent rather than to the extent that is easy or readily achieved. The System Controller should implement cross-checking of appropriate risk exposure for outages, particularly overlapping outages.	28	System incidents suggest this has improved across 2018-19. None of the major system incidents stem from accumulation of risk due to overlapping outages.	Complete
Darwin-Katherine region (2017-18)			
8 **Pine Creek and Katherine island management** Existing protocols are not sufficiently robust to ensure correct operation of this island.	26	Further evidence in 2018-19 to support the original recommendation.	In progress
9 **Outage coordination** Coordination of network and generation outages to ensure adequate reliability for customers is maintained.	28	EDL notes that while it is provided some notification of network outages from PWC, there is little coordination of network and generation outages, and suggests annual forecasts, generator outage testing requests and return to service forms submitted to PWC be used as the basis for coordination.	In progress

continued

	Page no.	Comments on observed progress	Overall assessment
Alice Springs region (2017-18)			
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.	43	Ongoing Owen Springs generation issues are delaying the Ron Goodin power station retirement. Implementing recommendations following the system black investigation in 2019-20 will provide greater focus.	In progress
Tennant Creek region (2017-18)			
NIL			

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1 | Darwin-Katherine power system

This chapter focuses on the 2018-19 generation and network performance of the Darwin-Katherine power system. Where possible it compares 2018-19 performance to historical data to identify trends. Specifically this chapter considers:

- overall customer impact
- generator performance, observed UFLS and single generator trips, generation availability, non-reliable periods, major generation incidents, generation constraints, and generation planned and recent enhancements
- network performance, network utilisation, network adequacy, major network incidents, network constraints, network power quality notifications, quality of service complaints, and network planned and recent enhancements.

Power system description

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

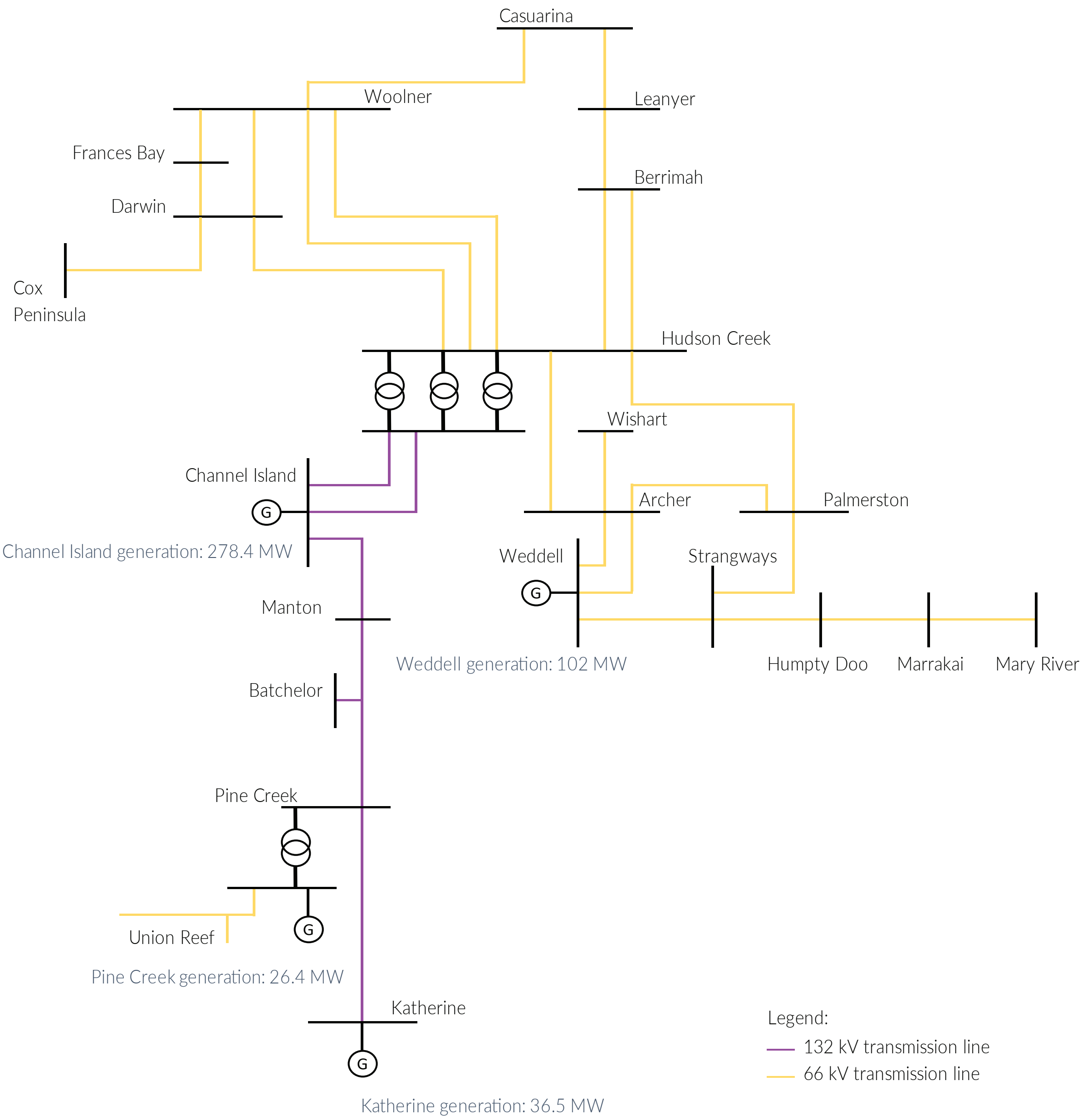
The energy sent out by grid-connected generators in 2018-19 is shown in the Table 1.

Table 1: Darwin-Katherine energy sent out in 2018-19

Power system	Energy sent out (GWh)
Darwin-Katherine	1 573

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

Figure 1: Darwin-Katherine power system[2]



2 Generation capacities relate to non-summer (dry season).

Overall customer impact

This section shows the overall performance for the Darwin-Katherine region.

Table 2 shows the effect on customers from major and minor incidents in the Darwin-Katherine region across the last three years.

The number of customers impacted and total duration (minutes) of an incident is reported by System Control to the commission as part of its System Control Technical Code (SCTC) obligations. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as System Average Interruption Distribution Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 2: Overall customer impact from major and minor incidents in the Darwin-Katherine region

		2016-17	2017-18[3]	2018-19
Darwin-Katherine	Number of incidents	78	71	61
	Customers impacted	131 976	111 368	81 105
	Total duration (minutes)	10 853	10 939	8 823
	SAIDI	169.3	194.3	115.0
	SAIFI	1.95	1.55	1.16
	Reliability (% of year)	0.032	0.037	0.022
	System blacks			
	Region wide	0	0	0
	Katherine island blacks[4]	7	7	3
Darwin	Number of incidents	68	61	51
	Customers impacted	106 876	83 523	62 335
	Total duration (minutes)	10 269	9 933	7 548
	SAIDI	156.9	178.2	108.6
	SAIFI	1.68	1.24	0.95
	Reliability (% of year)	0.030	0.034	0.021
Katherine	Number of incidents	10	10	10
	Customers impacted	25 100	27 845	18 770
	Total duration (minutes)	584	1 006	1 275
	SAIDI	360.2	442.9	210.3
	SAIFI	6.07	6.35	4.25
	Reliability (% of year)	0.069	0.084	0.040

3 Excluding Tropical Cyclone Marcus.

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

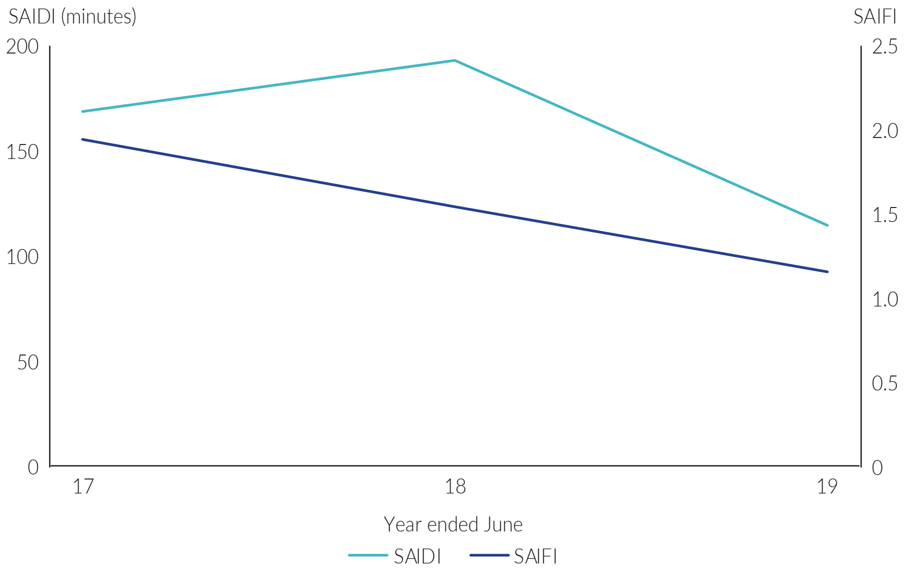
SAIDI is a measure in minutes of the average duration of an incident weighted by the number of customers affected by each incident. That is, if 10 customers suffer a 10-minute interruption but there are 100 customers in the region in total then this would lead to a SAIDI of 1 minute. Multiple incident 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 events 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 incident.

Reliability (percentage of year) is calculated based on SAIDI and is the percentage of a year the average duration of incidents per customer represents. This varies from the reliability standard[5] for generation of 0.002 per cent applied in the National Electricity Market (NEM), which is also adopted by the commission in its NTEOR reliability assessments in the absence of a formal Territory target.

SAIDI and SAIFI for the combined Darwin-Katherine region are shown in Figure 2. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, SAIDI and SAIFI indicators derived from the number of customers impacted and total duration (minutes) of an incident may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Figure 2: Overall SAIDI and SAIFI performance, Darwin-Katherine region[6]



The last three years have seen a decrease in SAIFI, while SAIDI increased in 2017-18 before a significant decrease in 2018-19. This is a positive result for the overall Darwin-Katherine system.

However, the incidents noted in the following sections and Entura's analysis as to the causes of these incidents suggest a deterioration in the performance in Katherine and a lower level of performance in general compared to Darwin, even though the overall Darwin-Katherine performance is improving. The commission notes that licensees have undertaken work in the last two years in an attempt to resolve the issues at the Katherine end of the power system.

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

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

Generation

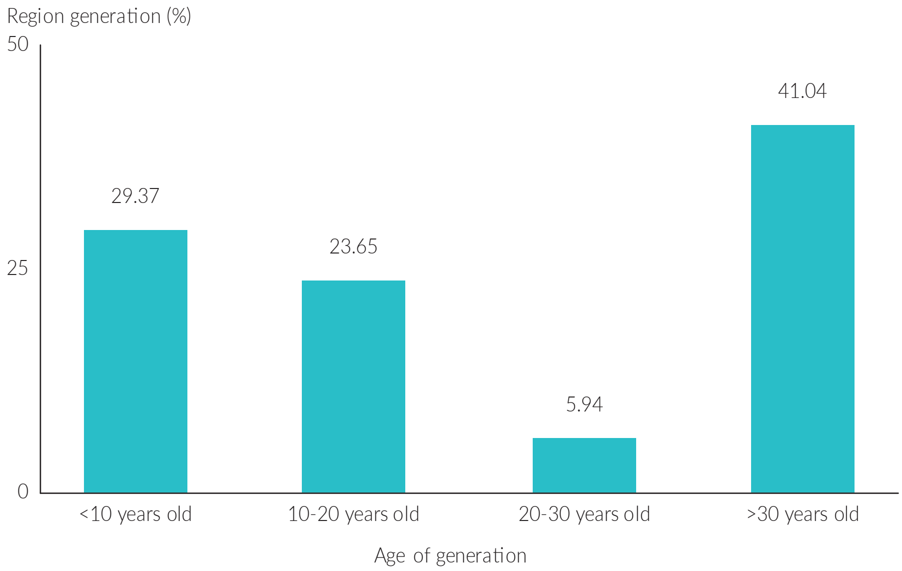
The total non-summer (dry season) grid connected in front of the meter generation capacity in the system is over 444 megawatts (MW)[7]. This does not include behind-the-meter rooftop solar PV generation capacity, which totalled around 59 MW in 2018-19. The fuel type of the generation units is made up of dual fuel (gas/diesel), gas only, heat recovery steam and landfill gas.

Table 3: Maximum non-summer (dry season) grid connected in front of the meter generation capacity in Darwin-Katherine in 2018-19[8]

	(MW)
Channel Island	278.4
Weddell	102
Katherine	36.5
Pine Creek	26.4
Shoal Bay landfill	1.1
Total generation	**444.4**

Figure 3 shows around 41 per cent of Darwin-Katherine power system generation capacity is more than 30 years old.

Figure 3: Age of generators in Darwin-Katherine by percentage of maximum generation capacity[9]



Generation capacity as a percentage of total capacity that is over 30 years old has reduced from 2017-18, however this is not because of new generation being commissioned. It is due to Channel Island unit 3 being removed from service, which was greater than 30 years old.

7 Generation capacity relates to non-summer (dry season) grid connected in front of the meter generation capacities.
8 Generation capacities relate to non-summer (dry season) capacities.
9 Generation capacity relates to non-summer (dry season) grid connected in front of the meter generation capacities.

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.

Generator performance

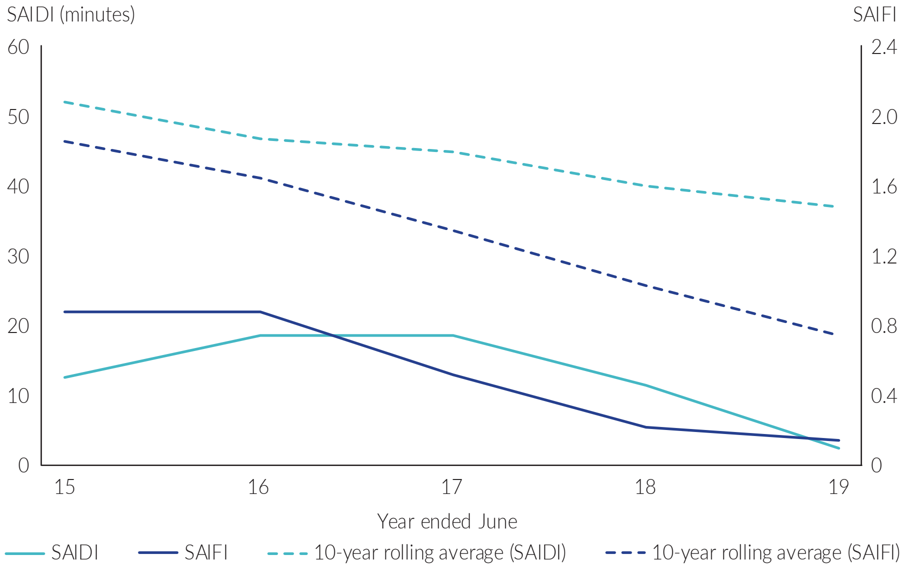
The EIP Code does not set targets for generation SAIDI and SAIFI performance indicators. Historical performance is used to provide commentary on generator performance in 2018-19.

While both Territory Generation and EDL have provided a report in accordance with the EIP Code, EDL's report states that System Control did not notify EDL of generation interruption incidents associated with its Pine Creek power station for the 2018-19 period. Consequently, EDL's SAIDI and SAIFI are assessed as zero, and therefore do not feature in the subsequent generator performance analysis of this chapter.

Darwin region

The generation performance level for the Darwin region is shown using the SAIDI and SAIFI (see Figure 4).

Figure 4: SAIDI and SAIFI performance for generation, Darwin



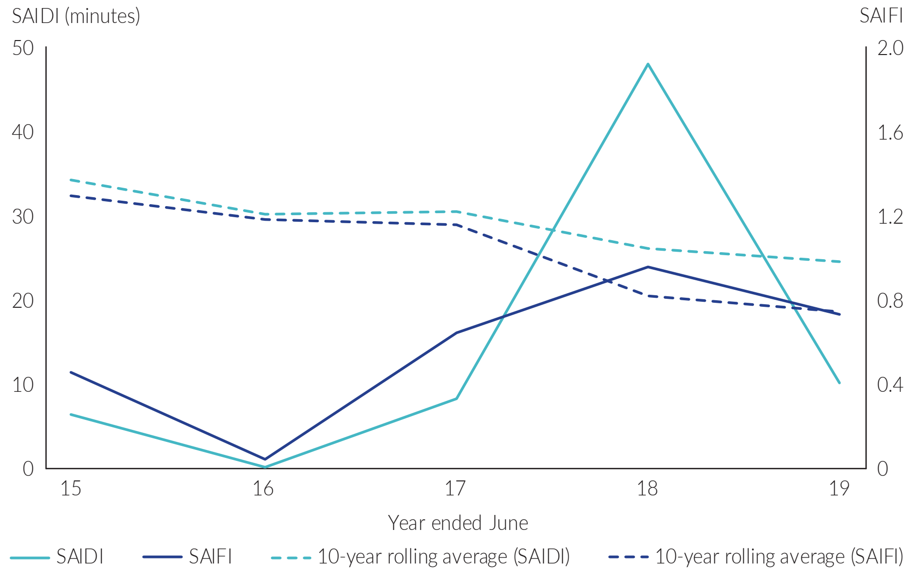
The trend for these indices continues to improve, with generator performance improving year on year since 2016-17, and is performing well relative to the 10-year average. Most of this improvement can be attributed to the reduction in customer interruptions due to single unit trips, which has been achieved in part by changes to spinning reserve. Therefore, while the robustness of the units themselves is not improving, the impact of that robustness, or lack thereof, is not being felt by customers. However, there remains a high number of single unit trips, which is discussed in the following section.

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 such that the loss of a single unit does not lead to load shedding. It is positive that both of these indices are trending towards zero, however there are still a small number of avoidable reliability issues that are limiting performance from improving further.

Katherine region

SAIDI and SAIFI are compiled for the generating units in the Katherine region separately with these results shown in Figure 5.

Figure 5: SAIDI and SAIFI performance for generation, Katherine



SAIDI shows an improvement from the previous period and even though it remains the second worst result across the last five years, it is below the 10-year average. This demonstrates an ability for the power system operators to more quickly respond to unplanned generation outages, which reduces the duration of generation related interruptions. Power system operators may achieve this by implementing measures, such as increasing spinning reserve and applying constraints at periods of heightened risk, however this may increase costs, particularly Territory Generation's costs.

SAIFI has returned to the 10-year average with a slightly improved result from the previous year.

Entura notes the region has recorded zero against both indices in previous years. However, this level of performance in a small subregion, such as the Katherine region, may skew the 10-year average and does not necessarily represent a fair benchmark.

For SAIDI, based on the five years of data, it appears that a value of around 10 would be an appropriate benchmark. The Katherine region generating units met this nine times over the previous 20 years.

For SAIFI, a value of between 0.75 and 1 appears to be the right level with the region meeting that standard in 11 of the last 20 years.

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

In Entura's opinion, 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.

Therefore on balance, in Entura's opinion, 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 being undertaken by System Control in incident reports is adequate for this purpose.

The reporting requirements within the schedules of the EIP Code, including the reporting of SAIDI and SAIFI, will be considered by the commission as part of a future review of the EIP Code.

Observed UFLS and single generator trips

The commission's reviews in relation to power system performance have 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 have in managing these incidents without loss of load, due to the large relative size of the generating units.

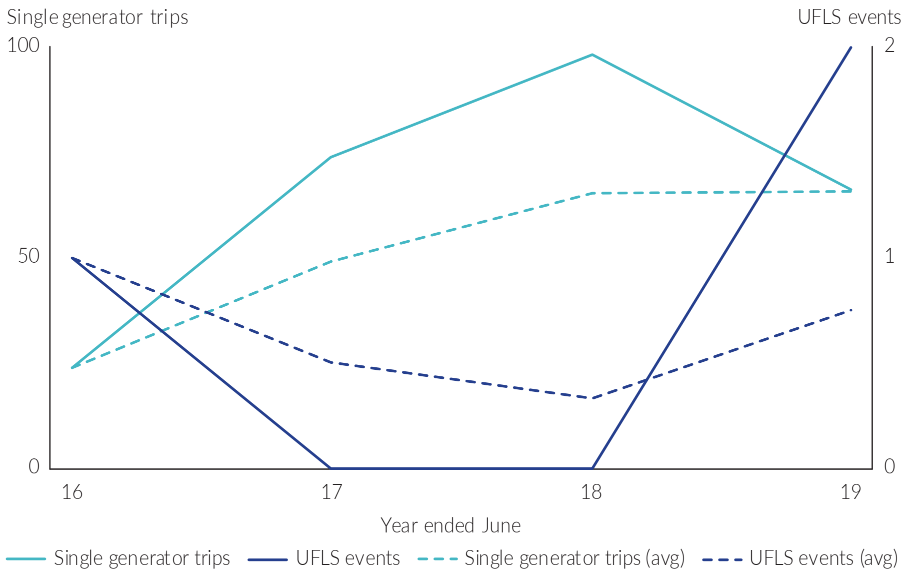
Until recently, the Darwin-Katherine network was dispatched in such a way as to require UFLS to arrest frequency fall for most large single generating unit incidents. This practice was ended in an attempt to improve system performance. Since that time the power system has seen a steady increase in single unit trips but a stark reduction in coincident UFLS incidents. In fact there have only been three such incidents across the last four years, which indicates a significant improvement in the effectiveness of managing these incidents.

However, the commission notes this improvement has been achieved in part through System Control changes to spinning reserve, which may increase costs, particularly for Territory Generation. Further, given there is no competitive process for the provision of spinning reserve, or ancillary services more broadly, there is little incentive for the associated increased costs to be minimised.

System Control's biannual reports[10] show the rise in unit trips as summarised in Figure 6.

10 As required by the System Control Technical Code.

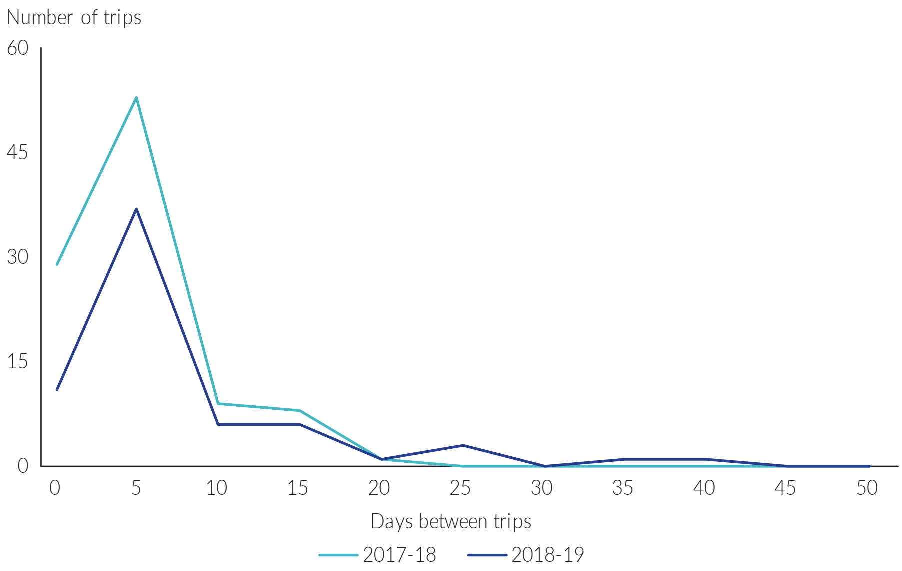
Figure 6: Darwin-Katherine single generator trips versus UFLS (due to single generator trips)



In 2018-19, the number of single unit trips decreased, however there were two UFLS incidents. Entura considers this a disappointing result given the previous two years had seen no such instances. As Entura has observed in previous reviews, the number of single unit trips may represent an unacceptable lack of robustness in the generation fleet.

System Control also provide statistics relating to the time between single unit trips. These are shown in Figure 7.

Figure 7: Time between single unit trips in Darwin-Katherine



A reduction in trips is evident relative to the previous period. This reduction lowers the height of the graph for the current period, however the overall trend remains similar. It is unsurprising when there are more than 60 generator trips in a year, the mode interval is around one week. Based on these results, little has changed with respect to generating unit robustness. This is further demonstrated by the forced outage factor results discussed in the following section.

While generator trips are not exclusive to Territory Generation, with a significant number of generator trips occurring at EDL's Pine Creek power station in 2018-19, it provides some explanation as to why there continues to be a high level of single unit trips with its generators. Its hypothesis is the number of units within the system, coupled with low levels of redundancy in the systems that support these units, leads to the high level of unit trips. Territory Generation advises it is doing some work to prevent or detect possible failures before they lead to a loss of generation.

Entura finds this hypothesis to be plausible, however would think that where plant design leads to low levels of redundancy, these design issues might be investigated to see if alternative arrangements can be made to reasonably increase redundancy, while balancing improvements against any increased costs.

As per recommendation 4 of the 2017-18 NTPSPR, which is included in the Key findings and recommendations section of this review, the commission recommends reporting the causes of these trips to determine if there are trends and possible remedial actions. System Control's biannual reports now include the unit, loading and a brief description of the cause for each trip, however not all causes are fully investigated according to Territory Generation.

Generation availability

A number of indices are calculated as per the EIP Code for generating units to reflect their availability. The factors discussed in the following sections are:

- availability factor (full and unplanned) – the availability factor represents the percentage of time a unit is available to generate. The unplanned availability factor is the percentage of time the unit is available other than for forced outages. The difference between these two indices is the planned outages and de-rating effect
- forced outage factor – the forced outage factor is the percentage of time the unit is not available for dispatch due to an issue with the generator, such as an internal fault. This includes time taken to repair the unit if it is damaged or a component requires replacement or refurbishment due to an incident that is unplanned.

The measures provide some insight into the availability of the generating units and allow an assessment to be made as to the security of supply.

Availability factor

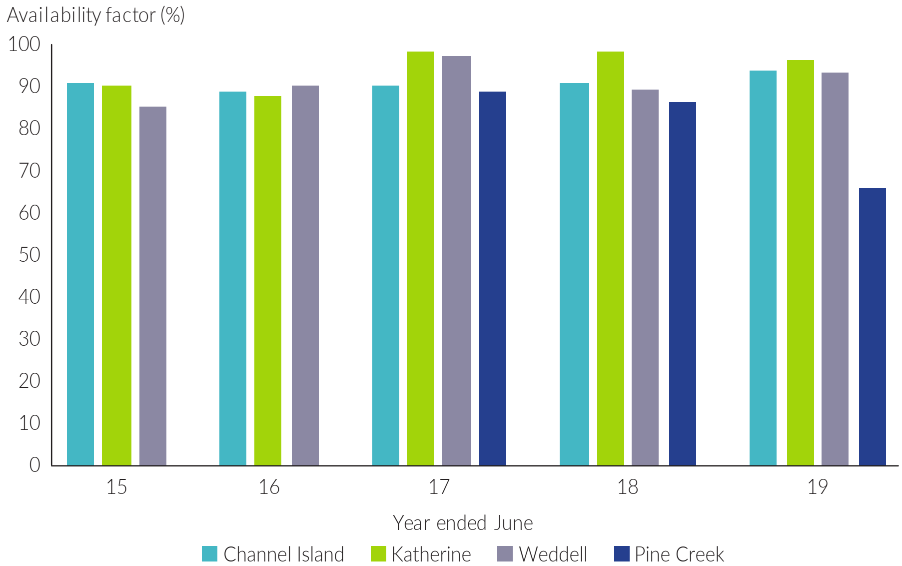
The overall availability of the generators recovered to around 2016-17 levels in 2018-19. Figure 8 shows a three-year period with strong performance relative to the 10-year trend.

Figure 8: Capacity weighted average availability factor for Darwin-Katherine generating units

The overall availability and unplanned availability track within a 2 per cent band. The stable performance of Channel Island, the largest power station, and stronger performance from the Weddell power station limits the effect of poor performance from the smaller power stations (notably Pine Creek) on the overall result (see Figure 9).

Figure 9 shows the availability factor for the individual Darwin-Katherine power stations.

Figure 9: Availability Factor for Darwin-Katherine power stations[11]



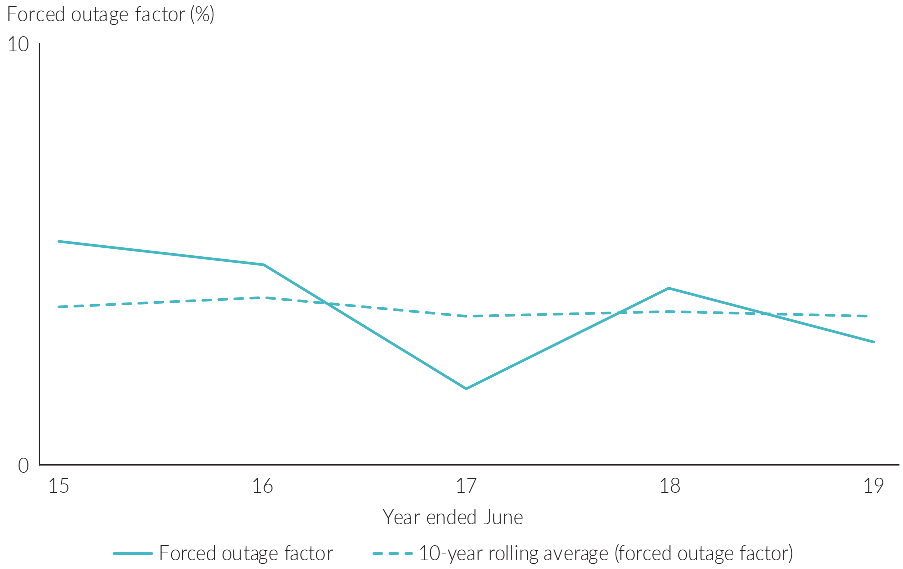
The low availability factor of the Pine Creek power station units has impacted the overall availability factor of the system. Discussions with EDL highlighted an extensive maintenance effort over the period including stator rewinds and boiler repairs, which should improve its reliability from 2019-20. These repairs have affected the forced outage factor for the Pine Creek power station as shown in the following section, noting the trends for the remaining generating units appear to be positive.

11 No data is available for EDL's Pine Creek power station prior to 2016-17, as EDL were granted a generation licence at the end of 2015-16.

Forced outage factor

The forced outage factor has reduced in 2018-19 (see Figure 10).

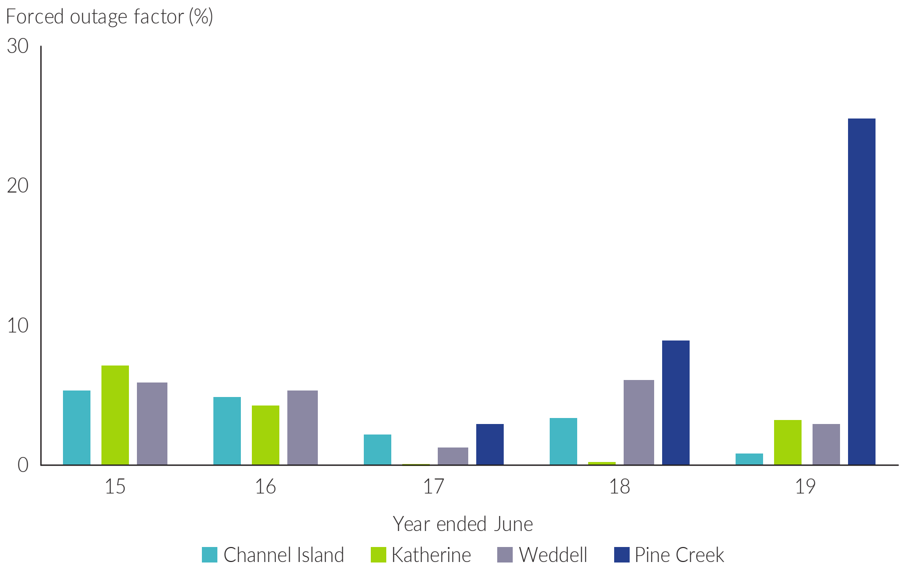
Figure 10: Capacity weighted average forced outage factor for Darwin-Katherine generating units



The current performance is better than 2017-18 and slightly better than the 10-year average. Improvements in both Channel Island and Weddell power station performance in this regard lead to a better overall result, notwithstanding the atypical performance of the Pine Creek power station as discussed above.

Figure 11 shows the forced outage factor for the four main power stations in the Darwin-Katherine region.

Figure 11: Forced outage factor for Darwin-Katherine power stations[12]



12 No data for EDL's Pine Creek power station prior to 2016-17 as EDL were granted a generation licence at the end of 2015-16.

The commission remains concerned with this aspect of the generation assessment results. While generators have indicated to the commission that condition monitoring and preventative maintenance is managed internally, the data may indicate an inconsistency in this management of the generating units and this may be having an impact on their usefulness in ensuring supply adequacy. While there remains significant margin for generator-forced outages within the requirements of peak demand, the unreliability and increased system risk from high forced outage rates will affect the efficiency of supply and customer experience. This result contributes to Entura's finding with respect to the need for improved performance and condition monitoring of generators.

The high forced outage factor for the Pine Creek units this year was due to a major electrical fault on one of the alternators. EDL have since inspected the other alternator and elected to upgrade that piece of equipment to pre-empt a repeat of the forced outage. While Entura does not wish to provide direct advice as to how the condition of a generating unit should be monitored, Entura does find that inspection and condition monitoring can be useful in predicting failure of large electrical machines.

The future reduction in the number of synchronous machines that are dispatched at any one time due to increased variable renewable penetration will place greater onus on an individual unit's reliability. Appropriate performance standards and a robust compliance framework for condition monitoring in accordance with good electricity industry practice would assist to ensure units can be sufficiently relied upon to maintain system security.

In other jurisdictions, generators such as Territory Generation are responsible for the ongoing compliance of their units to the technical code or their generator performance standards (GPS). This responsibility includes a requirement to advise the system operator of possible breaches and actual breaches. This provides some transparency around units that may not be fully reliable or able to perform as expected. This in turn allows the system controller to place constraints on the units concerned to ensure power system security is maintained.

In the Territory, while the Network Technical Code requires users to agree to a compliance monitoring program and notify the Network Operator if a generating unit is not complying with the relevant technical standards, the grandfathering arrangements in place through a derogation have allowed almost all of Territory Generation's generators (all those connected as at 1 September 2012) to operate at a lower standard. While grandfathering of this kind is a practical way of allowing older generating units to remain in service without costly overhauls or upgrades, it has made it more difficult to maintain system security.

This issue, at least in part, is being addressed through new GPS recently approved by the commission. The revised Network Technical Code, which incorporates the new GPS, will require generators connected to the network prior to 1 April 2019 to document compliance or level of non-compliance of all generating units against the new standards as required by the Network Operator. Further, if the generator materially modifies, alters or enhances the existing plant, it must comply with the new automatic standards (or negotiate access standards), if required by the Network Operator.

The commission considers clear standards need to be coupled with robust compliance monitoring and therefore looks forward to reviewing whether the strengthened framework achieves performance improvements in future reviews.

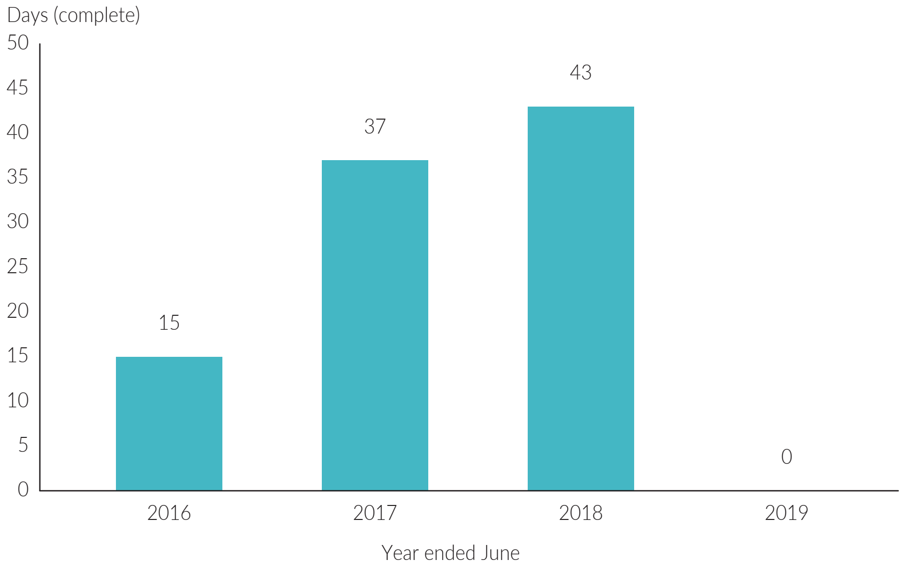
Non-reliable periods

Non-reliable periods are declared when the system operator finds they cannot maintain power system reliability. There are a number of causes for such a state, such as:

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

There were no non-reliable periods in the Darwin-Katherine system in 2018-19 as shown in Figure 12. This is a significant improvement from the previous three periods.

Figure 12: Non-reliable periods for generators in Darwin-Katherine



In previous reviews, the commission has made note of overlapping activities in risk notices issued by System Control. The reduction in non-reliable periods in the reporting period suggests some of these issues around outage planning and the like have been resolved. Discussions with Territory Generation and System Control suggest there are good, regular communications between the two organisations in this regard.

Generation incidents

There were four major generation related incidents recorded in the Darwin-Katherine region in 2018-19. These incidents are summarised in Table 4.

Customer minutes without supply, which is shown in the Table 4, is calculated by multiplying the number of customers impacted by the total incident duration (minutes). The commission notes that as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, the customer minutes without supply indicator shown in the table may be overstated, and is considered a ‘worst case’. However, the commission considers the results and trends to be indicative.

Table 4: Darwin-Katherine generation incident summary[13]

ID	Date of incident	Description	Cause	UFLS/black	Incident duration (minutes)	Customers impacted	Customer minutes without supply
1	24-Jul-18	C8 shutdown	Equipment failure: C8 GT enclosure flame detector fault	UFLS stage 2A	21	9 924	208 404
2	18-Aug-18	Channel Island power station 132CI802 tripped	Testing error		80	0	0
3	23-Oct-18	Pine Creek unit 2 tripped	Secondary systems issue: coordination of controls between system control and generation	Pine Creek -Katherine UFLS	68	2 243	152 524
4	17-Apr-19	WPS unit 2 tripped	Equipment failure: W2 fuel metering valve inner ring failure	UFLS stage 1	17	2 275	38 675

These incidents show similar symptoms to those noted last year. That is:

- testing errors (incident 2)
- secondary system failures (incident 3)
- plant failures (incidents 1 and 4).

Entura notes in both incidents 1 and 4 the system constraint regarding the loading of the Frame 6 units was breached leading to UFLS operation where it might not have been required. System Control's incident report for incident 4 states that prior to the incident solar oscillations were observed, which resulted in the power system's spinning reserve dropping to its minimum requirement. The solar oscillations were due to the power fluctuations and uncertainty of the state of behind-the-meter renewable energy resources.

Entura considers it positive that incident 2 has been raised to the level of major incident. This is a near-miss for the power system in terms of an UFLS event and it is encouraged that the recommendations from this incident are carefully considered by the relevant parties.

Incident 3 appears to be due to a failure in signalling either in the SCADA control system or the operators. Discussions with EDL, Territory Generation and System Control suggest the level of visibility and the fidelity of the signalling between System Control and Pine Creek power station is not robust enough to ensure frequency control is always handed over and remains handed over correctly during an incident.

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

Impact of incidents

A significant transformation in the Darwin-Katherine region has been the reduction in UFLS events. This general decline is mainly due to the changes around spinning reserve allocation and management. The incident reports however show this is being undermined by less than strict adherence to the spinning reserve dispatch constraints.

While the number of UFLS incidents increased in 2018-19, the time to restore customers remains low (see Table 5). As mentioned previously, as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 5: Darwin-Katherine customer impact of major generation incidents[14]

	2015-16	2016-17	2017-18	2018-19
Number of incidents	3	5	6	4
Customers impacted	49 300	34 170	24 740	14 442
Total duration (minutes)	156	237	318	186
SAIDI	38.1	25.0	26.7	5.7
SAIFI	0.72	0.51	0.34	0.21
Reliability (% of year)	0.007	0.005	0.005	0.001
System blacks				
Number	0	0	0	0
Katherine island blacks[15]	0	2	2	0

The overall result in terms of SAIDI is around 6 minutes per customer for the year, or 0.001 per cent, with the frequency of interruptions around 0.2. This is a very good result.

Generation constraints

Table 6 summarises the generation constraints in the Darwin-Katherine region.

Table 6: Darwin-Katherine normal system constraints

	Constraint description	Applied to	Limit	System condition	Comments
1	C8/C9 maximum output constraint	Channel Island units C8 and C9	35 MW each	System demand above 180 MW	Prevents UFLS operation from a C8 or C9 trip
2	C8/C9 maximum output constraint	Channel Island units C8 and C9	30 MW each	System demand below 180 MW	Prevents UFLS operation from a C8 or C9 trip
3	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	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

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

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

These constraints lead to inefficiency in the dispatch of generation in the Darwin-Katherine region, noting the low level of inertia on units other than the older Frame 6 machines at Channel Island and the limited governor response of some units make frequency management in the power system difficult.

System Control have put in place these constraints 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 the first two constraints to be lifted. However, there would be a cost of supply implication to this course of action.

A switching rearrangement in the Channel Island substation (completed in the second half of 2018) has reduced the potential impact of an incident involving the C4/C5/C6 units. Prior to this work, a single fault could remove all three units. Even under a switching rearrangement, it would still be the case that a single fault could remove half the output of the C4/C5/C6 combined cycle. This would be a slower event that could be managed more easily by spinning reserve. System Control reassessed the constraint in the first half of 2019, and plans to reassess in 2020 with an update to the Secure System Guidelines as required.

Planned and recent enhancements

EDL advised it undertook significant works to its units both electrically (stator rewinds) and mechanically (boiler refurbishment).

Territory Generation advised it completed upgrade work on the C6 steam turbine.

There are no planned enhancements to the existing generation fleet in the Darwin-Katherine region.

While strictly a network issue, there is a looming issue with security on the Channel Island 132 kV bus. The part in question is the end of the bus that connects to the 132 kV line to Katherine. Territory Generation advises the addition of large-scale solar PV generation at Katherine coupled with the existing generation at Pine Creek power station may raise the contingency size for a fault on that region of the network.

The addition of solar (both behind the meter and large scale) is set to transform the Darwin-Katherine power system, if not already occurring. The development of a forecasting tool for behind-the-meter solar should add to the ability of System Control to predict variation in generation demand across the important 15-30 minute period it takes to bring additional dispatchable units on line.

Network

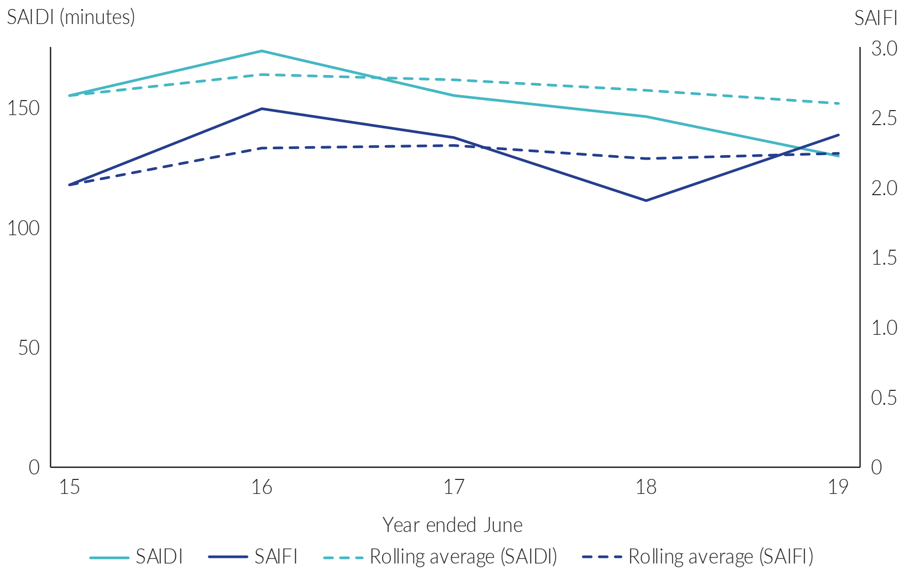
The Darwin-Katherine network covers the Darwin and Katherine areas with a corridor between Darwin and Katherine to the south. The highest transmission voltage is 132 kV. The network in Darwin is relatively robust with the 66 kV network forming a series of loops. The 132 kV and 66 kV networks are strongly 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 Power Services as part of the EIP Code requirements. The SAIDI and SAIFI performance for the Darwin-Katherine network is presented in Figure 13.

Figure 13: Adjusted SAIDI and SAIFI performance for the Darwin-Katherine network[16]



The last three years (2016-17 to 2018-19) show an improvement in SAIDI while SAIFI remains within a steady band around 1.7 to 2.5. There is no standard stipulated for overall network SAIDI and SAIFI but it is worth considering how this performance relates to the customer experience. On average, if there is an interruption then it will go for more than 130 minutes (SAIDI) and each customer will likely have 2.5 interruptions (SAIFI) from network incidents.

While distribution SAIDI and SAIFI performance is no longer reported on by feeder category and power system, Power Services does identify the worst performing feeders for each category. This approach is in line with the EIP Code. The number of feeders from the Darwin-Katherine region listed as problematic by Power Services are summarised in Table 7.

16 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 Power Services' EIP Code reporting by combining data reported for Darwin and Katherine, weighted by the number of customers in each region.

Table 7: Darwin-Katherine worst performing distribution feeders

Feeder category	Feeders	SAIDI	Mitigation planned
CBD	NIL		
Urban	22KA22 Katherine	14.03	Investigation (mostly storm impact)
	11DA27 Stuart Park	10.33	Nil (isolated poor performance)
	11WN02 Fannie Bay	5.69	Recloser relocation
	11CA12 Marrara	4.44	Nil (isolated poor performance)
Rural short	22SY11 Herbert	22.87	Replacement of some conductor and hardware. Animal protection
	22SY03 Virginia	22.62	Replacement of some conductor and hardware
	11CA23 Moil	13.62	nil (one-off event)
	22PA202 Howard Springs	12.83	Replacement of some conductor and hardware. Animal protection
	22SY15 Darwin River	10.74	Reconfiguration and equipment improvement
Rural long	22SY04 Dundee	1284.8	Investigation (mostly storm impact)
	22KA10 Mataranka 1	84.14	Nil (isolated poor performance)

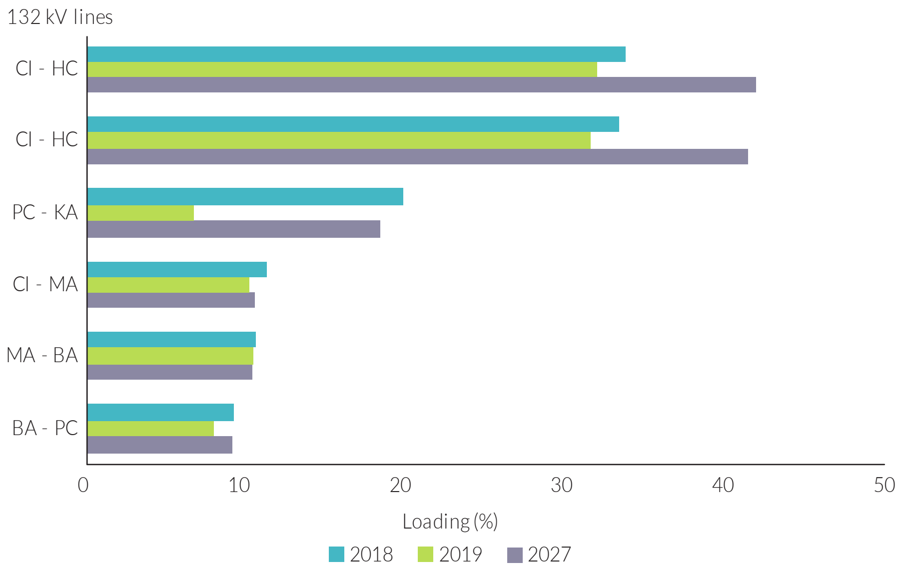
The practical approach to mitigating feeder performance issues appears appropriate from a purely customer weighted performance perspective. Using SAIDI and SAIFI in this way should ensure feeders with fewer customers are not disadvantaged in the assessment and so problematic feeders in any of the regions should appear in the reporting. Entura considers an improved approach may be to set a threshold for identifying problematic performance of individual feeders, which works to a more objective basis, rather than a list of top five worst performing feeders. The reporting requirements within the schedules of the EIP Code will be considered by the commission as part of a future review of the EIP Code.

The commission notes that no CBD feeders were identified by Power Services through this process. While this is not in strict adherence with the existing EIP Code, Power Services has indicated to the commission that no CBD feeder has performed poorly in consecutive years and the majority of incidents related to CBD feeders have been the result of human error. The overall Territory CBD feeder performance, including a comparison against a commission approved target, is shown in the distribution feeders section of this review.

Network utilisation

The network utilisation (see Figure 14) shows an updated dataset to that of previous reviews.

Figure 14: Transmission network utilisation Darwin-Katherine (132 kV)



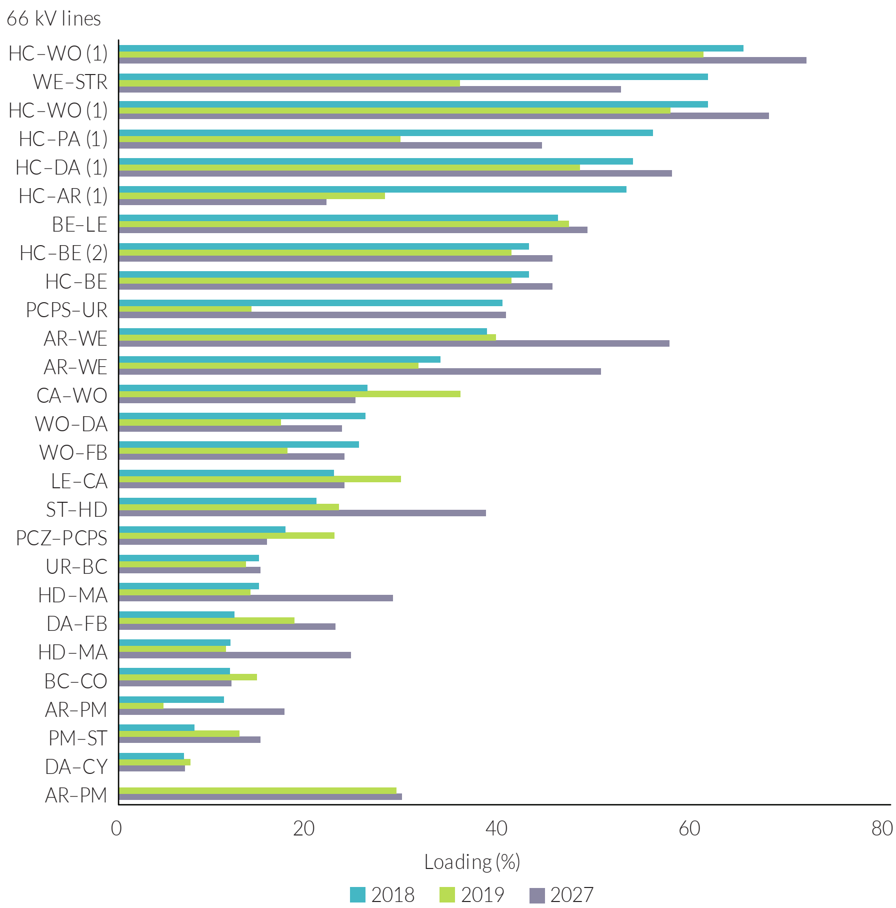
132 kV line loadings remain well within rating. Entura makes this assessment on the following basis:

- parallel lines such as the CI-HC lines do not exceed 50 per cent of their rating and so can be considered to run firm. This means 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 Channel Island via Manton, Batchelor 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 sufficient spare capacity on those lines to allow for some additional generation in that region.

The 66 kV line loadings are shown in Figure 15.

Figure 15: Transmission network utilisation Darwin-Katherine (66 kV)



The upgrades between Hudson Creek and Palmerston appear to have been effective in reducing flows on the existing circuits in that corridor. Entura notes the ongoing load balancing issues required in the Weddell 66 kV loop. The new Archer-Palmerston 66 kV line has reduced, but not eliminated, the reliance on generation from Weddell power station to manage network flows.

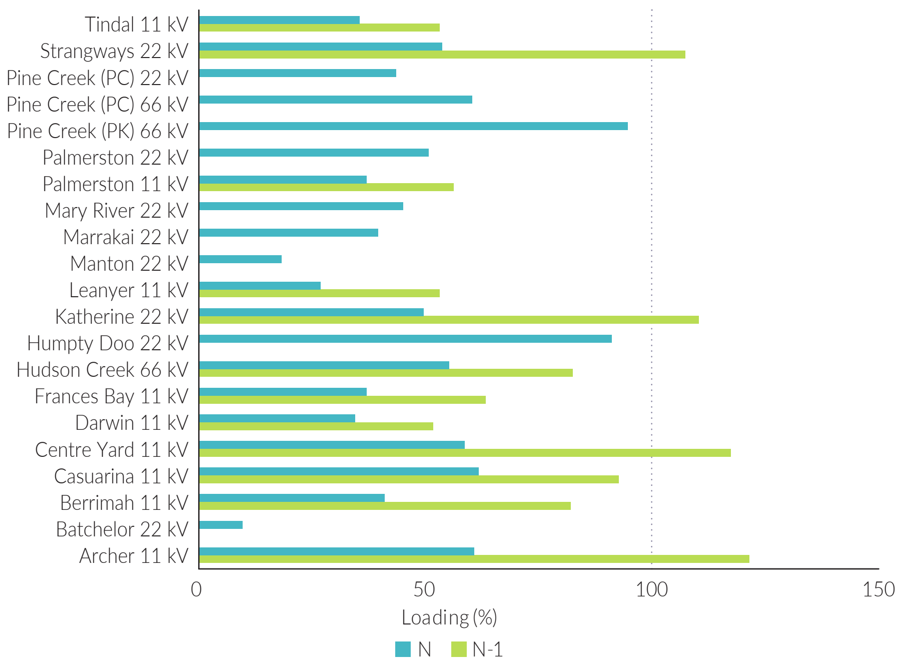
Network adequacy

Zone substations

The zone substation transformer loading under N-1 conditions is shown in Figure 16.

Generally, it is expected a substation can supply point of exceedance (POE) 10 or the 90th percentile demand with one transformer out of service. The substations of concern in the figure are those where either the N or N-1 loading exceeds 100 per cent.

Figure 16: Substation utilisation for N and N-1 conditions Darwin-Katherine (POE 10)[17]

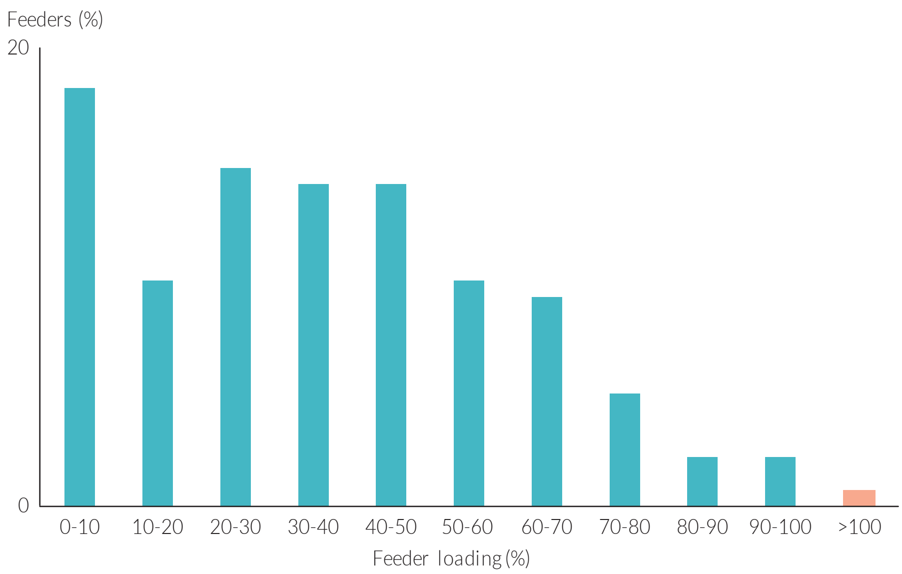


On the basis that substation loading should not exceed 100 per cent, Katherine remains problematic (see 2017-18 NTPSPR), along with Archer, Strangways and Centre Yard, where the N-1 loading exceeds the rating. Load transfers are underway at both Strangways and Archer, while non-network solutions are being pursued at Katherine. The N-1 overload at the Centre Yard zone substation is not addressed in PWC's Transmission and Distribution Annual Planning Report (DAPR) 2019.

Feeders

The distribution of feeder loadings for Darwin-Katherine is shown in Figure 17.

Figure 17: Feeder utilisation for Darwin-Katherine (POE 10)



Around 3 per cent of feeders exceed 90 per cent of their capacity. The 11CA15 (hospital) feeder at the Casuarina substation is the only feeder that exceeds its rating during high demand.

The PWC DAPR specifies load transfers and or feeder upgrades to manage any overloads.

17 Based on data in PWC's Transmission and Distribution Annual Planning Report 2019.

Network incidents

There were five major network incidents in Darwin-Katherine in 2018-19 (see Table 8).

Customer minutes without supply, which is shown in the Table 8, is calculated by multiplying the number of customer impacted by the total incident duration (minutes). The commission notes that as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, the customer minutes without supply indicator shown in the table may be overstated, and is considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 8: Darwin-Katherine major network incident summary[18]

ID	Date of incident	Description	Cause	UFLS/black	Incident duration (minutes)	Customers impacted	Customer minutes without supply
1	18-Sep-2018	Darwin zone substation – 66/11kV transformer 3 and 11KV bus 3 tripped	Operational error		64	2 391	153 024
2	9-Nov-2018	Dual 66kV reclose HC-PA/ HC-AR – loss of Weddell power station	Weather		27	0	0
3	17-Jan-2019	132KV MT BA PK tripped	Weather/ lightning strike	Katherine system black/ UFLS stage 2 and 3	28	4 673	130 844
4	11-Feb-2019	132KV PC – KA tripped	Weather/ lightning strike	Katherine system black/ UFLS stage 2	18	3 132	56 376
5	22-Mar-2019	132kV Pine Creek – Katherine line trip	Weather/ transient	Katherine system black/UFLS stage 1	13	4 673	60 749

The incidents fall in two categories, namely operator error and weather, as discussed below:

1. Operator error

Incident 1 falls into this category.

The commission observes the serious nature of this incident, particularly from a work health and safety perspective. It is reassuring to see the recommendations in the incident report relating to safety and emergency response, as well as a comprehensive list of maintenance documentation that includes improved control measures to assist personnel operate the network safely and correctly. However, the commission is concerned there has been little scrutiny of progress or acceptance of incident recommendations. Following the Alice Springs system black investigation, which occurred early in the 2019-20 reporting period, System Control now maintains a register of incident recommendations for all three regulated power systems, with a requirement to report on the progress against recommendations.

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

2. Weather

Incidents 2, 3, 4 and 5 fall into this category.

This category of incidents is unavoidable, however the impact on customers may have been reduced.

Incident 2 shows the coordination of auto reclose in meshed networks is important particularly when islands with generation can form. The recommendations for a synchronism check review for this incident are key to this incident not reoccurring.

Incidents 3, 4 and 5 demonstrate how difficult it is to manage the long 132 kV line to Katherine. This appears to be made more difficult due to the failure of coordinating control signals between System Control and licensed generators that would allow the inter-operation of Territory Generation's Katherine power station units with EDL's Pine Creek power station units. The failure of secondary systems and communications with System Control appears to be at the core of the cause for the customer impact from these incidents. It appears to Entura the existing operating protocols and equipment do not deliver the levels of robustness that could reasonably be expected.

Impact of incidents

Table 9 shows the impact of these network incidents on customers. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 9: Darwin-Katherine customer impact of major network incidents[19]

	2015-16	2016-17	2017-18[20]	2018-19
Number of incidents	7	10	13	5
Customers impacted	21 010	38 630	33 680	14 869
Total duration (minutes)	152	360	1 272	150
SAIDI	7.4	20.8	53.7	5.7
SAIFI	0.31	0.57	0.47	0.21
Reliability (% of year)	0.001	0.004	0.010	0.001
System blacks				
Number	0	0	0	0
Katherine island blacks[21]	6	5	5	3

Excluding the Tropical Cyclone Marcus outages from last year, the result for 2018-19 shows improvement to a level not seen since 2015-16 across all indicators.

A comparison between 2015-16 and 2018-19 shows a decrease in the number of customers impacted, however the same length of outage duration. This indicates some customers are seeing many more disruptions than others.

19 Based on data from System Control incident reporting ('customers impacted' and 'total duration (minutes)').
20 Excluding Tropical Cyclone Marcus.
21 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.

Network constraints

Table 10 summarises the network constraints in the Darwin-Katherine region.

Table 10: Darwin-Katherine normal system constraints

	Constraint description	Applied to	Limit	System condition	Comments
1	Weddell generation constraint	Total Weddell output	64 megavolt ampere (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 SCADA	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 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 output from Weddell under certain demand conditions in case of the loss of transmission lines. In Entura's opinion an automated run-back may be used to manage this flow limit. This would free the Weddell power station 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. PWC 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.

Constraint 2, and its associated impact on generation, highlights the system security implications of the single circuit line to Katherine. Specifically, this constraint 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.

While the commission notes that System Control's obligations include to ensure 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 Eni Australia Limited's (Eni) Katherine solar power station is commissioned and electricity transmission across the 132 kV line increases.

Network customer power quality notifications

Low voltage quality

Figures 18 and 19 show the steady state voltage distribution for the Darwin and Katherine regions, respectively, in 2018-19.

Figure 18: Steady-state voltage performance, Darwin

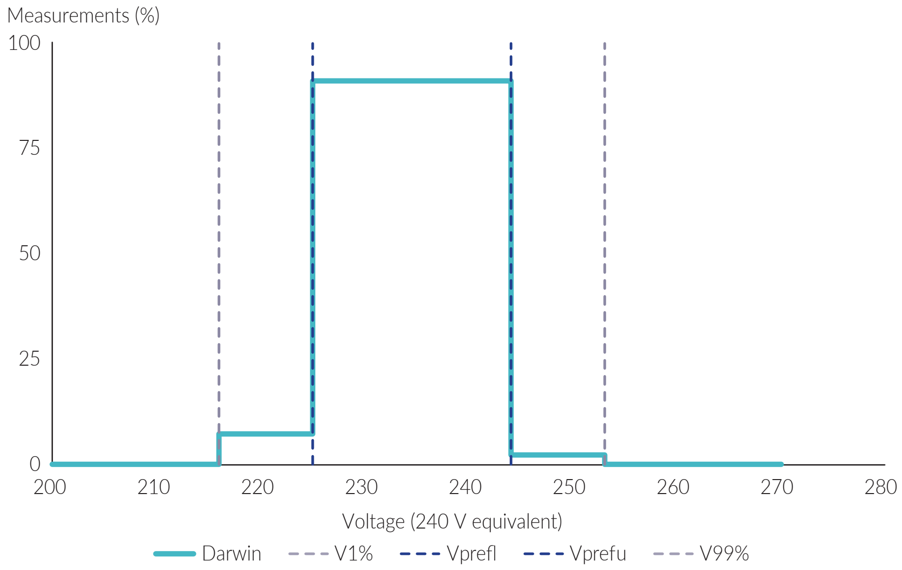
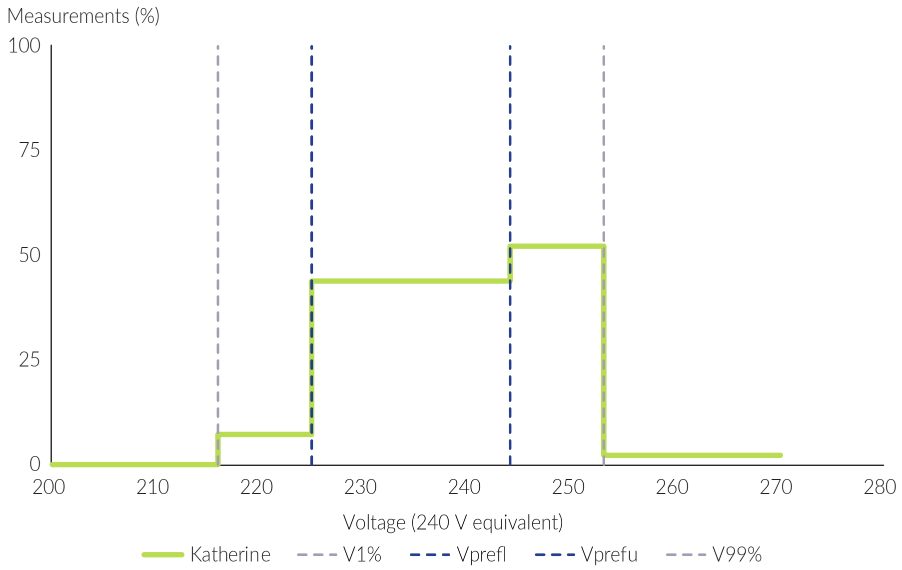


Figure 19: Steady-state voltage performance, Katherine



The measurement and reporting against this criterion is important in modern power systems where voltage can no longer be reliably regulated by distribution transformers alone. Voltage regulation in Darwin remains acceptable with the voltage in the preferred zone between Vprefl and Vprefu in excess of 90 per cent of the time with minimal high voltage periods. This is contrasted with Katherine where Power Services reports 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 fact, the voltage is outside the preferred zone more often than not. This must be addressed as it will affect customers' electrical equipment if not managed.

Power Services has indicated to the commission that it is progressing options to address this issue, which include the installation of shunt reactors and engaging a third party for reactive power control during low load periods.

Quality of service complaints

Power Services reports on the number and types of power quality complaints. Figure 20 shows the Darwin-Katherine customer notifications marginally decreased in 2018-19 with the Katherine notifications increasing.

Figure 20: Total customer notifications relating to the quality of supply in Darwin-Katherine

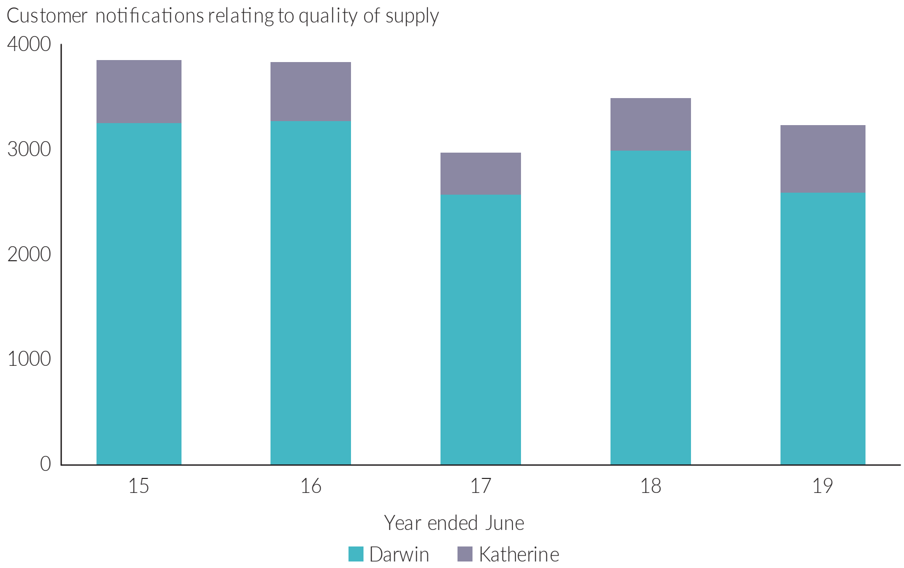
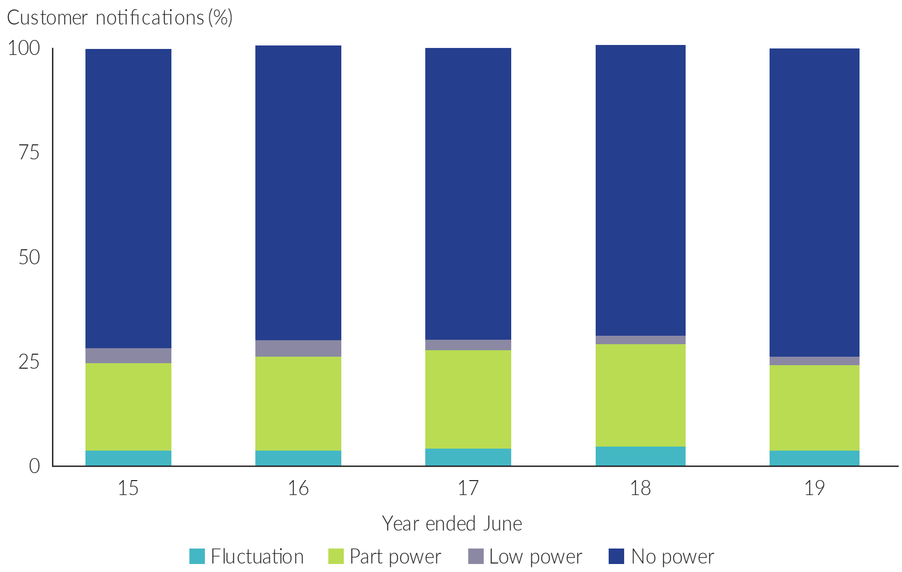


Figure 21 shows notifications are largely made in response to no power rather than in relation to part power or the quality of power.

Figure 21: Type of customer notifications relating to the quality of supply in Darwin-Katherine



The share of 'no power' notifications has increased in the 2018-19 period. This increase is mostly due to notifications from the Katherine region, which is understandable given the high customer impact from incidents in that region.

Other customer complaints are summarised in Table 11.

Table 11: Number and nature of customer complaints 2018-19 for the Darwin-Katherine power system

	Darwin		Katherine		Darwin-Katherine total	
	Total	%	Total	%	Total	%
Reliability of supply	26	11	3	19	29	11
Technical quality of supply	37	15	3	19	40	16
Admin process/customer service	84	35	5	31	89	35
Augmentation	6	3			6	2
Connection	4	2			4	2
Other	83	35	5	31	88	34
Total	**240**		**16**		**256**	

The commission notes a high percentage of 'other' complaints. The commission suggests Power Services consider expanding on the nature of reporting these complaints as identifying trends may be useful in responding to customer needs.

Planned and recent network enhancements

The following network enhancements have been completed:

- the new Archer-Palmerston line
- the 132kV Darwin-Katherine transmission line islanding scheme is now operational. However, it is expected a major rework of the scheme will be required to facilitate the operation of additional solar PV generation sites in the region. Further, as noted in the incident analysis, the Pine Creek and Katherine islanding scheme requires further enhancements to improve robustness.

2 | Alice Springs power system

This chapter focuses on the 2018-19 generation and network performance of the Alice Springs power system. Where possible it compares 2018-19 performance to historical data to identify trends. Specifically this chapter considers:

- overall customer impact
- generator performance, observed UFLS and single generator trips, generation availability, non-reliable periods, major generation incidents, generation constraints, and generation planned and recent enhancements
- network performance, network utilisation, network adequacy, major network incidents, network constraints, network power quality notifications, quality of service complaints, and network planned and recent enhancements.

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.

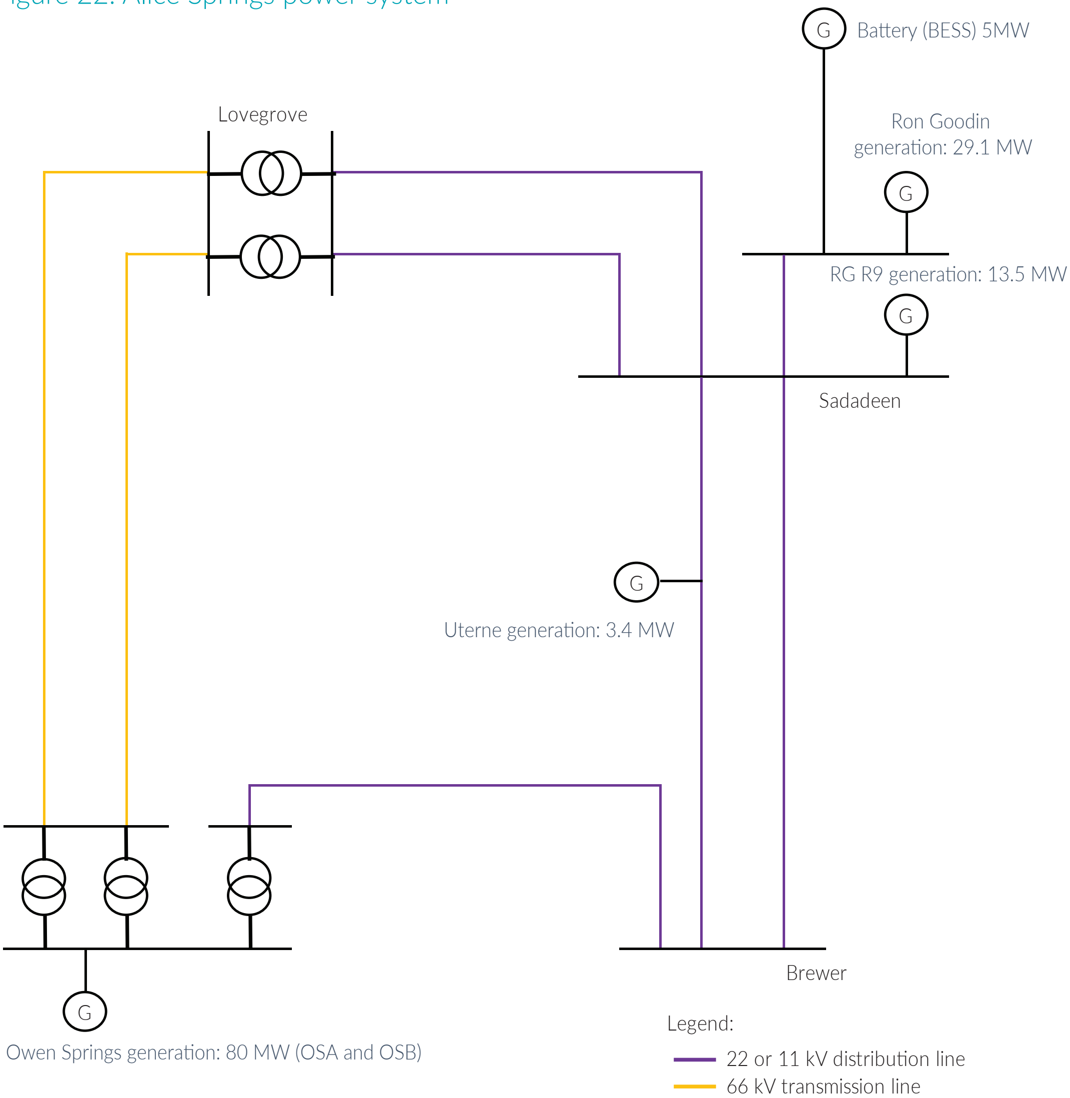
The energy sent out by grid connected generators in 2018-19 is shown in Table 12.

Table 12: Alice Springs energy sent out in 2018-19

Power system	Energy sent out (GWh)
Alice Springs	221

Figure 22 shows the Alice Springs power system. The highest voltage of the network is 66 kV.

Figure 22: Alice Springs power system[22]



Overall customer impact

This section shows the overall performance for the Alice Springs region.

Table 13 shows the impact on customers from major and minor incidents in the Alice Springs region across the last three years.

The number of customers impacted and total duration (minutes) of an incident is reported by System Control to the commission as part of its SCTC obligations. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

22 Generation capacities relate to non-summer capacities.

Table 13: Overall customer impact from major and minor incidents in the Alice Springs region

	2016-17	2017-18	2018-19
Number of incidents	10	14	14
Customers impacted	33 730	43 270	18 691
Total duration (minutes)	415	1 247	1 867
SAIDI	152.9	570.3	223.0
SAIFI	2.77	3.45	1.53
Reliability (% of year)	0.029	0.108	0.042
System blacks			
Number	0	2	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 it 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 it would be added to the first incident and lead to a SAIDI of 2.5 minutes.

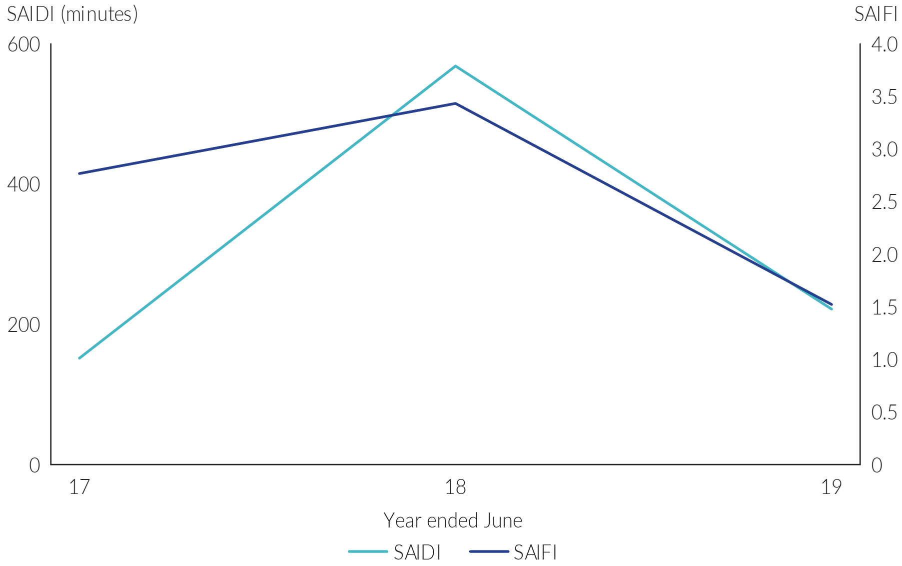
SAIFI is a measure of the average number of events weighted by the number of customers affected by each incident. Using the examples above, the SAIFI would be 0.1 after the first incident and 0.2 after the second incident.

Reliability (percentage of year) is calculated based on SAIDI, and is the percentage of a year that the average duration of incidents per customer represents. This varies from the reliability standard[23] for generation of 0.002 per cent 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 overall performance of the system for the 2018-19 year is close to normal for this power system, as shown in Figure 23. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, SAIDI and SAIFI indicators derived from the number of customers impacted and total duration (minutes) of an incident may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

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

Figure 23: Overall SAIDI and SAIFI performance, Alice Springs[24]



Points to note are the small numbers of customers affected but the high number of customer minutes without supply. This suggests there is an imbalance across the power system in terms of customer experience. However, this imbalance may be reasonable depending on the circumstances. The relativities between customer connection types are managed through feeder type performance targets.

Generation

The total non-summer (winter) grid connected in front of the meter generation capacity is 126 MW[25] in Alice Springs and the fuel type of the generation units is currently made up of dual fuel (gas/diesel), diesel only, gas only and solar PV. This does not include behind-the-meter rooftop solar photovoltaic generation capacity, which totalled around 10 MW in 2018-19. The operational maximum demand in 2018-19 was 52.76 MW.

Table 14: Maximum non-summer (winter) grid connected in front of the meter generation capacity in Alice Springs in 2018-19[26]

	(MW)
Ron Goodin	42.6
Uterne	3.4
Owen Springs	80
Total generation	**126**

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.

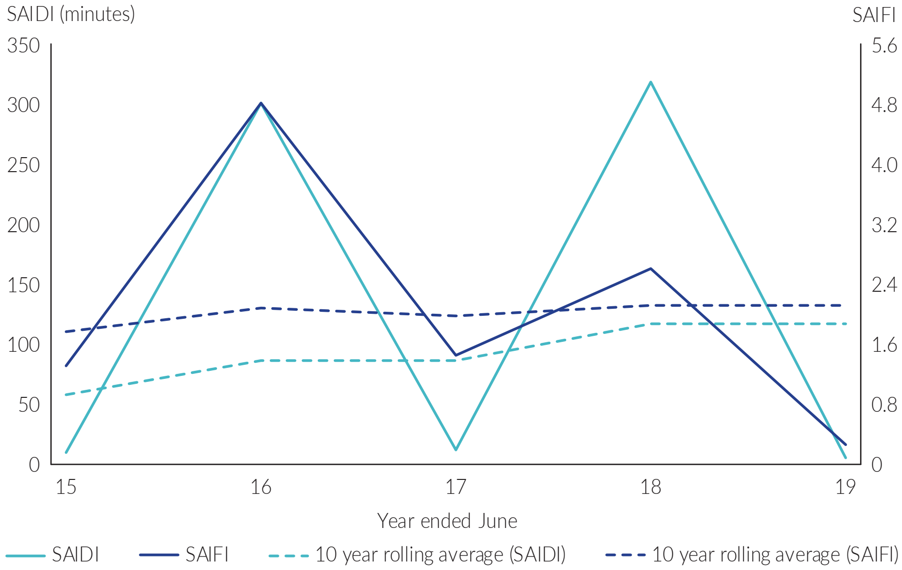
The following sections show the generation in Alice Springs continues to present reliability and availability challenges.

24 Based on data from System Control incident reporting ('customers impacted' and 'total duration (minutes)').
25 Generation capacity relates to non-summer (winter) grid connected in front of the meter generation capacities.
26 Generation capacities relate to non-summer (winter) capacities.

Generator performance

The SAIDI and SAIFI performance for the Alice Springs generating units is presented in Figure 24.

Figure 24: SAIDI and SAIFI performance for generation, Alice Springs



The two indices demonstrate the number of issues that have beset Alice Springs over the last 10 years.

The commission had been expecting the generation upgrades at Owen Springs and the battery energy storage system (BESS) to improve the performance. Unfortunately, these upgrades are yet to meet this expectation in a consistent manner. While the result for the 2018-19 period is very good, this was followed by a large system black incident shortly thereafter. Therefore, the commission considers the new generating units at Owen Springs and the rearrangement of the network connection continue to cause security issues.

The commission notes, regardless of these upgrades, the generation mix and high penetration of solar PV leads to a challenging system control problem. This control problem was managed better in the 2018-19 year but remains problematic. The management of issues like reducing minimum demand due to the high penetration of behind-the-meter solar PV generation is challenging in a small system such as Alice Springs. Therefore, careful planning in relation to how the system is operated is necessary in coordination between the relevant stakeholders, such as government, System Control and Power Services.

Observed UFLS and single generator trips

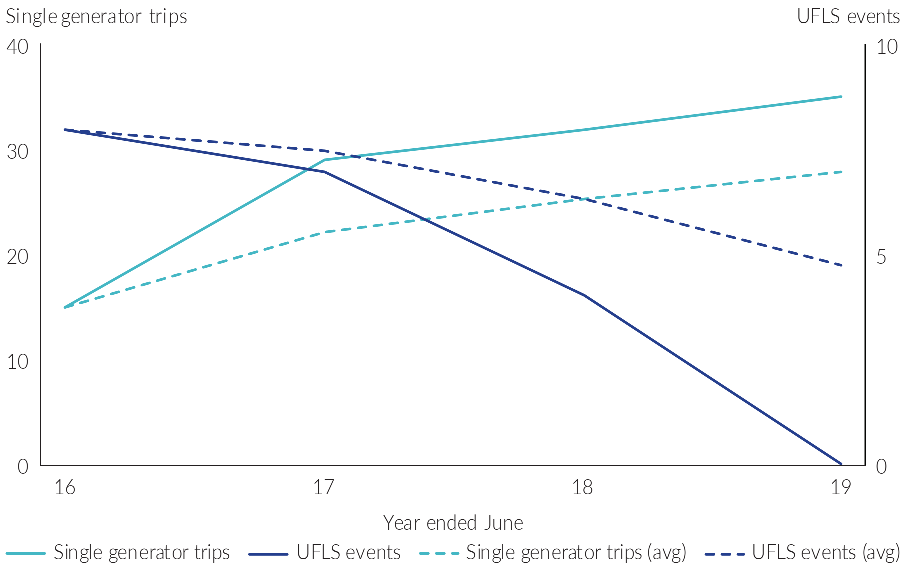
The commission's reviews in relation to power system performance have focused on single unit trips and their impact on customers for a number of years now. The focus is due to the high incidence of single unit trips (relative to other power systems) and the challenge that smaller power systems have in managing these incidents without loss of load due to the large relative size of the generating units.

Until recently, the Alice Springs power system was dispatched in such a way as to require UFLS to arrest frequency fall for most large single generator trips. This practice was ended in an attempt to improve 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.

However, the commission notes that this improvement has been achieved in part through System Control changes to spinning reserve, which may increase costs, particularly for Territory Generation. Further, given there is no efficient price or competitive process for the provision of spinning reserve, or ancillary services more broadly, there is little incentive for the associated increased costs to be minimised.

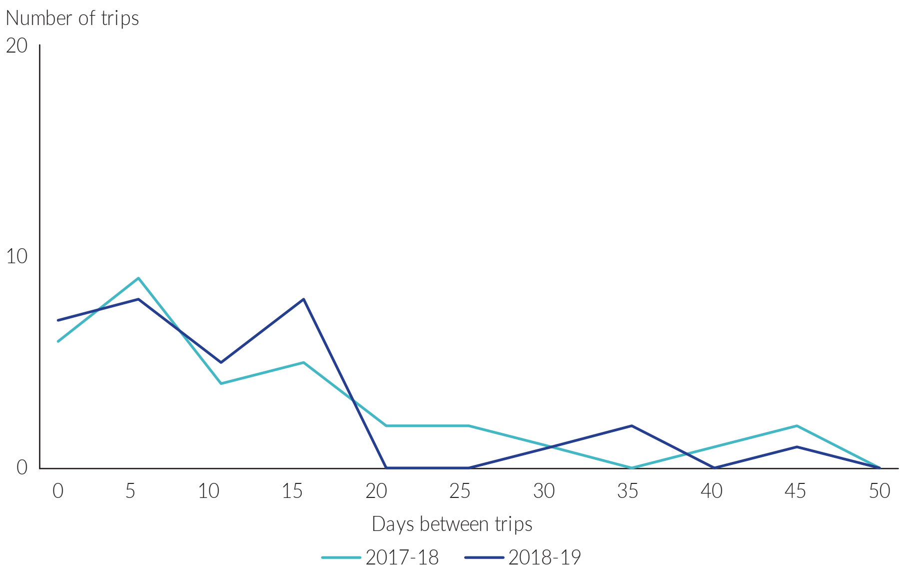
There were no single generator trips that led to UFLS in Alice Springs in 2018-19.

Figure 25: Alice Springs single generator trips versus UFLS (due to single generator trips)



The reduction in UFLS operation due to single generator trips is a good result. However, this good result is undermined by the increase in single unit trips. The incidence of these trips continues to be a concern and remains similar to the previous reporting period in number and distribution (as shown in Figure 26).

Figure 26: Alice Springs single generator trip frequency



The significant change is the better performance of the system in terms of frequency control.

The size of single generator trips compared to the minimum spinning reserve (MSR) in Alice Springs during 2018-19 is shown in Figure 27.

Figure 27: Alice Springs single generator trip by size

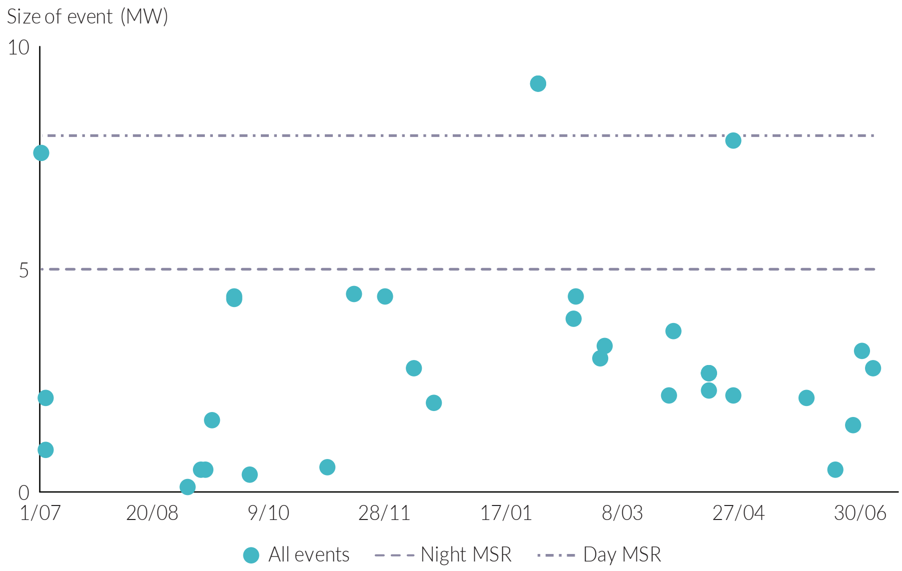


Figure 27 shows that even though individual generator trips are near or above the MSR, the system can cover these events with a combination of traditional spinning reserve and battery control. This differs from the 2017-18 result, with many UFLS operations occurring with generation events in excess of the night minimum spinning reserve limit.

In summary, even though the number of trips are high, the spinning reserve approach taken is reducing the customer impact of these trips, however this may come with increased costs, in particular Territory Generation's costs.

Generation availability

A number of indices are calculated as per the EIP Code for generating units to reflect their availability. The factors discussed in the following sections are:

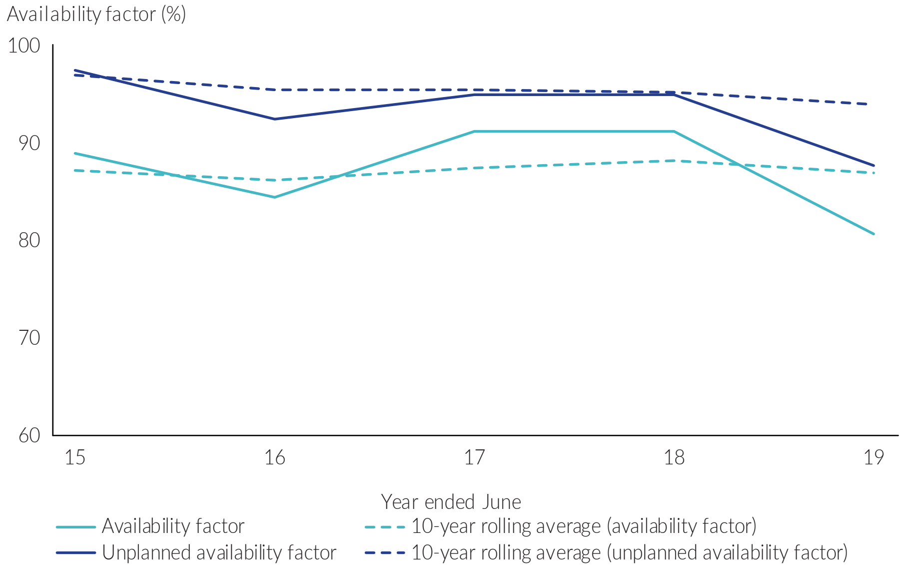
- availability factor (full and unplanned) – the availability factor represents the percentage of time a unit is available to generate. The unplanned availability factor is the percentage of time the unit is available other than for forced outages. The difference between these two indices is the planned outages and de-rating effect
- forced outage factor – the forced outage factor is the percentage of time the unit is not available for dispatch due to an internal fault. This includes time taken to repair the unit if it is damaged or an element requires replacement or refurbishment due to an incident that is unplanned.

The measures provide some insight into the availability of the generating units and allow an assessment to be made as to the security of supply.

Availability factor

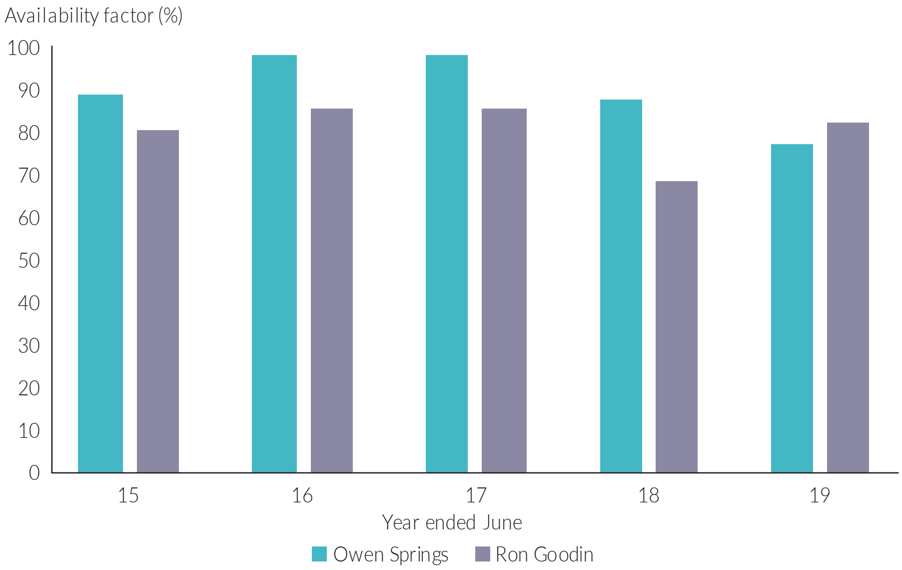
The overall availability for the generators showed a large decline in 2018-19 over the previous reporting period (see Figure 28).

Figure 28: Capacity weighted average availability factor for Alice Springs generating units



The power station results (see Figure 29) indicate the Alice Springs generating units have performed poorly. While the performance at the Ron Goodin power station in 2018-19 is consistent with past results, the performance at the Owen Springs power station has been poor for the second consecutive year.

Figure 29: Availability factor for Alice Springs generating units



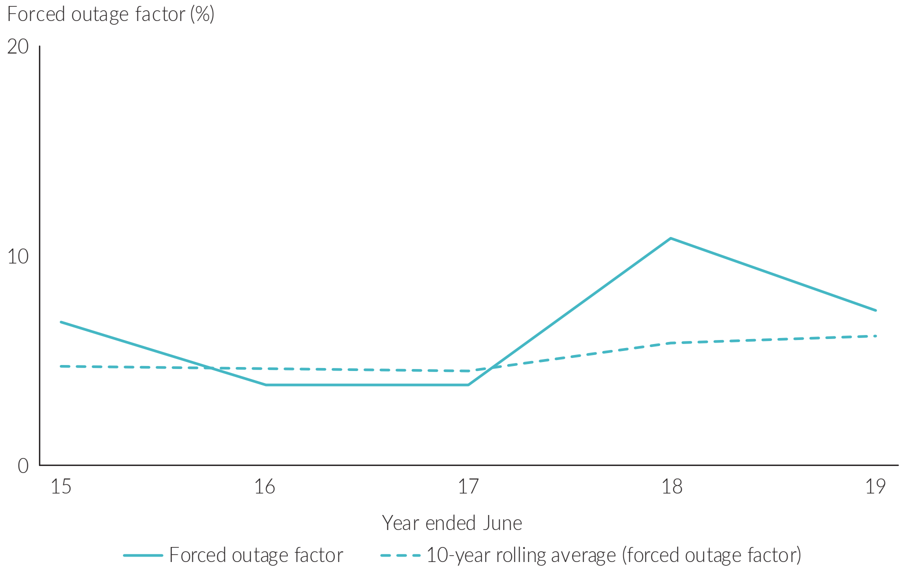
Availability continues to be low. This is explainable due to continued ageing effects at the Ron Goodin power station and continuing teething problems at Owen Springs power station. Often these two effects are described as opposite ends of a bathtub curve. Generating plant suffers annoying, niggling unreliability as the 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 Ron Goodin power station is now, that the frequency of failures start to increase again due to wear and tear on all components. Accordingly, this performance is almost inevitable.

While the Owen Springs power station performance is low, the forced outage factor is also low, suggesting the commissioning and 'bedding down' period, though protracted, is being managed proactively. The performance at the Ron Goodin power station and its impact on customers is difficult to mitigate due to the age of the plant (and now the extension of operation beyond the planned decommissioning date).

Forced outage factor

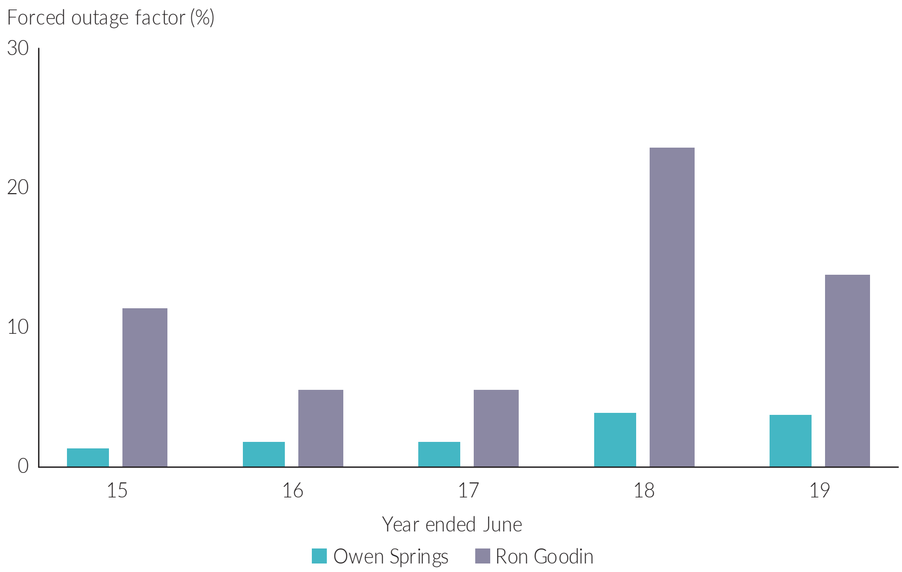
The forced outage factors reduced slightly for both power stations in 2018-19, which reduced the overall Alice Springs forced outage factor result (see Figure 30).

Figure 30: Capacity weighted average forced outage factor for Alice Springs generating units



In particular, an improvement of the performance of the Ron Goodin power station significantly contributed to the overall improvement in this factor compared to 2017-18 (see Figure 31).

Figure 31: Forced outage factor for Alice Springs generating units



The Owen Springs power station performance is similar to previous years. The reduction in outages at the Ron Goodin power station suggests a reduced reliance on that station.

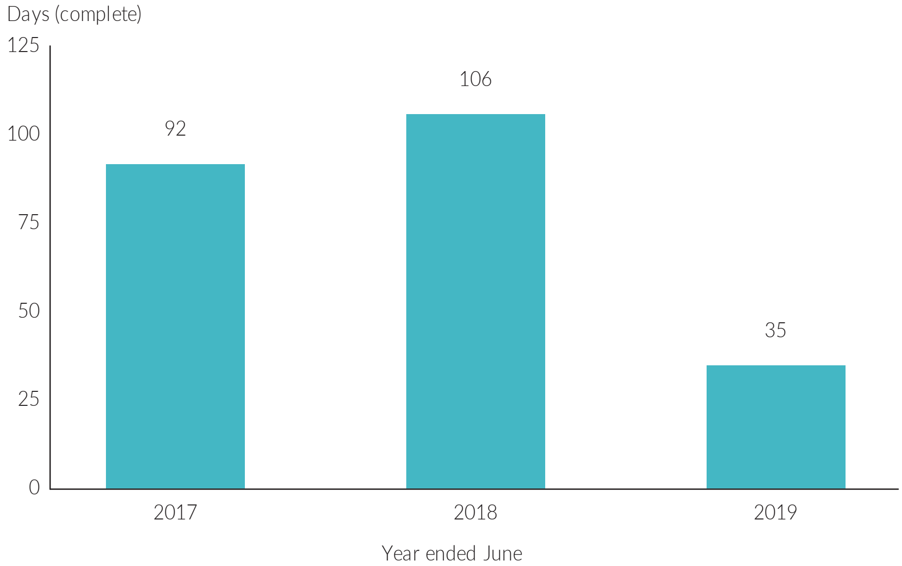
Non-reliable periods

Non-reliable periods are declared when the system operator finds power system reliability cannot be maintained. There are a number of causes for such a state such as:

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

There was a reduction in non-reliable periods in 2018-19 (see Figure 32).

Figure 32: Non-reliable periods for generation in Alice Springs



All of the non-reliable periods are due to forced outages and since these reduced (as discussed in the previous section), the length of time the system was under non-reliable notices also decreased. However, almost 10 per cent of the year is still high. Entura expects that with the current reliability level, the non-reliable notice periods should reduce further.

Generation incidents

Table 15 shows a summary of the major generation incidents in Alice Springs in 2018-19.

Customer minutes without supply, which is shown in the Table 15, is calculated by multiplying the number of customers impacted by the total incident duration (minutes). The commission notes that as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, the customer minutes without supply indicator shown in the table may be overstated and is considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 15: Alice Springs major generation incident summary[27]

ID	Date of incident	Description	Cause	UFLS/black	Incident duration (minutes)	Customers impacted	Customer minutes without supply
1	25-Jul-2018	Ron Goodin power station – operational non-conformance	Protection removed from in service equipment		0	0	0
2	11-Dec-2018	Generation plant (Owen Springs Unit 1 (O1)	Unauthorised testing		0	0	0
3	11-Apr-2019	Gen 5/6/13/14 tripped	Testing equipment failure/ operator error	UFLS stage 1	23	1 687	38 801
4	21-Apr-2019	Owen Springs power station unit 3 and Ron Goodin power station unit 9 tripped on 22RG13 fault	Feeder fault leading to incorrect generator control action	UFLS stage 2	158	4 237	669 446

The incidents fall into two broad categories, namely operator error and incorrect control operation:

1. Operator error (incidents 1, 2 and 3)

These types of incidents should be rare in the electricity industry. Commissioning and testing activities have a number of critical requirements to be met including plant safety, personnel safety and eliminating customer impact. Two out of three of these incidents have no customer impact. The commission considers it positive that the incidents have been reported and actioned by System Control regardless of the customer impact.

However, the occurrence of the incidents leads the commission to question whether sufficient care is being taken in the preparation for and during testing. This is a serious breach of good electricity industry practice and further scrutiny should be applied in this area, both by the relevant generator and System Controller.

2. Incorrect control operation (incident 4)

While this is the only such incident reported in the 2018-19 period, there have been many such incidents in previous years. The commission raised concerns in the 2017-18 NTPSPR in relation to commissioning practices. These concerns have increased following information collected during the Alice Springs system black investigation of late 2019, which although outside this 2018-19 reporting period, warrants discussion. Specifically, this investigation raised a concern over the integration and knowledge of OEM controls relating to the MAN and Jenbacher generators at the Owen Springs power station. The commission anticipates improvements in this area as Territory Generation works through the recommendations of these incident reports and the system black report.

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

Impact of incidents

Table 16 shows the impact of these generation incidents on customers. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 16: Alice Springs customer impact of major generation incidents[28]

	2015-16	2016-17	2017-18	2018-19
Number of incidents	12	7	6	4
Customers impacted	51 120	18 700	33 320	5 924
Total duration (minutes)	676	189	625	181
SAIDI	428.6	42.9	525.8	58.1
SAIFI	4.14	1.53	2.66	0.49
Reliability (% of year)	0.082	0.008	0.100	0.011
System blacks				
Number	1	0	1	0

Generation incidents had a low impact on customers in 2018-19 compared to previous years. The performance in 2018-19 is only slightly inferior in terms of SAIDI and better in terms of SAIFI to that of 2016-17, which also saw a low impact on customers.

Generation constraints

Table 17 summarises the generation constraints in the Alice Springs region.

Table 17: Alice Springs normal system constraints

	Constraint description	Applied to	Limit	System condition	Comments
1	Maximum dispatch	Owen Springs power station	45 × power factor	All	Prevent overloading of 66/11kV Owen Springs transformers 1 or 2
2	Dispatch level management	Ron Goodin power station	17 MVA	All	Manage power flow through RG/Sadadeen 11/22 kV transformers
3	Station limit	Owen Springs power station	50% of total demand	Single circuit operation of Lovegrove – Owen Springs 66 kV	Reduction in single contingency size

Constraints 1 and 2 are network constraints. They curtail (or preferentially dispatch) generation to manage loading on a network element. Constraint 1 may be able to be relaxed now that the third Owen Springs transformer is available.

Constraint 3 will be reviewed by System Control once the BESS is fully operational. It represents a large risk to the system if generation is only sourced from the Owen Springs power station under this constraint.

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

Planned and recent enhancements

Two significant enhancements to be made in the generation space in Alice Springs are the reliable full operation of the Jenbacher generators at the Owen Springs power station and the BESS unit. There are ongoing functional performance issues to be resolved in both cases.

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 and Ron Goodin at one end and Owen Springs at the other.

Network performance

The overall measure of SAIDI and SAIFI do not have a standard set by the EIP Code. However, the standards are set at the feeder type level for the sum of the three systems.

The SAIDI and SAIFI performance for the Alice Springs network is shown in Figure 33.

Figure 33: Adjusted SAIDI and SAIFI performance for the Alice Springs network[29]

Both indices remain around the long term average. SAIFI appears to be on a long-term increasing trajectory, however using the short rural feeder global target as a reference, then both indices are well within that benchmark. Further, the SAIFI result achieves the higher urban benchmark. Therefore in Entura's opinion, at this stage the increasing trajectory of SAIFI is of minor concern.

There have been no transmission level (66 kV lines) outages in Alice Springs across the last four financial years. This is an excellent result. However, the change in operation in the network associated with the decommissioning of the Ron Goodin power station may lead to some unexpected network incidents in the future. The commission expects the System Controller to work to pre-empt these issues where possible.

29 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.

Power Services identifies the worst performing feeders for each category as per the EIP Code. Power Services has only identified one feeder in the Alice Springs region as problematic, which is summarised in Table 18.

Table 18: Alice Springs worst-performing distribution feeders

Feeder category	Feeders	SAIDI	Mitigation planned
Urban	11RG02 GOLF	10.35	Nil (isolated poor performance)

The low number of feeders reported suggests the SAIDI issues in Alice Springs are not due to feeder performance issues.

Network utilisation

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

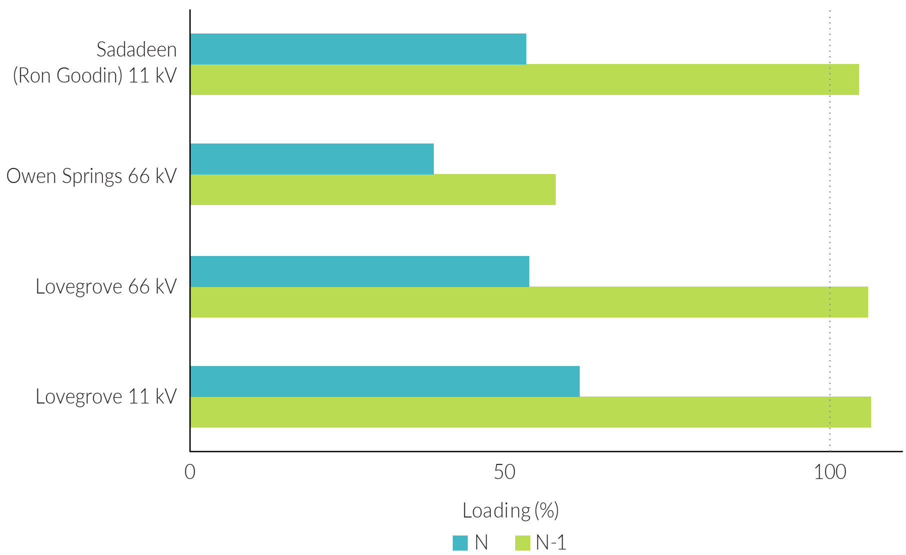
Network adequacy

Zone substations

The zone substation transformer loading under N-1 conditions is shown in Figure 34.

Generally, it is expected a substation can supply POE 10 or the 90th percentile demand with one transformer out of service. The substations of concern in the figure are those where either the N or N-1 loading exceeds 100 per cent.

Figure 34: Substation utilisation for N and N-1 conditions, Alice Springs (POE 10)[30]



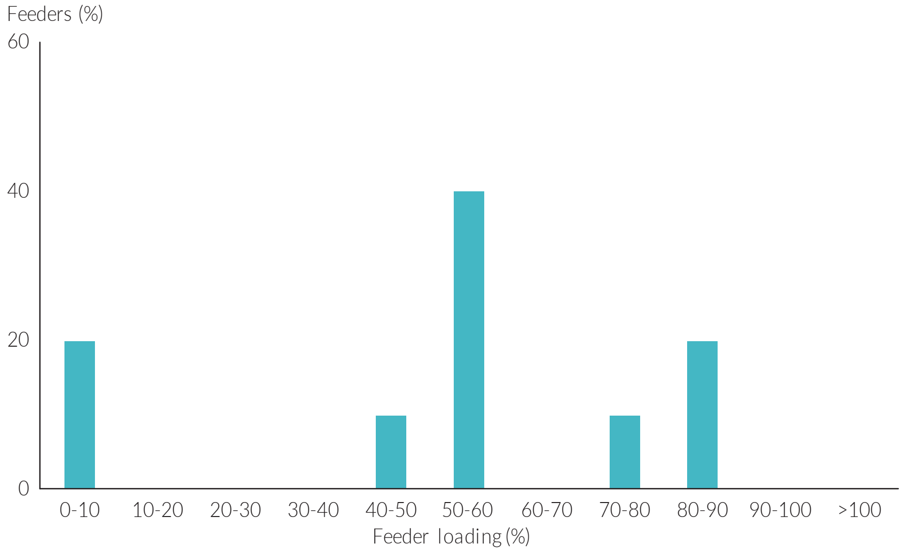
On the basis that substation loading should not exceed 100 per cent, all substation normal loading continues to be within the asset ratings, however there are a number of asset overloads at the N-1 level. The N-1 overload at the Sadadeen zone substation is being managed using Territory Generation's BESS ahead of an upgrade to the Sadadeen switchboard and the addition of a third transformer.

30 Based on data in PWC's Transmission and Distribution Annual Planning Report 2019.

Feeders

The distribution of feeder loadings for Alice Springs is shown in Figure 35.

Figure 35: Feeder utilisation for Alice Springs (POE 10)



This demonstrates that feeder loadings are well managed in the Alice Springs region with no feeders loaded above 90 per cent of capacity.

Network incidents

There was one major network incident in Alice Spring in 2018-19 (see Table 19).

Customer minutes without supply, which is shown in the Table 19, is calculated by multiplying the number of customer impacted by the total incident duration (minutes). The commission notes that as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, the customer minutes without supply indicator shown in the table may be overstated, and is considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 19: Alice Springs major network incident summary[31]

ID	Date of incident	Description	Cause	UFLS/black	Incident duration (minutes)	Customers impacted	Customer minutes without supply
1	23-Dec-2018	Brewer 1 (22SD13) tripped	Transient feeder fault	UFLS stage 1A	26	2 238	35 684

The incident should not, under normal circumstances, lead to UFLS operation. Uterne did not ride through the event and so this may have been enough generation lost to require UFLS but it should have been within the spinning reserve margin. System Control's incident report recommends a review of the dispatch rules in Alice Springs to manage faults of this nature, which the commission considers should be undertaken in consultation with Territory Generation. Entura would further recommend an investigation of the loss of synchronism at Uterne and whether there is a need for more sophisticated controls to ensure customer or network equipment is not damaged from inadvertent reconnection out of synchronisation.

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

Impact of incidents

Table 20 shows the impact of major network incidents in Alice Springs. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 20: Alice Springs customer impact of major network incidents[32]

	2015-16	2016-17	2017-18	2018-19
Number of incidents	1	3	1	1
Customers impacted	7 500	15 030	2 600	2 238
Total duration (minutes)	63	226	20	27
SAIDI	38.3	110.0	4.1	5.0
SAIFI	0.61	1.23	0.21	0.18
Reliability (% of year)	0.007	0.021	0.001	0.001
System blacks				
Number	0	0	0	0

With only one incident again in 2018-19, the result is very similar to that from 2017-18.

Network constraints

Table 21 summarises the network constraints in the Alice Springs region.

Table 21: Alice Springs network constraints

	Constraint description	Applied to	Limit	System condition	Comments
1	Minimum operating level	Owen Springs power station	Dependent on Lovegrove load	Load dependent	Prevent overloading of Lovegrove Sadadeen ties 1 or 2 in the event of a contingency
2	66 kV lines	Owen Springs power station – Lovegrove	Single circuit operation	Low load	Reduces capacitive loading in the network
3	22/11kV transformers	Sadadeen	17 MVA	All	

Constraint 1 seeks to address a balancing problem in the network. However, in the long term this constraint may no longer be relevant as the majority of generation will be sourced from the Owen Springs power station, and therefore the minimum operating level of the constraint will be exceeded by normal dispatch.

Constraint 2 is unusual in the opinion of Entura. While line switching is an established method to reduce capacitive charging in the network, Entura is concerned the switching of this line poses an unacceptable risk to system security. Entura further expects this will not be an acceptable mode of operation once generation is solely located at the Owen Springs power station.

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

System Control has since advised in its latest biannual report (July to December 2019) and in discussions with the commission that this constraint has now been removed. Further, System Control advised that although the constraint existed, it was not applied in recent years due to the increased reliance on the Owen Springs power station to provide generation, and the deterioration in the reliability of generation at the Ron Goodin power station.

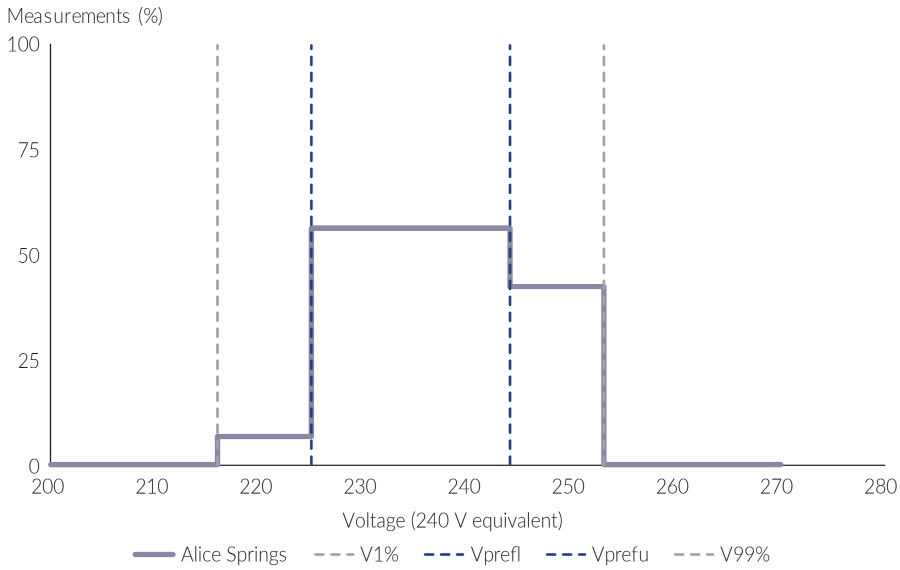
Constraint 3 is a simple thermal limit that addresses a limit to the flexibility of the Alice Springs network topography. These issues should be resolved where they impact on efficient dispatch.

Network customer power quality notifications

Low voltage quality

Figure 36 shows the steady state voltage distribution for the Alice Springs region in 2018-19.

Figure 36: Steady-state voltage performance, Alice Springs



The Alice Springs network topology does not lend itself to strong voltage regulation. This is particularly true when Ron Goodin power station units are not dispatched. The distance from Lovegrove to Owen Springs means a lot of charging or line drop must be managed at Lovegrove. It seems this is not possible. The relatively high penetration of rooftop solar in the Alice Springs urban area will also contribute to the high percentage of time customers experience higher than preferred voltages. This issue must be resolved.

Further, PWC advises there is a voltage control coordination issue when Ron Goodin power station units are dispatched. This issue should also be resolved, given the extended period the Ron Goodin power station will be in operation following the 13 October 2019 system black.

Quality of service complaints

Power Services reports on the number and types of power quality complaints. Figure 37 shows the Alice Springs customer notifications marginally increased in 2018-19.

Figure 37: Total customer notifications relating to the quality of supply in Alice Springs

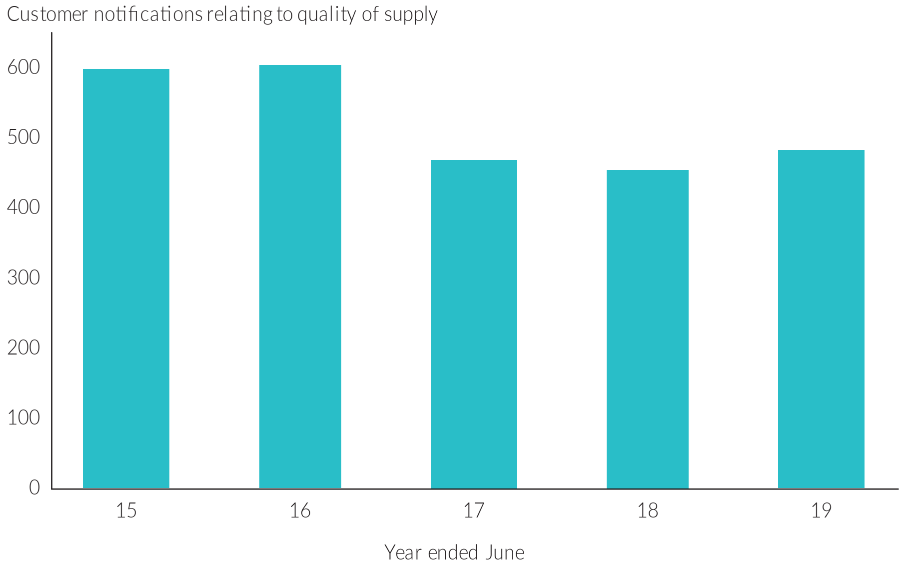
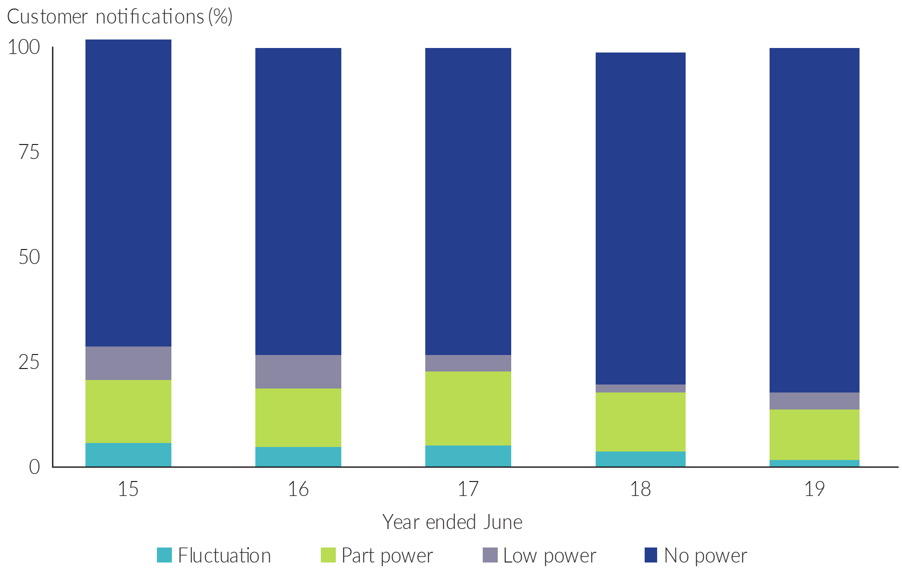


Figure 38 shows notifications are largely made in response to no power rather than in relation to part power or the quality of power.

Figure 38: Type of customer notifications relating to the quality of supply in Alice Springs



The share of 'no power' notifications has increased in the 2018-19 period.

Other customer complaints are summarised in Table 22.

Table 22: Number and nature of customer complaints 2018-19 for the Alice Springs power system

	Alice Springs total	
	Total	%
Reliability of Supply	8	19
Technical Quality of Supply	6	14
Admin Process/Customer Service	14	33
Augmentation		
Connection	1	2
Other	13	31
Total	**42**	

The commission notes a high percentage of 'other' complaints. The commission suggests Power Services consider expanding on the nature of reporting these complaints as identifying trends may be useful in responding to customer needs.

Planned and recent network enhancements

The following enhancements have been undertaken:

- UFLS: three feeders have been placed onto an interim scheme with the remaining envisaged to be transitioned over in the 2019-20 financial period
- the UFLS is again subject to review after the system black incident in late 2019.

3 | Tennant Creek power system

This chapter focuses on the 2018-19 generation and network performance of the Tennant Creek power system. Where possible it compares 2018-19 performance to historical data to identify trends. Specifically this chapter considers:

- overall customer impact
- generator performance, observed UFLS and single generator trips, generation availability, non-reliable periods, major generation incidents, generation constraints, generation planned and recent enhancements
- network performance, network utilisation, network adequacy, major network incidents, network constraints, network power quality notifications, quality of service complaints, network planned and recent enhancements.

Power system description

The Tennant Creek power system is the smallest of the regulated systems in the Territory. This system supplies the township of Tennant Creek and surrounding rural areas from its centrally located power station. The energy sent out by grid connected generators in 2018-19 is shown in Table 23.

Table 23: Tennant Creek energy sent out in 2018-19

Power system	Energy sent out (GWh)
Tennant Creek	30

The total non-summer (dry season) grid connected in front of the meter generation capacity in the Tennant Creek power system is around 25.75 MW, which includes three new Jenbacher generators. This does not include behind-the-meter rooftop solar PV generation capacity, which totalled around 0.4 MW in 2018-19. The fuel type of the generation units is currently made up of diesel and gas.

The power station at Tennant Creek has undergone a significant transformation with the commissioning of new generating units and the retirement of a large number of existing units. This was expected to be completed in late 2019, however remains outstanding at the time of writing this review.

Overall customer impact

This section shows the overall performance for the Tennant Creek power system.

Table 24 shows the impact on customers from major and minor incidents in the Tennant Creek region across the last three years.

The number of customers impacted and total duration (minutes) of an incident is reported by System Control to the commission as part of its SCTC obligations. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 24: Overall customer impact from major and minor incidents in the Tennant Creek region

	2016-17	2017-18	2018-19
Number of incidents	7	11	19
Customers impacted	3 780	6 435	16 825
Total duration (minutes)	225	1 784	667
SAIDI	93.7	363.2	587.0
SAIFI	2.47	4.00	10.82
Reliability (% of year)	0.018	0.069	0.112
System blacks			
Number	2	2	3

SAIDI and SAIFI continue to increase. 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, this would be added to the first incident and lead to a SAIDI of 2.5 minutes.

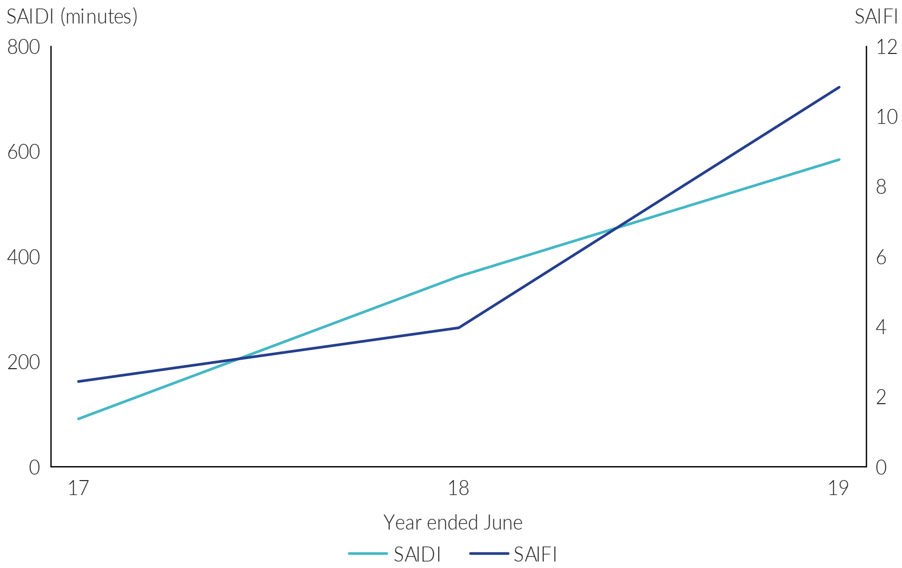
SAIFI is a measure of the average number of incidents weighted by the number of customers affected by each incident. Using the examples above, the SAIFI would be 0.1 after the first incident and 0.2 after the second incident.

Reliability (percentage of year) is calculated based on SAIDI, and is the percentage of a year the average duration of incidents per customer represents. This varies from the reliability standard[33] for generation of 0.002 per cent applied in the NEM, which is also adopted by the commission in its NTEOR reliability assessments in the absence of a formal Territory target.

Tennant Creek performance is worsening against each of these indices. The rise in SAIDI and SAIFI is shown in Figure 39. As customers are restored in stages, not all customers are impacted for the full duration of the incident. Therefore, SAIDI and SAIFI indicators derived from the number of customers impacted and total duration (minutes) of an incident may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

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

Figure 39: Overall SAIDI and SAIFI performance, Tennant Creek[34]



The commission has made recommendations elsewhere in this review regarding coordination of protection between generating units and feeders that may reduce the number and severity of incidents in the Tennant Creek system in the future. Discussions with Territory Generation and Power Services suggest that further work on SCADA commissioning will also enhance visibility of the power system. This should lead to decreased outage times and reduced customer impact.

Prior to writing the 2018-19 NTPSPR, through the monitoring of incidents and System Control's biannual reports, the commission identified a deterioration in the performance of the Tennant Creek power system during 2018-19. The commission observed that customers in Tennant Creek received a significantly lower level of performance compared to the overall Territory level, particularly in relation to the frequency of incidents, with five of the 13 incidents in the second half of 2018-19 impacting more than 79 per cent of customers, and a group of 47 customers impacted by all 13 incidents. Further, during the same period, the commission understands that 90 per cent of single generator trips in Tennant Creek resulted in UFLS. This compares to 3.7 and 0 per cent in Darwin-Katherine and Alice Springs, respectively.

As a result of these observations, the commission wrote to PWC and Territory Generation on 30 September 2019 to highlight its concerns and request a response to explain the poor performance in the system from their perspectives, along with advice on how the two licensees may address the issues to improve the level of service to customers. In the letter, the commission acknowledged that managing a system such as Tennant Creek may be challenging, however the commission considers that customers in Tennant Creek, which is a regulated system, should receive a level of service similar to that provided in the Darwin-Katherine and Alice Springs systems.

Territory Generation provided a response on 15 November 2019, and a further response on 13 February 2020, which included an update of the actions Territory Generation is progressing to improve the performance of generation in Tennant Creek. PWC provided a response on 25 March 2020, which outlines the cause of the increase in incidents, the short-term solution and potential long-term solutions.

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

Territory Generation acknowledged the reduced performance in 2018-19, while PWC acknowledged there had been an increase in the number of single contingency outages.

PWC stated there has been a change in generation dispatch following the completion of Territory Generation's recent major project, which included the installation of three new Jenbacher generators (T19, T20 and T21). This resulted in the removal of the T15 generator at the Tennant Creek power station from normal dispatch and increased use of the new Jenbacher generators. The older T15 generator is a large, high inertia machine, while the new Jenbacher generators are smaller and more efficient but provide substantially less inertia. PWC states the reduction in online dispatched inertia has resulted in a larger number of trips, leading to UFLS. Where UFLS did not occur, the impact was often greater (that is, a system black).

PWC also advised the commission that network faults and the power system response is similarly impacted by this reduction in inertia. Further, while restoring feeders during an incident, the step change in load exceeds the capability of online generation to respond without the system frequency dropping below UFLS thresholds, prolonging the restoration.

Territory Generation stated System Control issued a series of risk notices around September 2019 that updated a number of security requirements and generator dispatch merit order. From PWC's letter, the commission understands this mainly involves returning the T15 generator to the dispatch order, with this generator running at all times. PWC states this is a short-term solution that will increase Territory Generation's operating costs. However, the solution will return the overall power system performance to closer to long-term averages.

In addition to the System Control risk notices, Territory Generation stated that following the commission's letter, it undertook an immediate review of the performance of its generation assets to identify actions that could be implemented to improve performance and commenced a body of work to investigate further measures.

Territory Generation advised it has considered recent changes to the power system and engaged with system participants, including Jemena, and as a result implemented an updated operating approach with its power station, which effectively adds an additional 1 MW of reserve.

Based on data provided by Territory Generation and the commission's observations from incident reporting following the changes made by System Control and Territory Generation, there appears to be an increase in performance from the end of October 2019. However, the commission notes that while the improved level of performance is good for the customers of Tennant Creek, the changes made, such as carrying extra reserve and prioritising more secure but potentially less efficient generators, will lead to increased costs.

PWC advised the commission that the long-term solution to addressing the issues in the Tennant Creek power system at a high level includes network and generation augmentation and protection changes. To support this view, PWC noted the installation of similar Jenbacher generators by Territory Generation in Alice Springs was coupled with an engineering solution to address the low inertia and step response of the Jenbacher generators, being the installation of the BESS.

The commission consider any long-term solution should be carefully and appropriately considered by licensees and government, including a thorough cost benefit analysis, to ensure the best outcome for Tennant Creek customers and Territory taxpayers.

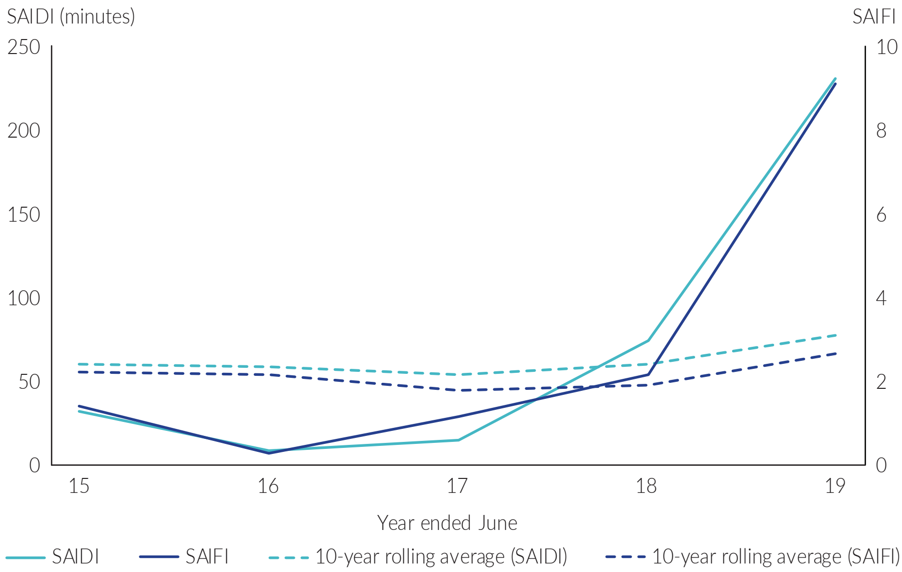
Generation

The generation system performed poorly in 2018-19 with a higher SAIFI result compared to historical data. Entura expects this to improve once the new generators are fully commissioned and 'bedded down', and the old machines are decommissioned.

Generator performance

The SAIDI and SAIFI performance for the Tennant Creek generating units is shown in Figure 40.

Figure 40: SAIDI and SAIFI performance for generation, Tennant Creek



The performance in the 2018-19 period is the worst result for Tennant Creek in over 10 years. The frequency and duration of incidents, while not individually unprecedented in the Territory in the last 20 years, combined contribute to one of the worst reported results across the Territory in that timeframe. Entura expects improvements in this performance, particularly as the new Jenbacher units 'bed in'. However, this may require longer-term solutions to assist further performance improvements or to fully utilise the new Jenbacher generators, such as generation dispatch constraints or an engineering solution, as discussed earlier in this review.

Observed UFLS and single generator trips

It is rare for a single unit trip to not result in UFLS in Tennant Creek due to the minimum spinning reserve approach taken in this power system. Generation trips were common in Tennant Creek in 2018-19. These trips, which resulted in major incidents, are discussed in the generation incident section of this chapter.

Generation availability

A number of indices are calculated as per the EIP Code for generating units to reflect their availability. The factors discussed in the following sections are:

- availability factor (full and unplanned) – the availability factor represents the percentage of time a unit is available to generate. The unplanned availability factor is the percentage of time the unit is available other than for forced outages. The difference between these two indices is the planned outages and de-rating effect

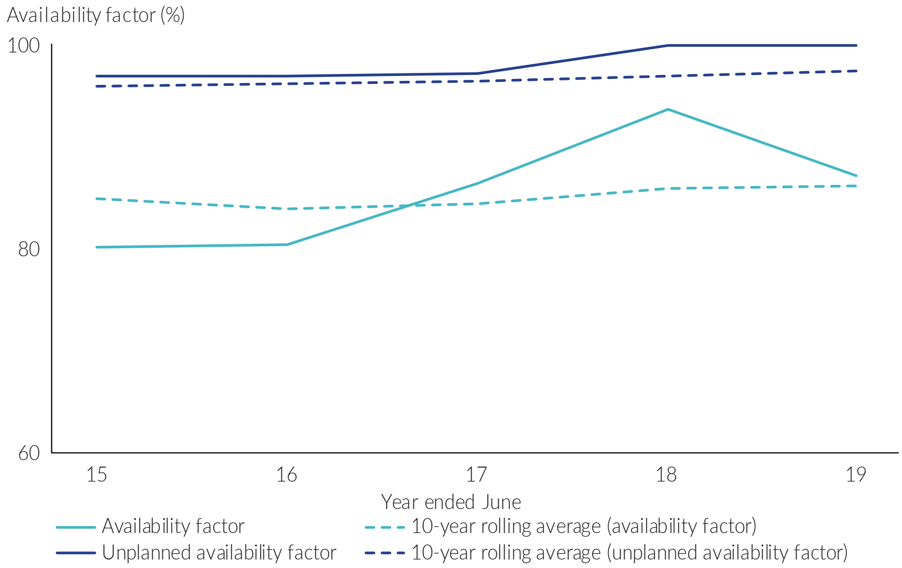
- forced outage factor – the forced outage factor is the percentage of time the unit is not available for dispatch due to an internal fault. This includes time taken to repair the unit if it is damaged or an element requires replacement or refurbishment due to an incident that is unplanned.

The measures provide some insight into the availability of the generating units and allow an assessment to be made as to the security of supply.

Availability factor

The availability for the generators has decreased slightly in 2018-19 but remains above the 10-year average (see Figure 41).

Figure 41: Availability factor for generation, Tennant Creek

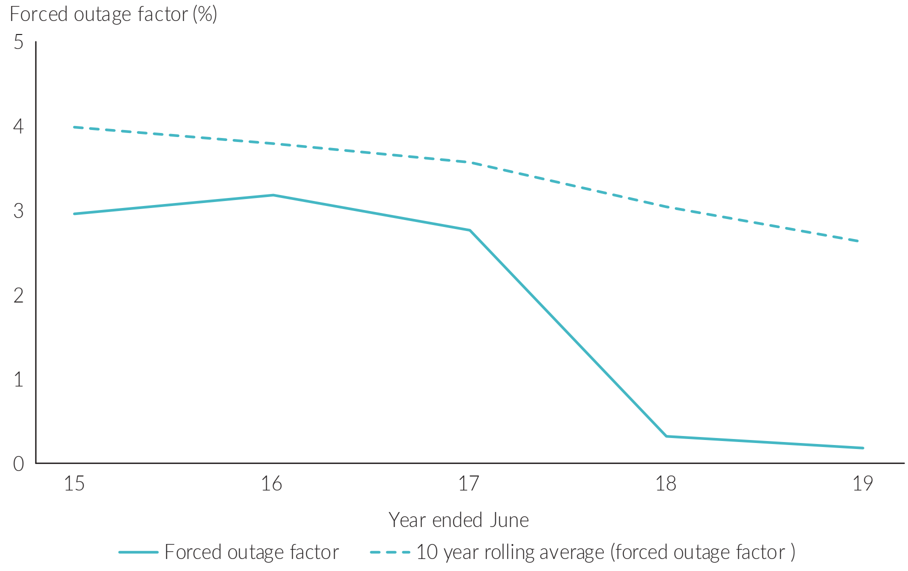


When read in conjunction with the forced outage factor, this is a good result. The forced outage factor remains low while the availability factor has also lowered. This indicates a higher degree of planned unavailability. While excessive planned unavailability is not ideal, it represents preventative maintenance type activities and withdrawal from service of units that are of questionable reliability. This, from a system management perspective, is preferable due to the reduced customer impact. Therefore, even though the SAIFI performance was poor, it may well have been worse if a higher availability had been attempted.

Forced outage factor

The forced outage factor remains low in 2018-19 (Figure 42).

Figure 42: Forced outage factor for generation, Tennant Creek



This is clearly an exceptionally good result. Tennant Creek is a challenging power system to operate, however 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 declared when the system operator finds they cannot maintain power system reliability. There are a number of causes for this state such as:

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

There were no instances of non-reliable periods across 2018-19 in Tennant Creek. The system is simple and the abundance of generation options should lead to this level of reliability.

Generation incidents

There were fourteen major generation incidents in the Tennant Creek system in 2018-19. The incidents are summarised in Table 25.

Customer minutes without supply, which is shown in the Table 25, is calculated by multiplying the number of customers impacted by the total incident duration (minutes). The commission notes that as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, the customer minutes without supply indicator shown in the table may be overstated, and is considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 25: Tennant Creek generation major incident summary[35]

ID	Date of incident	Description	Cause	UFLS/black	Incident duration (minutes)	Customers impacted	Customer minutes without supply
1	18-Aug-2018	Set 15 and set 16 trip/22TC05 tripped	Operation of incorrect circuit breaker/ operational error	UFLS stages 1 and 3A	17	704	11 968
2	26-Sep-2018	Generator 15 tripped	Fire testing procedure issues/ operational error	All UFLS stages (1, 3A, 4A, and BU)	20	1 684	33 680
3	24-Nov-2018	Gen 15 tripped	Equipment failure	All UFLS stages (1, 3A, 4A, and BU)	47	1 684	79 148
4	3-Feb-2019	Set 19 tripped	Unit T19 tripped/ operational error	UFLS stage 1	12	47	564
5	14-Feb-2019	Set 16 tripped	Equipment failure	UFLS stage 1	5	108	540
6	17-Feb-2019	Set 10 tripped	Equipment failure	UFLS stage 1	17	108	1 836
7	21-Feb-2019	Set 10 tripped	Equipment failure	UFLS stage 1	10	108	1 080
8	22-Feb-2019	Set 10 tripped	Equipment failure	UFLS stage 1	13	108	1 404
9	25-Feb-2019	Set 20 tripped	Equipment failure	UFLS stage 1	7	108	756
10	23-Mar-2019	Set 19 tripped	Dispatch issues	UFLS stage 1,3A , 4A	18	1 454	22 068
11	29-Mar-2019	Gen 15 tripped	Contractor error	All UFLS	17	1 226	24 718
12	18-Apr-2019	Gen 21 tripped	Equipment failure	UFLS stage 1	7	1 454	756
13	3-Jun-2019	Gen 21 tripped	Transient fault	UFLS stage 1	15	49	735
14	10-Jun-2019	TCPS set 21 tripped	Equipment failure	UFLS stage 1, 3A, 4A	30	1 226	36 780

The incidents fall into two main categories, namely operational errors and generation equipment failure:

1. Operational errors (Incidents 1, 2, 4, 10 and 11)

Planning for unusual plant operation is critical in avoiding incidents caused by testing or pushing generating units into regions where they should not operate. These incidents show not enough care and attention is applied to the planning of testing or the management of generating unit loading under changed conditions. The recommendations from these incidents should be sufficient to provide greater assurance in the future. Entura remains concerned that there is insufficient scrutiny of third-party work procedures.

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

2. Generation equipment failure (Incidents 3, 5 to 9 and 12 to 14)

These incidents all point to the delicate nature of the Tennant Creek power system. The size of single units, their minimum load and the low levels of demand make managing spinning reserve in an efficient way difficult. This then leaves customers exposed to single unit trips. There are a large number of these trips mainly due to the commissioning and 'bedding down' of the newer generating units and the new switchgear. The incidents, though frequent, are being managed quickly (that is, there are a lot of events but they are generally of short duration) and so the expectation would be that both indices improve or approach acceptable once these 'teething' issues are managed and the SCADA upgrade is completed.

Impact of incidents

Table 26 shows the impact of major generation incidents in Tennant Creek. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 26: Tennant Creek customer impact of major generation incidents[36]

	2015-16	2016-17	2017-18	2018-19
Number of incidents	5	4	2	14
Customers impacted	500	1 730	154	10 068
Total duration (minutes)	153	91	27	261
SAIDI	9.4	24.2	1.1	169.3
SAIFI	0.31	1.13	0.10	6.47
Reliability (% of year)	0.002	0.005	0.000	0.032
System blacks				
Number	0	1	0	2

Generation incidents had a very high customer impact in 2018-19. The performance of the generating units in Tennant Creek continues to be of concern.

Generation constraints

No 'normal' generation constraints are applied to the Tennant Creek power system.

Planned and recent enhancements

The completion of the generation upgrade consisting of the installation and commissioning of the new Jenbacher units is the main enhancement completed in 2018-19.

The diesel Cummins unit (T18) is still undergoing compliance testing. This was scheduled to be completed in late 2019.

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

Network

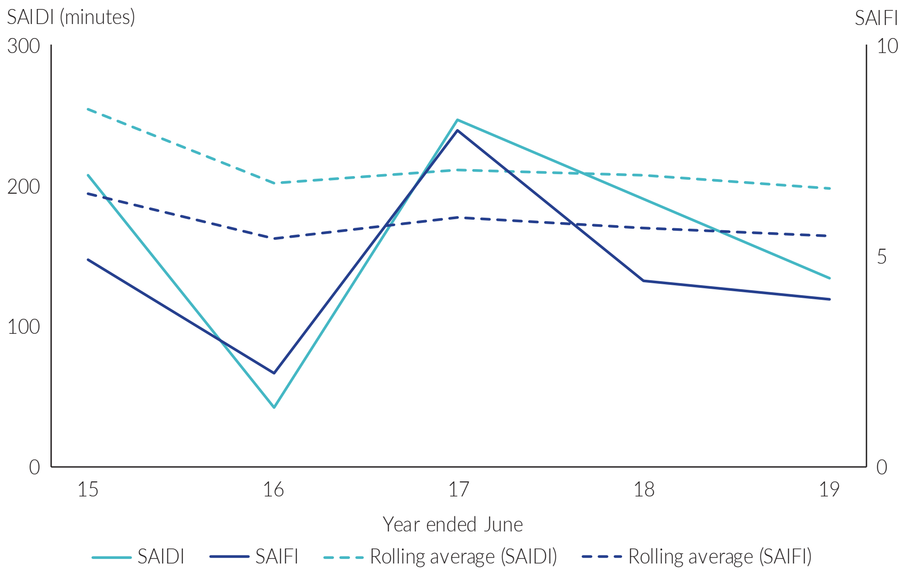
This network has a single zone substation and a maximum voltage of 22 kV.

Network performance

There is no transmission infrastructure in the Tennant Creek network.

The SAIDI and SAIFI performance for the Tennant Creek network is presented in Figure 43.

Figure 43: Adjusted SAIDI and SAIFI performance for the Tennant Creek network[37]



SAIDI and SAIFI for the Tennant Creek network continue to track in the range of the long-term average. The performance is better than the rural short feeder global target in both cases. This is a very good result considering the nature of the network.

Power Services identifies the worst performing feeders for each category as per the EIP Code. Power Services has only identified one feeder in the Tennant Creek region as problematic, which is summarised in Table 27.

Table 27: Tennant Creek worst-performing distribution feeders

Feeder category	Feeders	SAIDI	Mitigation planned
Urban	22TC01 Ali Curung	78.36	An upgrade to the feeder recloser

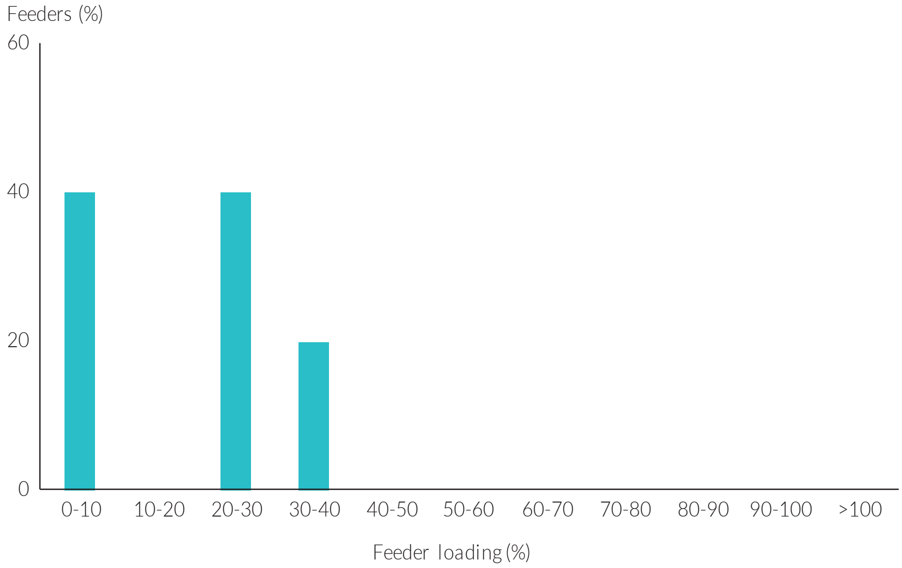
The high SAIDI for this feeder represents over half of the Tennant Creek SAIDI for 2018-19. The feeder recloser upgrade should allow better sectionalising of the feeder so fewer customers are exposed to outages depending on where line faults occur along the length of the feeder.

Network utilisation

The feeder utilisation distribution is shown in Figure 44.

37 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.

Figure 44: Feeder loading distribution, Tennant Creek



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

Network adequacy

The substation remains close to capacity under N-1 conditions.

Network incidents

There were five major network incidents in Tennant Creek in 2018-19 (see Table 28).

Customer minutes without supply, which is shown in Table 28, is calculated by multiplying the number of customers impacted by the total incident duration (minutes). The commission notes that as customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, the customer minutes without supply indicator shown in the table may be overstated, and is considered a 'worst case'. However, the commission considers the results and trends to be indicative.

Table 28: Tennant Creek major network incident summary[38]

ID	Date of incident	Description	Cause	UFLS/black	Incident duration (minutes)	Customers impacted	Customer minutes without supply
1	15-Nov-2018	Warrego (22TC09) feeder tripped	Equipment failure	UFLS stage 1, 3A,4A	272	1 684	458 048
2	21-Nov-2018	Warrego (22TC09) feeder tripped	Weather/ lightning strike	System black	79	1 684	133 036
3	22-Nov-2018	Threeways (22TC07) feeder tripped	Transient fault	UFLS stage 1	12	1 247	14 964
4	23-Mar-2019	Transient fault on 22TC07 three ways feeder CB trip on instantaneous OC/EF	Transient fault	UFLS stage 1	25	704	17 600
5	29-Jun-2019	Double feeder fault (22TC07/ Threeways and 22TC01/ Ali Curung)	Transient	UFLS all stages	18	1 438	25 884

The incidents fall into two categories, namely equipment failure and transient faults:

1. Equipment failure (incident 1)

This is a borderline network incident. The incident is started by a network event, however is made more severe due to the failure of a generating unit. It is more akin to the events described in the generation incident section.

2. Transient faults (incidents 2 to 5)

Transient faults are inevitable in a power system. Smaller power systems are less resilient to these faults because of higher impedances, lower fault levels and smaller numbers of generating units. Most of these incidents are exacerbated by a generating unit also tripping. The recommendations stemming from the investigations into these faults should be considered carefully by Power Services and Territory Generation to try and eliminate avoidable tripping by ensuring protection equipment (both primary and secondary) is designed, installed, commissioned and maintained to standard. The Tennant Creek network continues to be unduly affected by unreliable performance of a range of control and protection functions. This should not be allowed to continue.

Impact of incidents

Table 29 shows the customer impact of major network incidents. As customers are restored in stages, not all customers are impacted for the full duration of an incident. Therefore, indicators derived from the number of customers impacted and total duration (minutes) of an incident to show the impact on customers, such as SAIDI and SAIFI, may be overstated and are considered a 'worst case'. However, the commission considers the results and trends to be indicative.

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

Table 29: Tennant Creek customer impact of major network incidents[39]

	2015-16	2016-17	2017-18	2018-19
Number of incidents	1	2	8	5
Customers impacted	100	1 500	6 181	6 757
Total duration (minutes)	17	66	1 218	406
SAIDI	1.0	45.1	328.6	417.7
SAIFI	0.061	0.980	3.842	4.345
Reliability (% of year)	0.000	0.009	0.063	0.079
System blacks				
Number	0	1	2	1

The table shows a similarly unacceptable result to last year. All indices are the worst recorded across the four-year period but from fewer incidents than for the previous year. The management of incidents and the post-event recovery must become a focus for System Control and local operators. This should be facilitated by the commissioning of the upgraded SCADA system.

Network constraints

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

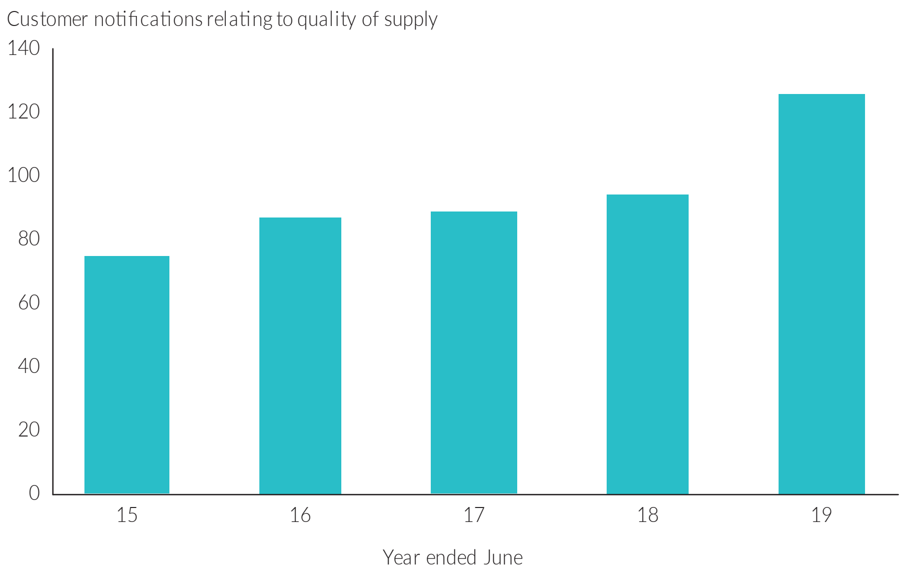
Network power quality notifications

Network power quality notification data is not reported by PWC in relation to the Tennant Creek network.

Quality of service complaints

Power Services reports on the number and types of power quality complaints. Figure 45 shows the Tennant Creek customer notifications increased markedly in 2018-19.

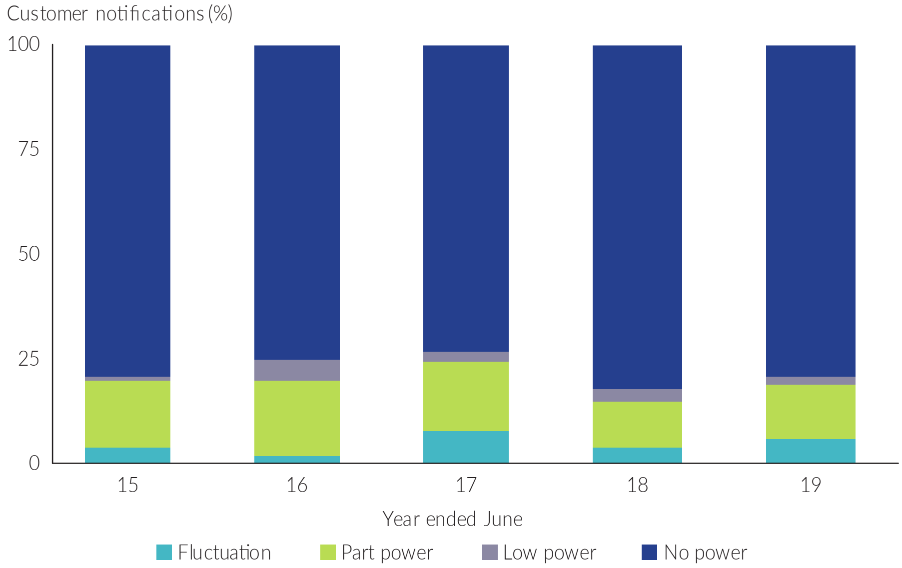
Figure 45: Total customer notifications relating to the quality of supply in Tennant Creek



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

Figure 46 shows notifications are largely made in response to no power rather than in relation to part power or the quality of power.

Figure 46: Type of customer notifications relating to the quality of supply in Tennant Creek



The share of 'part power' notifications has increased in the 2018-19 period.

Other customer complaints are summarised in Table 30.

Table 30: Number and nature of customer complaints 2018-19 for the Tennant Creek power system

	Alice Springs total	
	Total	%
Reliability of supply		
Technical quality of supply	1	14
Admin process/customer service	3	43
Augmentation		
Connection		
Other	3	43
Total	**7**	

The commission notes a high percentage of 'other' complaints. The commission suggests Power Services consider expanding on the nature of reporting these complaints as identifying trends may be useful in responding to customer needs.

Planned and recent network enhancements

The following enhancements have been complete in the 2018-19 period:

- all feeders and the two 22/11 kV transformers now have event data recorders fitted to provide better fault analysis
- SCADA: Tennant Creek power station SCADA was commissioned, tested and completed in early 2019.

Both of these developments will help System Control more accurately diagnose the numerous system incidents that occur in Tennant Creek. This should lead to improved performance over time. It is hoped the SCADA upgrade will provide better visibility of the station operations and ensure generating units are maintained within their minimum and maximum loading levels in a more consistent manner. This should avoid some generator trips.

Appendix A: Additional electricity industry performance

This appendix includes data from Power Services' EIP Code reporting that is not region specific. The data covers performance relating to:

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

Distribution feeders

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

- CBD
- urban
- rural short
- rural long.

The results for 2018-19 are shown in Table 31.

Table 31: SAIDI and SAIFI performance by feeder type

	Adjusted SAIDI (minutes)			Adjusted SAIFI (interruptions)		
	Target standard[40]	Actual Performance	Result	Target standard[41]	Actual performance	Result
CBD	4.0	14.20	Target not met	0.1	0.20	Target not met
Urban	140.0	70.44	Target met	2.0	1.66	Target met
Rural short	190.0	172.10	Target met	3.0	3.04	Target not met
Rural long	1 500.0	1 447.27	Target met	19.0	15.68	Target met
Whole of network	175.8	132.08	Target met	2.6	2.40	Target met

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

The results are shown graphically in Figure 47.

40 Target standards for a regulatory control period are submitted by PWC 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.

Figure 47: Historical feeder performance by feeder type

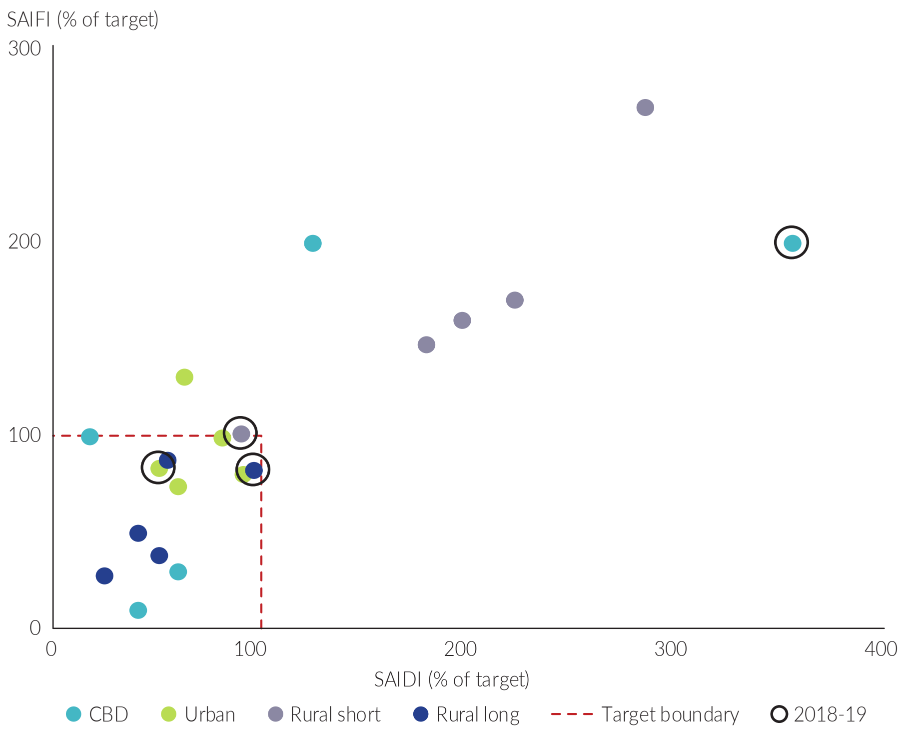


Figure 47 shows that generally the SAIDI and SAIFI targets are met for the rural long and urban feeders, and this is the case in 2018-19. The CBD feeder performance has varied across the last five years, however 2018-19 is the worst performance across that period. The rural short feeder performance is generally outside the target and remains so by a small margin in 2018-19.

A range of actions are being undertaken by Power Services across the three networks to address the performance shortfall for the CBD and rural short feeder classes. These actions include hardware upgrades, replacement and improvements to switchgear.

These actions are in-line with the agreed best endeavours approach to these targets. However, failure to meet these targets on an ongoing basis will draw closer inspection by the commission.

Phone answering

The EIP code (section S.3.6.3) requires reporting on telephone call answering for all calls taken by PWC in the Territory. The reporting requirements changed in 2017-18 with the commencement of the EIP Code, however 2018-19 was the first year Power Services reported against the new requirements. No historical data is available for the performance indicators prior to this.

Table 32: Telephone answering performance

	2018-19
Number of calls received	11 344
Calls to fault line – average waiting time before call answered	6 seconds
Number of calls not answered within 30 seconds	3 774
Percentage of calls not answered within 30 seconds	33%
Number of calls abandoned	881
Percentage of calls abandoned	8%

As no historical data is available for comparison, and the Australian Energy Regulator does not publish a report that compares distribution network service providers' telephone answering performance, the commission's 2018-19 Northern Territory Electricity Retail Review and the Australian Energy Regulator's 2018-19 Annual Retail Markets reports have been used to provide a benchmark.

For the 'level of calls not answered within 30 seconds' performance indicator, PWC achieved a similar level of performance as Jacana Energy of around 33 per cent. This level of performance is in the middle of that reported by the six major National Energy Customer Framework (NECF) retailers.

PWC achieved a lower level of performance than Jacana Energy for the 'percentage of calls abandoned' performance indicator of 8 per cent, compared to Jacana Energy, which achieved a level of around 4 per cent. Further, PWC's performance regarding this indicator was in the bottom half of that reported by the six major NECF retailers.

PWC's phone answering, and in particular the number of calls abandoned before being answered, will be monitored by the commission for trends in subsequent reviews.

New connections

Table 33 shows the average time taken to provide network access to new subdivisions where minor extensions or augmentation is required.

Table 33: New connections in urban areas to new subdivisions

	2015-16	2016-17	2017-18	2018-19
Total	83	53	60	58
Average weeks	11.1	10.8	11.45	9.96

The average time taken to complete new connections has reduced in 2018-19 compared to the previous three years. The volume of these new connections has been relatively stable for the last three years.

Guaranteed service level payments

PWC makes payments to customers where they do not meet guaranteed service levels (GSL) as set out in the EIP Code. These payments are shown in Table 34.

Table 34: Guaranteed service level payments

GSL Measure	Performance indicator	2015-16		2016-17		2017-18[41]		2018-19	
		No.	Amount $	No.	Amount $	No.	Amount $	No.	Amount $
Duration of a single interruption	Between 12 and 20 hours	299	23 920	1	80	139	11 120	5	400
	More than 20 hours	1	125	0	0	0	0	1	125
Frequency of interruptions	> 12	n.a.	n.a.	n.a.	n.a.	1 225	98 000	2734	218 720
	> 16 (rural feeders)	369	29 520	468	37 440	n.a.	n.a.	n.a.	n.a.
	> 12 (urban feeders)	365	29 200	0	0	n.a.	n.a.	n.a.	n.a.
Cumulative duration of interruptions	> 20 in a financial year	767	95 875	476	59 500	578	72 250	633	79 125
Time for establishing a connection	Reconnection > 24h[42]	8	1 150	25	3 350	17	1 700	12	2 900
	New connection > 5 business days[43]	20	3 700	33	6 850	27	5 400	2	250
Time for giving notice of planned interruptions	< 2 business days	212	10 600	209	10 450	472	23 600	159	7 950
Keeping appointments	> 30 minutes outside agreed time[44]	0	0	0	0	1	20	0	0
Total payments			**194 090**		**117 670**		**212 090**		**309 470**

n.a.: not applicable

The total GSL payments have been trending up since 2015-16 to a total of $309 470 in 2018-19, which has been largely driven by increases in payments related to the frequency of interruptions (2734 payments and $218 720 in 2018-19). Other GSL payment catagories have either been steady or fluctuated across the last four years. The commission will continue to monitor GSL payments in future reviews, particularly in relation to the frequency of interruptions, and investigate further if required.

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

Appendix B: Glossary

BESS	battery energy storage system
CBD	central business district
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
DAPR	Distribution Annual Planning Report
EDL	EDL NGD (NT) Pty Ltd
EIP Code	Electricity Industry Performance Code
Eni	Eni Australia Limited
GPS	Generator Performance Standards
GSL	guaranteed service level
GWh	gigawatt hours, 1GWh = 1 billion watt hours
kV	kilovolt, 1kV = 1 thousand volts
Major incident	A major reportable incident as defined in section 7.3.2 of the System Control Technical Code version 6
Minor incident	A minor reportable incident as defined in section 7.3.3 of the System Control Technical Code version 6
MSR	minimum spinning reserve
MVA	megavolt ampere
MW	megawatt, 1MW = 1 million watts
NECF	National Energy Customer Framework adopted by the Australian Capital Territory, New South Wales, Queensland, South Australia and Tasmania
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)
OEM	original equipment manufacturer
POE	point of exceedance
PSR	Power System Review
PWC	Power and Water Corporation
PV	photovoltaic
Regulated systems	Northern Territory power systems subject to economic regulation, which are the Darwin-Katherine, Tennant Creek and Alice Springs power systems

Regulatory minister	Minister for Renewables, Energy and Essential Services
RoCoF	rate of change of frequency
SCADA	supervisory control and data acquisition
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
UFLS	under frequency load shedding