UTILITIES COMMISSION

Power System Review

2013-14

May 2015

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Purpose of this Report

The Power System Review (Review) is prepared by the Utilities Commission (Commission) in accordance with section 45 of the *Electricity Reform Act* (ER Act).

Regular power system reporting aims to provide the routine release of comprehensive and authoritative data to industry participants, prospective participants, customers, regulators and policymakers, in order to:

- support planning and monitoring activities by providing data to assist identification of the optimal investment options and facilitate coordination of investment actions;
- advise on system performance against the price and service expectations; and
- assist in holding electricity businesses accountable for reliability performance outcomes.

The Review provides information on the performance of the power system including:

- planning information, which include demand forecasts, the adequacy of system capacity relative to forecast demand, and knowledge of planning and investment commitments;
- the performance and health of the system, which includes information on system performance trends, regulatory and technical compliance (including equipment capability relative to security standards), and the findings of investigations into power system incidents; and
- outcomes experienced by customers.

Disclaimer

The Review is prepared using information sourced from participants of the electricity supply industry, Northern Territory Government agencies, consultant reports, and publicly available information. The Commission understands this information to be current as at December 2014. Where there have been significant developments post December 2014, the Commission has noted these developments throughout the report.

The Review contains predictions, estimates and statements based on the Commission's interpretation of data provided by electricity industry participants and assumptions about the power system, including load growth forecasts and the effect of potential major developments in particular power systems. The Commission considers that the Review is an accurate report within the normal tolerance of economic forecasts.

Any person using the information in the Review should independently verify the accuracy, completeness, reliability and suitability of the information and source data. The Commission accepts no liability (including liability to any person by reason of negligence) for any use of the information in this Review or for any loss, damage, cost or expense incurred or arising by reason of any error, negligent act, omission or misrepresentation in the information in this Review or otherwise.

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Glossary

Term	Definition
2P Reserves	Proved and probable reserves
ER Act	*Electricity Reform Act*
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AMS	Agreed Minimum Standard
CIPS	Channel Island Power Station
DNSP	Distribution Network Service Provider
ESOO	Electricity Statement of Opportunities published by AEMO – provides technical and market data and information regarding investment opportunities in the NEM over the next ten years
ESS Code	Electricity Standards of Service Code
EUE	Expected Unserved Energy
Feeder	Any of the medium-voltage lines used to distribute electric power from a substation to consumers or to smaller substations
FiT	Feed-in-Tariffs
GMC	Sustainable Installed Capacity
GWh	Gigawatt hour
IPP	Independent power producer. Licensed IPPs are parties who do not wish to participate fully in the electricity supply market and generate electricity under contract for another generator
Jacana Energy	Power Retail Corporation, a government owned corporation established in accordance with the *Government Owned Corporations Act* and trading as Jacana Energy
kV	Kilovolt
LNG	Liquefied Natural Gas
LOLP	Loss of load probability – probabilistic analysis of the adequacy of generation capacity
MD	Maximum demand
MW	Megawatt
MVA	Megavolt ampere
N-X	Planning criteria allowing for full supply to be maintained to an area supplied by N independent supply sources, with X number of those sources out of service
NEM	National Electricity Market
NER	National Electricity Rules

NMP	Network Management Plan (prepared by PWC)
P50	Maximum demand projection that is expected to be exceeded, on average, five years in 10 (or one year in two)
p.a	Per annum
Power system	Refers to the Darwin-Katherine power system, Tennant Creek power system and/or the Alice Springs power system
Probabilistic analysis	Analytical tool for determining the likely range of outcomes over a system as a whole arising from a series of individual events.
PV	Photovoltaic
PWC	Power and Water Corporation[1]
PWC Networks	The networks business division of PWC
RGPS	Ron Goodin Power Station
Region	Refers to the Darwin Region, Katherine Region, Tennant Creek Region and/or the Alice Springs Region
Regulatory bargain	Optimisation of the price, service levels and risk relationship between distribution businesses and customers embodied in a regulatory decision
Reserve plant margin	Total system capacity available less the actual maximum demand (MD) for electricity in a particular year, expressed as a percentage of MD.
SAIDI	System Average Interruption Duration Index – The average number of minutes that a customer is without supply in a given period
SAIFI	System Average Interruption Frequency Index – The average number of times a customer's supply is interrupted in a given period
Spinning reserves	The ability to immediately and automatically increase generation or reduce demand in response to a fall in frequency
Territory Generation	Power Generation Corporation, a government owned corporation established in accordance with the *Government Owned Corporations Act* and trading as Territory Generation
TNSP	Transmission Network Service Provider
UFLS	Under Frequency Load Shedding – Reducing or disconnecting load from the power system to restore frequency to the normal operating range
VCR	Value of Customer Reliability
WA WEM	Western Australian Wholesale Electricity Market
WPS	Weddell Power Station
ZSS	Zone Substation

[1] From 1 July 2014, the generation and retail business units of Power and Water Corporation were structurally separated into standalone government owned corporations under the *Government Owned Corporations Act*. This Review relates to the period prior to structural separation of Power and Water Corporation.

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1. Executive Summary

1.1 Purpose of the Power System Review

On an annual basis, the Utilities Commission (Commission) is required by the *Electricity Reform Act* (ER Act) to prepare a Power System Review (Review) that reports on power system performance and capacity in the Northern Territory.[2]

The Review relates to the Darwin-Katherine, Alice Springs and Tennant Creek power systems (referred to as the market systems) and is prepared with the assistance and advice of participants in the electricity supply industry, other electricity industry stakeholders and consultant reports.

In December 2012, the Commission released a new Electricity Standards of Service Code[3] (ESS Code), which establishes standards of service and performance measures in the electricity supply industry. The ESS Code forms the basis for monitoring and enforcing compliance with and promotion of improved standards of services for this and future reviews. The 2013-14 Review is the first year that PWC is required to report in accordance with the ESS Code including against targets set for distribution and transition performance.

For the 2013-14 Review, the Commission engaged Entura, engineering consultants with expertise in all aspects of the energy supply market, to provide advice regarding to the generation, network, overall power system and customer service aspects of the review. Entura partnered with Marsden Jacob Associates and MDQ Consulting to provide advice relating to demand forecasting, gas markets, fuel supply and overall power system reporting analysis.

1.2 Objective of the 2013-14 Review and Report Structure

In addition to its statutory requirements, the Commission's aim is for the Review to be used as a strategic planning tool to provide authoritative data to support the identification of the most economic options for augmentation and expansion of infrastructure to maintain security and reliability standards on a cost-effective basis for the long-term benefit of Territory customers.

Regular reporting of performance should also allow comparison of power system performance between jurisdictions, in particular, systems with similar characteristics (such as geographical and environmental factors).

Regular and comprehensive reporting on power systems, and distribution network performance and health is a feature of the electricity supply industry elsewhere in Australia. Consistent with good electricity industry practice and noting the Northern Territory Government's regulatory reform agenda for the electricity market[4], the Commission continues to transition reporting requirements in the Territory to be consistent with those of the National Electricity Market (NEM).

The objective of the Review is to produce not just an obligatory reporting mechanism for regulated entities but also a strategic planning tool to provide authoritative data to support the identification

[2] Section 45, *Electricity Reform Act*.

[3] Available from the Commission's website, www.utilicom.gov.au.

[4] Department of Treasury and Finance, Northern Territory Electricity Market Reform, Information Paper, February 2014, http://www.treasury.nt.gov.au/PMS/Publications/Economics/Electricity%20Market%20Reform/I-EMR-2014.pdf

of the most economic future options for augmentation and expansion of electricity infrastructure in the Territory to maintain security and reliability standards on a cost-effective basis.

The Commission's overall objective is that the Review provides the following key information:

- data to support the identification by market participants of the most economic future options for augmentation and expansion of infrastructure to maintain security and reliability standards;
- credible and dependable medium and long-term forecasts of future supply and demand conditions under various scenarios;
- possible future generation, transmission and distribution capacity constraints (projected system adequacy for medium and long term), taking into account maintenance and outage plans;
- integration with the planning and maintenance management of infrastructure assets;
- analysis of generation, transmission and distribution performance data;
- adequacy of sources of fuel for electricity generation for the medium and long term;
- analysis of generation and networks reliability performance, and customer service performance information; and
- analysis of power system incidents and identification of underlying systemic issues.

For the 2013-14 Review, the Commission continues to place considerable focus on actual system availability (generation and networks) to assess the security and reliability of the system, including voltage, forced outage rates and spinning reserve.

2013-14 Report Structure

The 2013-14 Review covers the following components:

- overall power system issues;
- maximum demand (MD) projections;
- generator adequacy and reliability;
- generation performance;
- fuel supply;
- network adequacy; and
- customer service performance.

1.3 Key Findings

The Commission’s key findings for the 2013-14 Review are detailed below.

Overall Power System Issues

- The Darwin-Katherine power system is not as reliable as it should be and effectively declined during 2013-14. On 12 March 2014, there was a System Black caused by action taken by Power and Water Corporation (PWC) in response to a malfunctioning circuit breaker. The various responses, including failures of the black start generators, to the System Black incident either exacerbated or extended the incident. In addition to the System Black incident, there were a significant number of generation related load shedding events that were not due to insufficient generation capacity, but rather the dynamic response of some generator units (at times not being able to respond appropriately following an outage of a single generator unit).

- The Alice Springs power system performed better than Darwin-Katherine as there were fewer generation related load shedding events. Tennant Creek had a System Black in 2013-14, however the size of the power system and single power system supply suggests such outages are not unexpected.
- The Commission is concerned that the customer benefit of power system performance is not well defined. The value of improved power system performance is an important planning tool and there requires some focus.
- Response to major incidents appears to be mixed. In particular, the Commission is concerned that the level and effectiveness of contingency planning is lacking.
- Continued poor customer service performance is reflected in a continued increase in the volume of customer telephone complaints and the percentage and total number of customer calls abandoned.
- Consideration needs to be given to how power system planning will occur post structural separation of PWC.
- As the electricity market develops, it is becoming more important to separate the System Control function of PWC and put in place fully independent governance structures and funding. The adequacy of funding is particularly relevant in light of the workload System Control is facing in establishing a number of market-related tasks such as economic dispatch arrangements, ancillary services framework, dynamic models for the systems and testing plant to ensure compliance with the technical codes.[5] The Commission recommends PWC System Control, review its resources and processes for the reporting of major incidents with the aim of improving the timing of major incident reports.

Maximum Demand Outlook

- The PWC and Commission 10-year MD projections of both a system-wide and zone substation (ZSS) basis, using different projection models, have similar levels of forecast accuracy based on 2013-14 MD forecasts undertaken by these models in 2013.
- The results of the 10-year system-wide MD projections (based on a 50 per cent probability of being exceeded and expected spot loads) undertaken by PWC and the Commission are shown in the table below. The larger variation between the two projections for Alice Springs and Tennant Creek reflects the small size of these power systems.

Table 1.1: System-Wide MD Annual Growth Projections (P50 Basis)

	PWC Projection	Commission Projection
Darwin-Katherine	6.1 MW p.a. (1.8 per cent p.a.)	5.2 MW p.a. (1.6 per cent p.a.)
Alice Springs	0.2 MW p.a. (0.2 per cent p.a.)	0.6 MW p.a. (1.0 per cent p.a.)
Tennant Creek	0.03 MW p.a. (0.5 per cent p.a.)	0.1 MW p.a. (1.7 per cent p.a.)

- The percentage of households with a rooftop photovoltaic (PV) installation is expected to increase uniformly over the next 10 years. The table below shows for 2014-15 the percentage

5 This view was also conveyed in the Commission's Review of Electricity System Planning and Market Operation Roles and Structures – Final Report, December 2011, page 40.

of households with rooftop PV and the associated percentage reduction in system wide MD, and the projection of this for the 2023-24 year. The lower level of growth in Alice Springs reflects the high penetration of rooftop PV in 2014-15 (which reduces the number of households available to install rooftop PV).

Table 1.2: Projected Households with Rooftop PV and Impact on System Wide MD

	Percentage of households with rooftop PV (%)		Reduction in System Wide MD (%)	
	2014-15	2023-24	2014-15	2023-24
Darwin-Katherine	8.5	24.4	2.3	4.1
Alice Springs	21.4	35.6	5.2	6.7
Tennant Creek	9.8	26.6	3.6	6.4

- The ZSS MD projections were consistent with the system-wide MD projections accounting for load diversity between the ZSS, load transfers and spot load movements. MD projections for Woolner ZSS are uncertain, which means that this needs to be closely monitored.

Generation Adequacy

- The Darwin-Katherine power system has sufficient generation capacity to meet an N-3 criterion across the 10-year review period, although peak system demand comes close to system capacity in 2019-20. Territory Generation's reinstatement of an N-2 planning criteria by 2018-19 on completion of the life extension program means there may be scope to delay additional generation capacity beyond 2023-24.
- The Alice Springs power system achieves the N-2 planning criteria but not consistently over the review period. This should be able to be managed through better alignment between Owen Springs machine commissioning and Ron Goodin machine retirements.
- The Tennant Creek power system achieves N-1 (gas) and N (diesel) for the 10-year review period. Tennant Creek can almost meet its standard with reliance on diesel generation (assuming no loss of gas supply).

Generation Reliability

- The Commission notes that generation reliability remains poor even though the compliance with the 'N-X' planning criterion across the three regions remains strong.
- Generator reliability declined markedly from 2012-13 to 2013-14. The generator reliability standard, Expected Unserved Energy (EUE) of 0.002 per cent (the standard used in the National Electricity Market (NEM) and the Western Australian Wholesale Electricity Market (WA WEM) was not met in the Darwin-Katherine region.
- Alice Springs and Tennant Creek generator reliability standards need to be developed taking into account the nature of those power systems.
- It was recommended in the 2012-13 Review that PWC finalise the spinning reserve review and ensure that any resulting findings be made available for the 2013-14 Review. The Commission understands this review is ongoing and its completion remains among the Commission's recommendation.

- The N-X approach is only applicable to systems where each individual component has very high availability (greater than 98-99 per cent) and this assumption is not applicable to Territory Generation's current generation units.
- System Average Interruption Duration Index (SAIDI) has not shown any improvement across a six-year period but remains within the AMS, ignoring abnormal events (but within the organisation's control) such as the 12 March 2014 System Black incident.
- System Average Interruption Frequency (SAIFI) has remained low in 2013-14. With SAIFI low but SAIDI not improving suggests that events, when they occur, are longer in duration and so planning for recovery from contingencies appears to be lacking.

Fuel Supply Outlook

- The Territory has sufficient fuel supply for the 10-year review period.
- PWC's annual contract quantity from Blacktip in the review period is in excess of its actual gas requirements.
- The annual contract quantities from Blacktip increase over time to allow for market growth in the Territory and are also considered to be in excess of PWC's forecast demand over the medium to long term.
- PWC has entered into long-term transportation agreements with the owners of the Bonaparte and Amadeus gas pipelines, sufficient to transport Blacktip gas to its various power station delivery points across the Territory.
- Gas supply to the Territory is assessed to have 'N-1' redundancy. That is, both Blacktip and Darwin LNG (subject to certain limitations) can supply 100 per cent of Territory's gas requirement, should supply be interrupted from either one of these sources of gas. If either Blacktip or Darwin LNG is undergoing planned maintenance, system security is reduced to 'n'.
- At peak production rates (approx. 110 TJ/d), the Wadeye processing facility does not have full redundancy to provide continuous supply during periods of planned maintenance or a trip in major processing elements of the facility.
- Without full 'N-1' redundancy on all major elements of Blacktip's gas production facilities, there is an increased risk of minor or major shortfalls and a corresponding increase in reliance on back-up gas arrangements and alternate sources of energy, such as diesel generation.
- Amadeus basin gas and diesel back-up generation provides additional energy support to the Territory, however these measures are not capable of replacing 100 per cent of the Territory's energy requirement in the event of a sustained period of concurrent Blacktip and Darwin Liquefied Natural Gas (LNG) outage that extends for a period in excess of a couple of days;
- The additional Inpex LNG back-up arrangement from 2017 will materially improve security of gas supply to the Territory, doubling the contingency supply period of up to twelve weeks at full demand and increasing gas system security to N-2 until 2022.
- Darwin/LNG and Inpex LNG can supply the southern region but is subject to sufficient pressure being available to transport gas from Darwin to Alice Springs. Diesel, spare pipeline line pack and/or new gas from Amadeus would be the alternate option if northern gas resources were unable to supply all of the southern gas demand.
- Although the 11 September event (gas supply failure following an electrical fault at the Blacktip gas platform) was outside the scope of the 2013-14 Review, the Commission has provided comments due to the significance of the event. The Commission considers the emergency management of the event did not produce the most effective outcomes because there was not a process that enabled a free flow of live information between all the key

stakeholders (such as ENI, APA/Amadeus pipeline, Darwin LNG, Amadeus gas producers, PWC and Territory Generation).

Networks Adequacy

- There is sufficient network capacity to meet future demand for the 10-year review period, subject to the following capacity concerns.
  - There are six 11kV feeders and zero 22kV feeders that exceed 100 per cent utilisation during periods of MD. According to PWC's Network Management Plan (NMP), work is underway to overcome these overloads. Of greater concern is the NMP predicts that the number of feeders loaded beyond 100 per cent will rise to 19 (11kV feeders) and four (22kV feeders) by 2018.
  - The investigation work completed by PWC Networks to determine the causes of circuit outages and the 2014-15 program to test the earthing on transmission towers is appropriate, which should help to reduce circuit interruptions due to lightning.
  - Poor performance of the 132kV Channel Island to Hudson Creek line and/or its protection systems would represent a real risk of a System Black.
  - The 'normal' and 'contingency' ratings that PWC Networks applied in evaluating adequacy of transmission lines causes some concern to the Commission because it is in conflict with the method used in other jurisdictions. PWC is implicitly assuming that the higher rating is available at the time of MD (likely a hot windless day).
- Significant progress seems to have been made in the areas of:
  - the transmission line loop between Hudson Creek, Palmerston, McMinns, Weddell and Archer substations; and
  - network reliability (excluding the 12 March 2014 System Black incident event) and feeder loadings.
- The NMP reports that during 2013-14 there were no poorly performing feeders. The Commission notes that this represents a significant improvement in the performance of the worst feeders for at least three consecutive years and is a very good result.

Customer Service Performance

- Continued poor performance in relation to answering customer calls.
- There was a 20 per cent increase in the number of calls received and the number of abandoned calls increased by over 128 per cent. The average time to answer a call also increased from 180 seconds in 2012-13 to 371 seconds in 2013-14. The Commission considers this performance a significant concern and a matter that needs to be addressed as a high priority.
- Structural separation of PWC and the establishment of Jacana Energy should place greater focus on customer service performance.
- The target standards for distribution SAIDI and SAIFI were not met for all feeders except for the Rural Long feeder category. The Commission considers the power systems are, in general, underperforming.
- The data that customers provide on service issues and power quality, in particular, is insufficient to assist PWC and the Commission to determine the cause of these issues. PWC needs to consider providing power quality monitoring data at key points in the network to better understand the power quality issues that customers are experiencing.

1.4 Commission's Focus for the 2014-15 Review

As part of the 2014-15 Review, the Commission will have particular focus on the following issues:

- improved timing and content of power system incident investigation reports to ensure the reports contain appropriate and timely information to assist with power system planning;
- completion of the power system model and consequently the spinning reserve review (and implementation of any recommendations) by PWC and Territory Generation;
- planning and assessment of future generation adequacy and the methods of forecasting generating unit availability post structural separation of PWC;
- progress towards finalisation of the remaining 12 recommendations from the System Black Recommendation reports;
- evidence of PWC monitoring MD growth at Woolner ZSS;
- generator reliability standards (EUE) for the Alice Springs and Tennant Creek regions be developed taking into account the nature of those power systems;
- the levels of EUE and other power system planning outcomes are directly related to the accepted Value of Customer Reliability (VCR) and a review of the VCR be undertaken;
- improved power system performance and reliability through a better understanding of system and generator response;
- Territory Generation adopting a probabilistic approach to determining generation availability;
- in relation to fuel supply issues, the development of an emergency response process that better manages emergency events and minimises electricity interruptions to customers;
- measurement and routine analysis of power quality data through the network as a method of determining the actual network performance;
- PWC Networks efforts for improving the reliability, durability and segregation of the Channel-Island to Hudson Creek 132kV lines;
- PWC Networks providing more exhaustive details regarding the options considered for network augmentations, including engineering review and financial and time considerations (included in separate documents to the NMP and be referenced in the NMP);
- PWC Networks methodology used to set normal and contingency ratings of its transmission lines;
- improved customer service performance, particularly telephone responsiveness and categorisation of complaint and customer issue data; and
- the impacts of structural separation, particularly in terms of power system planning and reporting.

2. Overview of the Northern Territory Power Systems

2.1 Legislative Framework

There are six main Acts that establish the legislative framework under which electricity supply operates in the Territory. These are:

- *Power and Water Corporation Act* 2002
- *Power Generation Corporation Act* 2014 (from 29 May 2014)
- *Power Retail Corporation Act* 2014 (from 29 May 2014)
- *Utilities Commission Act* 2001
- *Electricity Reform Act* 2000; and
- *Electricity Networks (Third Party) Access Act* 2002.

The *Power and Water Corporation Act* establishes PWC to generate, trade, distribute and supply electricity in the Territory (it also has functions in relation to water and sewerage services). From 1 July 2014, the commercial electricity retail and generation business units of PWC were structurally separated into standalone government owned corporations, Power Generation Corporation (trading as Territory Generation) and Power Retail Corporation (trading as Jacana Energy). The monopoly parts of the business (networks and system control) and some residual retail and generation functions remain with PWC.

The *Utilities Commission Act* establishes the Commission as an independent statutory body with defined roles and functions for economic regulation in the electricity, water and sewerage industries in the Territory.

The ER Act provides the legislative framework for the operation of the electricity supply industry in the Territory. The ER Act describes, among other things, the key functions and responsibilities of the Commission, which include:

- licensing of network operators;
- setting network prices;
- setting network access arrangements;
- setting minimum service levels for network reliability and power quality; and
- monitoring network capacity and performance.

The Electricity Networks (Third Party Access) Code (TPA Code)[6] specifies the access regime for persons wishing to access PWC's electricity network. By doing so, the TPA Code provides a

[6] The Territory's regional and remote networks are not subject to the third party access framework and the Commission has no role in setting conditions of service and charges. These networks transport electricity to customers in the 72 communities and 82 outstations where essential services are provided through the Territory Government Indigenous Essential Services program; eight remote townships and three mining townships.

framework for establishing competition in the generation and retail sectors. Key elements of the TPA Code include:

- network access terms and conditions;
- provision of information;
- ring fencing of regulated businesses; and
- network pricing.

Under the TPA Code, the Commission is responsible for determining the network conditions and charges, and monitoring and enforcing compliance with the determination. The Commission's final determination for the fourth regulatory control period (1 July 2014 to 30 June 2019) was released on 24 April 2014. The Territory Government will transfer network access and price regulation to the Australian Energy Regulator (AER) from 1 July 2015. The Commission will continue to maintain responsibility for network technical regulation (including standards of services) and licensing.

Section 45 of the ER Act requires the Commission to prepare an annual review on power system performance and capacity in the Territory.

The ER Act requires the Commission to:

- report forecasts of electricity load and generating capacity;
- report on the performance of the Territory's power systems;
- advise on matters relating to the future capacity and reliability of the Territory's power systems relative to forecast load;
- advise on other electricity supply industry and market policy matters; and
- review the prospective trends in the capacity and reliability of the Territory's power systems relative to projected load growth.

2.2 Interim Wholesale Electricity Generation Market

On 23 September 2013, the Commission received notice from the Regulatory Minister under Part 7 of the *Utilities Commission Act* requesting the Commission to conduct a review into wholesale electricity market arrangements that are appropriate for the Territory, and to recommend preferred arrangements.

The referral from the Minister identified that, in undertaking the review, the Commission should consider the following market objectives:

(a) to promote the economically efficient, safe and reliable production and supply of electricity and electricity related services of the Territory;

(b) to facilitate competition among generators and retailers in the Territory's electricity system, including by enabling efficient entry of new competitors;

(c) to minimise the long-term cost of electricity supplied to customers from the Territory's electricity system; and

(d) to encourage the use of measures that more efficiently manage the volume of electricity used including the variations between peak and average loads.

The Territory Government endorsed adoption of an interim wholesale electricity market from early 2015. The interim arrangements are to be implemented through amendments to the System Control Technical Code.[7]

2.3 Overview of the Transmission and Distribution Systems

The Territory's transmission and distribution systems are operated by PWC Networks. The network comprises poles, wires, substations, transformers, switching, monitoring and signaling equipment involved in transporting electricity from the generator to the customers.

PWC is a government owned corporation and is subject to oversight by a Shareholding Minister (the Treasurer) and Portfolio Minister (the Minister for Essential Services) under the *Government Owned Corporations Act*.

PWC's electrical networks operate at transmission voltages of 132kV and 66kV and distribution reticulation at 22kV and 11kV.

This Review focuses on the following three larger electricity systems operated in the Territory:

Darwin-Katherine system – the largest system, which supplies Darwin city, Palmerston, suburbs and surrounding areas of Darwin, the township of Katherine and its surrounding rural areas. Power stations are located at Channel Island, Weddell, Pine Creek (privately owned) and Katherine.

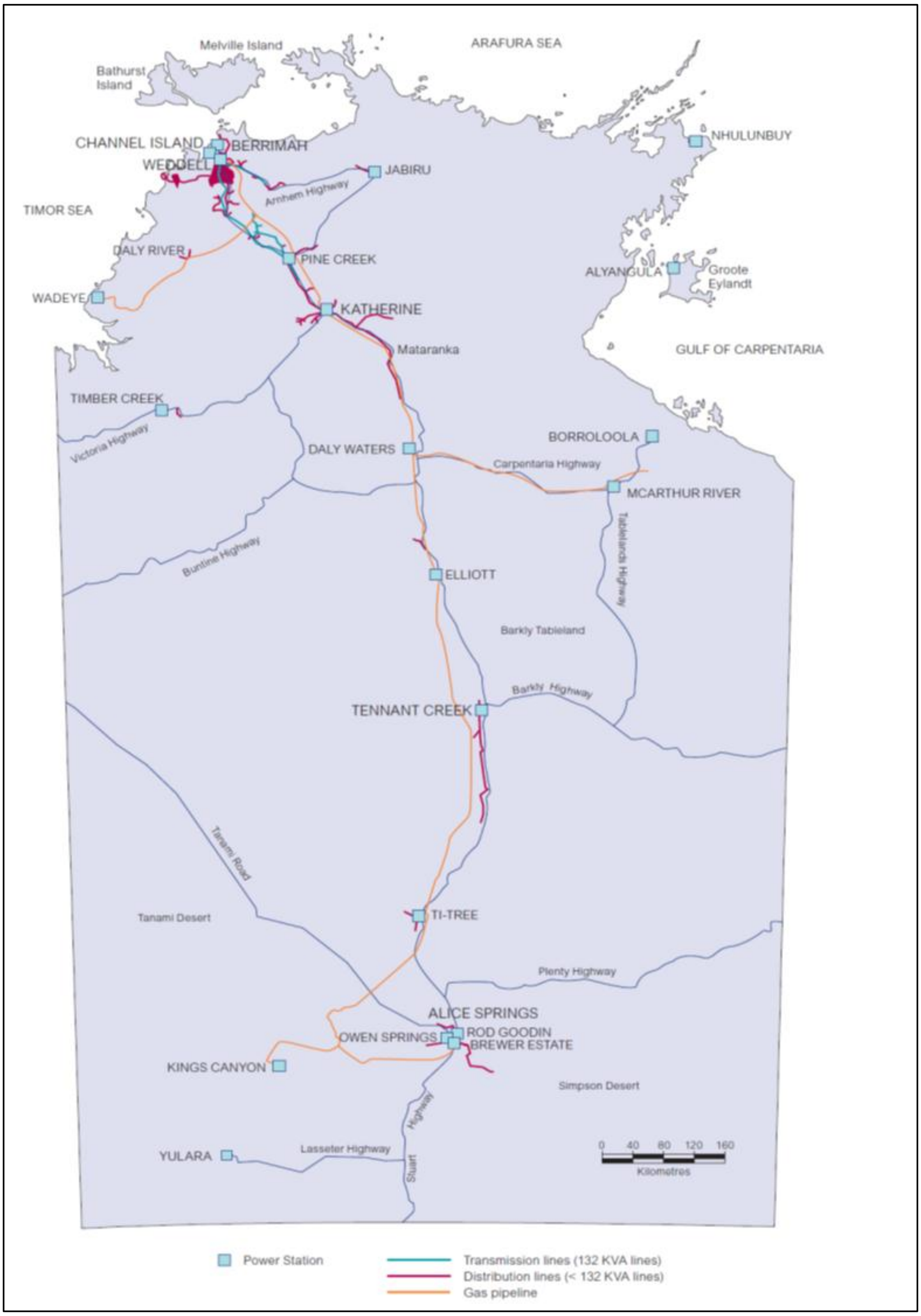
Alice Springs system – supplies its township and surrounding rural areas, from the Ron Goodin Power Station, Owen Springs Power Station and independent power producers (IPP) Brewer Power Station and Uterne Solar Power Station.

Tennant Creek system – supplies the township of Tennant Creek and surrounding rural areas from its centrally located power station.

Territory Generation also operates localised generation systems at Borroloola, Elliott, Daly Waters, Timber Creek, Ti Tree, Yulara and Kings Canyon. PWC also operates generation plant in indigenous communities under the Indigenous Essential Services (IES) program. In addition, Figure 2.1 provides an overview of the Territory's energy supply infrastructure.

7 The interim wholesale electricity market commenced on 27 May 2015.

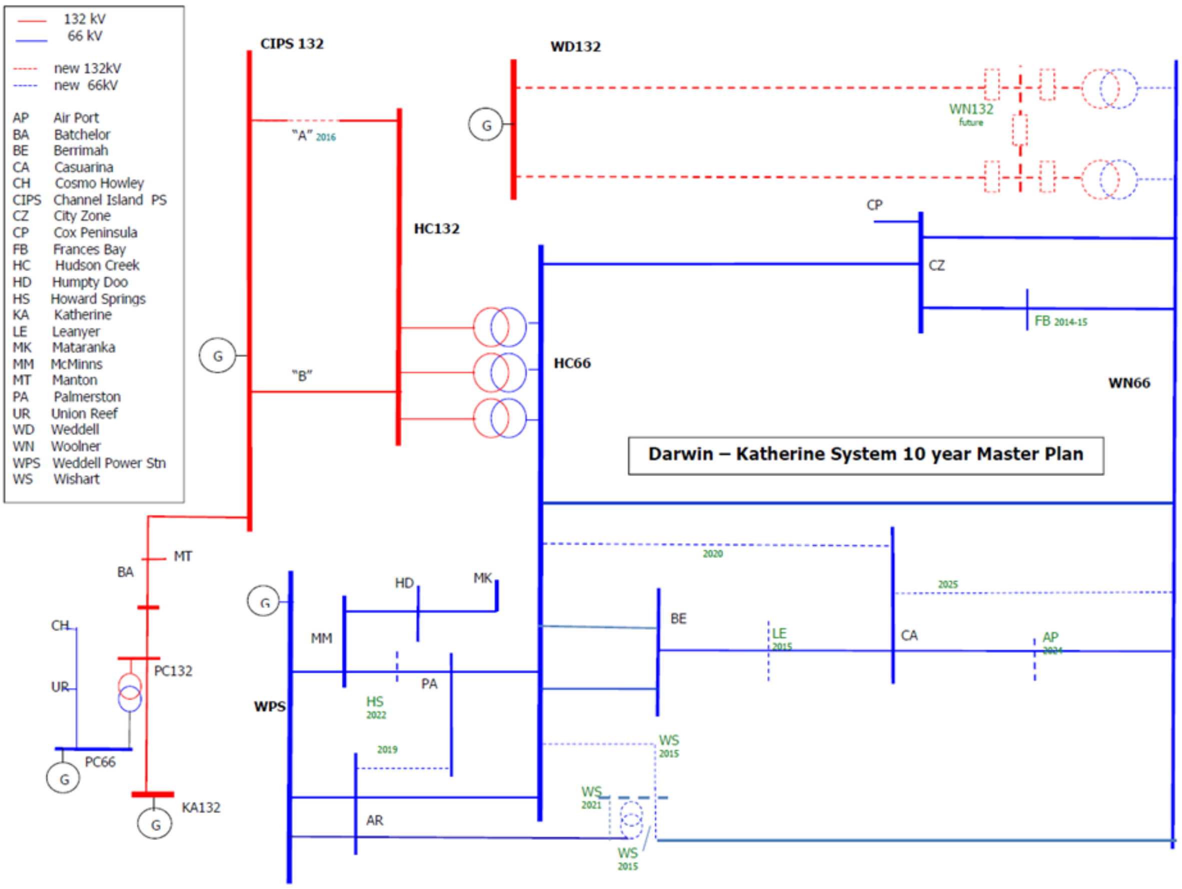
Figure 2.1: Northern Territory energy supply infrastructure



Source: Utilities Commission and PWC

A schematic of the existing and future Darwin-Katherine transmission and distribution network is presented in Figure 2.2.

Figure 2.2: Darwin-Katherine Transmission Network (major components)

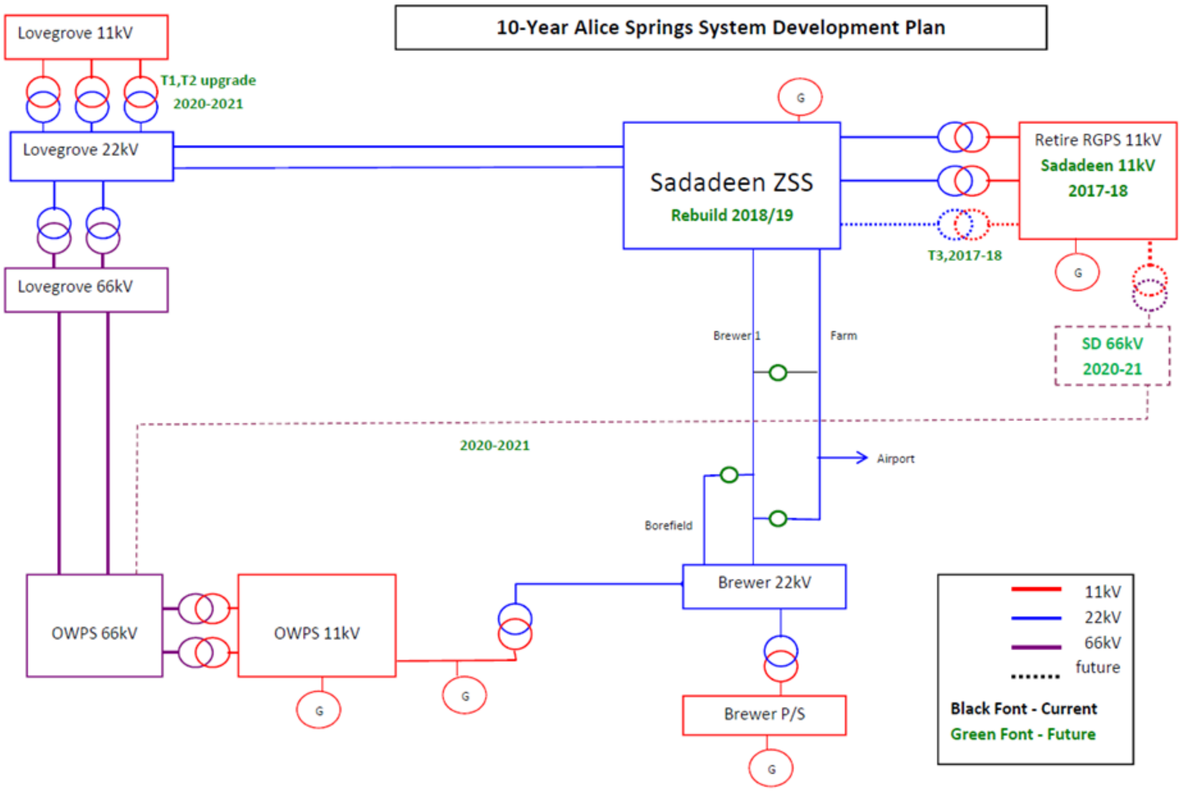


Source: PWC.[8]

A schematic of the existing and future Alice Springs transmission and distribution network is presented in Figure 2.3.

8 Following commissioning of the Archer to Woolner 66kV line, the second connection to Hudson Creek will be removed.

Figure 2.3: Alice Springs Transmission and Distribution Network



Source: PWC.

The majority of the Territory, except for Darwin and Alice Springs, has a very low customer density. The low-load density and geographical spread of customers impact on network topography, with much of the transmission and distribution network being characterised by long radial lines.

A number of geographic and climatic aspects pose major challenges for the network, including:

- regular cyclonic activity during the wet season;
- extreme lightning activity year-round;
- very high seasonal rainfall in the northern area;
- frequent flooding;
- high vegetation growth rates;
- hot conditions;
- extreme summer-winter and day-night temperature variations prevailing in inland areas;
- arid conditions and frequent dust storms in central Australia; and
- high termite activity.

These geographic and environmental variations influence the design criteria for the transmission and distribution systems.

The three major network systems are not connected to the national grid and operate as separate stand-alone systems. Table 2.1 below contains descriptive statistics for the regulated electricity networks.

Table 2.1: Power Networks' Statistics (regulated network)

Power Network Statistic	As at 30 June 2014		
Regulated System	**D-K**	**TC**	**AS**
Energy delivered (GWh)	1,547	31	216
Maximum demand (MW)	280	6.6	56
Number of transmission terminal stations	4		
Number of ZSS	24		
Number of distribution substations	4 503		
Number of major power transformers (22kV to 132kV)	58 (excludes generator and spare transformers)		
Transmission overhead (132kV and 66kV)	721 km		
Transmission underground (66kV)	39 km		
High voltage overhead (22kV, 11kV and SWER)	3 182 km		
High voltage underground	759 km		
Low voltage overhead (includes service mains and streetlights)	1 799 km		
Low voltage underground (includes service mains and streetlights)	2 172 km		

Source: PWC Network Management Plan – January 2015.

2.4 Overview of Generating Plant

The generation plant in the Darwin-Katherine power system are Channel Island Power Station (CIPS) (310MW), Weddell Power Station (WPS) (129 MW), Katherine power station (34.7MW) Pine Creek power station (26.6MW) and Shoal Bay (1.1MW) with a total of 501.4MW GMC (Sustainable Installed Capacity). The fuel type of the generation units is made up of a mix of dual fuel (gas/diesel), gas only, steam and landfill gas.

The generation plant in the Alice Springs power system are Ron Goodin power station (44.6MW), Owen Springs power station (36MW), Brewer power station (8.5MW) and Uterne (0.96MW), with a total of 90MW GMC. The fuel type of the generation units is made up of a mix of dual fuel (gas/diesel), gas only, steam and photovoltaic.

There is 16.7MW GMC installed in the Tennant Creek power system with a fuel type of diesel and gas.

Appendix A identifies the power stations in the three networks and the characteristics of the generating units that comprise them.

2.5 Industry Participants

Electricity industry participants licensed to operate in the Darwin-Katherine, Alice Springs and Tennant Creek power systems at 30 June 2014 are listed in Table 2.2.

Table 2.2: Electricity licence holders at 30 June 2014

Licensees	Darwin-Katherine	Alice Springs	Tennant Creek
Generation	PWC NGD (NT) P/L Cosmo Power P/L LMS Generation P/L	PWC Central Energy Power Uterne Power Plant P/L	PWC
Network	PWC	PWC	PWC
Retail	PWC QEnergy Limited ERM Power Retail P/L	PWC QEnergy Limited ERM Power Retail P/L	PWC QEnergy Limited ERM Power Retail P/L

Source: Utilities Commission.

On 1 July 2014, Part A of Schedule 2 of the generation licence issued to PWC was transferred to Territory Generation by section 18 of the Government Owned Corporations (Power and Water Electricity Business Restructure) Regulations. The transfer included all power stations previously included in PWC's generation licence except for the generation plant at Berrimah Power Station and Indigenous communities under the IES program which remain with PWC.

On 1 July 2014, Part A of Schedule 2 of the retail licence issued to PWC was transferred to Jacana Energy by section 49 of the Government Owned Corporations (Power and Water Electricity Business Restructure) Regulations. The transfer included all retail areas included in PWC's retail licence except for the retail areas of Jabiru, Nhulunbuy, Alyangula, McArthur River Mine and Indigenous communities under the IES program, which remain with PWC.

On 11 August 2014, the Commission issued a retail licence to Rimfire Energy Pty Ltd to sell electricity.

PWC holds a retail licence for the retail areas of Jabiru, Nhulunbuy, Alyangula, McArthur River Mine and Indigenous communities under the IES program.

On 26 November 2014 the Commission received applications from EDL NGD (NT) Pty Ltd for both retail and generation licences. Both applications are currently being assessed by the Commission in accordance with section 16 (3) of the ER Act.

The Commission received an application from Northern Power Opco Pty Ltd for a licence to generate electricity on 22 May 2014, however consideration of this application is pending further information being provided by the applicant.

PWC is responsible for providing System Control services and these are partly funded through a specific charge approved by the Commission and levied on retailers. As the market develops, it is becoming more important to separate the System Control function from PWC and put in place fully independent governance structures and funding. The adequacy of the level of funding is particularly relevant in light of the work load that System Control is facing in establishing a number of market-related tasks such as economic dispatch arrangements, ancillary services framework, dynamic models for the systems and testing plant to ensure compliance with the technical codes.[9]

There are five privately owned generation businesses. Three operate in the Darwin-Katherine system and two in the Alice Springs system, one of which (Uterne) is a renewable energy (photovoltaic) facility. These five businesses generate electricity under power purchase agreements with Territory Generation (PWC prior to structural separation).

9 This view was also conveyed in the Commission’s Review of Electricity System Planning and Market Operation Roles and Structures – Final Report, December 2011, page 40.

3. Overall Power System Issues

3.1 Introduction

This section comments on the overall effectiveness of the three main Northern Territory power systems and identifies common issues and gaps in responsibility and or regulation that may threaten the ongoing robustness of power system management in the future.

3.2 Supply Chain Robustness

The 12 March 2014 System Black incident and the gas supply failure event of 11 September 2014 demonstrate a lack of system robustness in the Darwin-Katherine region. The heavy reliance on gas supplies is discussed in Chapter 1. The March 2014 System Black incident is commented on a number of times throughout the report (including 3.2.1 below) and well documented outside this review.

A number of past reviews have assessed the reliability of the generation and the network and found adequate levels of redundancy and security of supply. The 2012-13 Review identified a risk that, in the event of a simultaneous failure of both Blacktip and Darwin LNG gas supply, there would be a lack of generation units able to run on diesel in the Darwin-Katherine region. The Commission highlighted the need for PWC to confirm alternative gas supply or at least consider instantaneous diesel needs to be maintained at CIPS to mitigate the risk. The Commission concludes that the traditional assumptions around system reliability are not always appropriate for the Darwin-Katherine region.

The Commission's view is that there are critical aspects of the supply chain that have limited redundancy. In addition there are multiple examples of underperforming equipment, including protection relays, circuit breakers or generator governors. In 2012-13, the Commission observed that many of the events that occurred in the power system were multiple contingency events. The Commission is pleased that this is less of a case in 2013-14 but it remains that there have been significant events.

The Commission is concerned that insufficient work has been done to determine the real impact of system failure and therefore the acceptable cost to mitigate such failures. The Commission acknowledges the work that PWC and Territory Generation have done in the aftermath of the March 2014 System Black incident. The Commission considers that further work is required to determine the value of lost load and how this value relates to the level of redundancy and contingency plans adopted by PWC and Territory Generation.

3.3 Assessment of Response to Major System Incidents

12 March 2014 System Black incident – Darwin Katherine (12 March 2014)

On 12 March 2014, a 132kV circuit breaker at Hudson Creek failed to open correctly during routine switching. This in itself was not the root cause of the System Black incident. The root cause of the System Black was the action taken by PWC in response to a malfunctioning circuit breaker.

Furthermore various responses to the System Black incident either exacerbated or extended the major incident.

The following equipment and personnel ‘responses’ caused the incident to be more disruptive than necessary:

- The switching sequence used to remove the failed circuit breaker from service caused a System Black incident. An alternative switching sequence may not have caused the System Black incident.
- The black start generator at CIPS failed to start and could not be started manually for some time due to a control system issue.
- The Kongsberg black start generator proved to be unreliable.
- A control system fault at CIPS caused emergency shutdown valves to operate in APA’s gas yard. Reversal of this emergency operation required an APA operator to attend the site from Darwin.
- Key systems at WPS were left in non-automatic mode, which prevented them from restarting as they should. This included the black start generator, the air compressors and the excitation system on unit 1.
- Numerous trips on Weddell generation units number 1 and 3 caused by high gas pressure. These trips were due to gas regulating valves not shutting off properly.

Any one of these problems occurring during a major system event would be of serious concern. Six such problems all occurred.

A detailed report was prepared on the event by the Commission. That report included a long list of recommended actions for PWC, PWC System Control and Territory Generation. The recommended actions, including additional recommendations identified by PWC, are now mostly complete and progress is being monitored by the Commission.

System Black – Tennant Creek (27 November 2013)

A generating unit fire led to damage to two generating units and subsequent failure of generation to maintain supply to the load leading to a System Black incident. The event’s duration was over four hours.

Gas supply failure – Darwin-Katherine (11 September 2014)

The Commission notes that this event is outside the scope of the 2013-14 Review but provides details and comments due to the significance of the event.

Blacktip (ENI) gas supply was interrupted due to an equipment failure. System Control took measures to reduce load in an attempt to maximise the usage of the advised remaining gas, the measures taken included both voltage and frequency reduction, as well as reducing the minimum required spinning reserve. Territory Generation was also required to change over several generating units to operate on liquid (diesel) fuel (C9, C5, K1, K2).

PWC System Control adopted a rotational load shedding scheme to further reduce load. The scheme involved eight blocks and each block was taken off supply for a duration of approximately one hour. Only seven blocks of the eight were used, as ENI restarted production in the evening.

3.4 System Operability

Standards of service adherence and adequacy

The Standards of Service report for 2013-14 was the first year PWC was required to report performance in accordance with the ESS Code. For 2012-13, PWC reported against the ESS Code on a best-endeavours basis as the Code commenced half way through the financial year. Since the establishment of the ESS Code the Commission has been pleased by the consistent reporting of system performance as it relates to standards of service. The Commission notes the following from the recent reports:

i) continued poor performance in relation to answering customer calls;

ii) increased customer calls;

iii) consistent breakdown across power quality issues; and

iv) increasing number of abandoned calls.

The Commission, acknowledging that the power systems are, in general, underperforming (as per the ESS Code's SAIDI and SAIFI measures) and is concerned the data that customers provide on service issues, and power quality in particular, is insufficient to assist PWC and the Commission to determine the cause of these issues (and only partially due to the high call abandonment rate).

The Commission would like PWC to consider providing power quality monitoring data at key points in the network to better understand the power quality issues that customers are experiencing. This will provide a point of reference for customer complaints and provide an understanding of any trends.

3.5 System Planning

In the interviews that the Commission conducted as part of the 2013-14 Review, it has become apparent that the structural separation of Territory Generation from PWC has led to the situation where responsibility for planning for generation adequacy to meet system peak demand must now transfer to the System Controller function. PWC Generation performed this function previously but with structural separation and possible competition in the generation market, it may not be appropriate for Territory Generation to undertake this role.

The Commission understands that structural separation only occurred in July 2014 and that some settling of the new roles would be expected. The Commission further observes that the forward plans for generation meet the adequacy criteria.

The Commission does not consider that the current level of system planning is adequate on the basis that it does not consider the value of lost load, assumptions regarding asset reliability or applies an appropriate level of security for planned outages. The Commission's view is that the assumed value of lost load should be assessed as it is an important planning input and there remains some uncertainty around an appropriate value for the three power systems.

4. Maximum Demand Projections

4.1 Introduction

For the 2013-14 Review, ZSS and system MD projections were undertaken by PWC and the Commission, both of which also provided MD projections (for the period 2014-15 to 2024-25). This was done for the Darwin-Katherine, Alice Springs and Tennant Creek electricity systems (the three power systems).

This chapter:

- reviews the MD projections developed by PWC and the Commission in 2014 for the 2012-13 Power System Review (including a comparison of 2013-14 projections with actuals);
- updates system wide and ZSS MD projections developed by PWC and the Commission, as part of the 2013-14 Network Management Plan and Power System Review processes, and the reasons for changes in the projections; and
- updates the finding on rooftop PV development expected in the three power systems and the associated impact this has to the respective system MDs.

Details of the issues identified, approaches used and results are contained in appendices.

4.2 Review of 2012-13 Actual MDs and Projections

The 2012-13 Review presented system-wide and ZSS MD projections for the 10-year period commencing 2013-14. These projections were undertaken by PWC as part of the annual Network Management Plan.

The Commission also undertook projections of the ZSS MD in an independent process as part of the 2012-13 Review process. Both sets of projections were based on average weather conditions[10] and expected changes in 'spot' loads[11]. While both projections were based on statistical modelling, the model form and explanatory variables were different.

Because the temperature and spot load changes were an assumption to the projections, the comparison of projections to actual is done on average weather conditions and excluding (or net) of spot loads. The results of these two projections and the actual recorded ZSS MD for the 2013-14 year 'weather corrected' and excluding spot loads are shown in Table 4.1.

It is noticeable that the demand estimates from the two models provided similar predictions with similar order of magnitude errors across the ZSSs. Overall, both sets of projections over-predicted the ZSS MD. This indicated that the simpler linear model used by PWC (in comparison to the log-linear model with data pooling used by the Commission) has a very similar performance. PWC had noted this in its research into different model forms. The conclusion of PWC's review was that there was no basis to prefer one model form over the other.

[10] The projections were based on a daily maximum temperature that has a 50 per cent probability of being exceeded each year.

[11] Spot loads are large loads that would be introduced or reduced based on known and specific projects, such as a large factory.

Table 4.1: Comparison of PWC and Commission 2012-13 ZSS projections to actuals recorded (MW)

ZSS	Actual				PWC		Commission	
	Recorded	Weather correction	Spot load	P50 /No spot load	Projection	PWC Error	Projection	Commission Error
Archer	18.7	1.7	0.0	20.4	19.7	-0.7	20.5	0.1
Batchelor	3.4	0.7	-1.5	5.6	2.0	-3.6	2.6	-3.0
Berrimah	33.8	4.8	-2.5	41.0	37.3	-3.7	37.6	-3.3
Brocks Creek	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0
Casuarina	47.6	3.7	3.2	48.1	57.7	9.6	57.0	8.9
Centre Yard	0.4	0.0	0.0	0.4	0.4	0.0	0.7	0.3
City	52.2	5.1	-8.5	65.8	54.9	-10.9	55.4	-10.3
Cosmo Howley	4.2	0.9	0.0	5.1	4.9	-0.2	4.2	-0.9
Frances Bay	11.2	1.5	0.0	12.7	12.1	-0.6	15.5	2.8
Humpty Doo	1.2	0.3	0.0	1.5	1.2	-0.3	1.6	0.1
Katherine	26.2	2.0	0.1	28.1	29.0	0.9	29.5	1.4
Leanyer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manton	0.0	0.0	-3.9	3.9	3.7	-0.2	4.1	0.2
Mary River	2.6	0.6	0.0	3.2	2.4	-0.8	2.7	-0.5
McMinns	23.6	0.7	4.2	20.1	22.4	2.3	21.4	1.3
Palmerston	31.5	1.7	-16.6	49.7	37.0	-12.7	38.2	-11.6
Tindal	4.5	0.4	0.0	4.9	4.6	-0.2	5.0	0.2
Union Reef	9.7	1.0	0.0	10.7	10.5	-0.2	10.4	-0.3
Weddell	6.6	0.3	0.4	6.5	9.3	2.8	7.8	1.3
Wishart	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Woolner	39.7	4.4	0.0	44.2	36.3	-7.9	36.4	-7.7

Source: PWC ZSS spreadsheets

Notes: Leanyer is modelled now to commence in 2016.
Delays in new demands at Casuarina, McMinns and Palmerston.

4.3 Rooftop PV

The 2012-13 Review presented a projection of rooftop PV in the three Territory power systems[12]. The report provided analysis of the profiles of solar generation and the relationship of this to summer and winter MD.

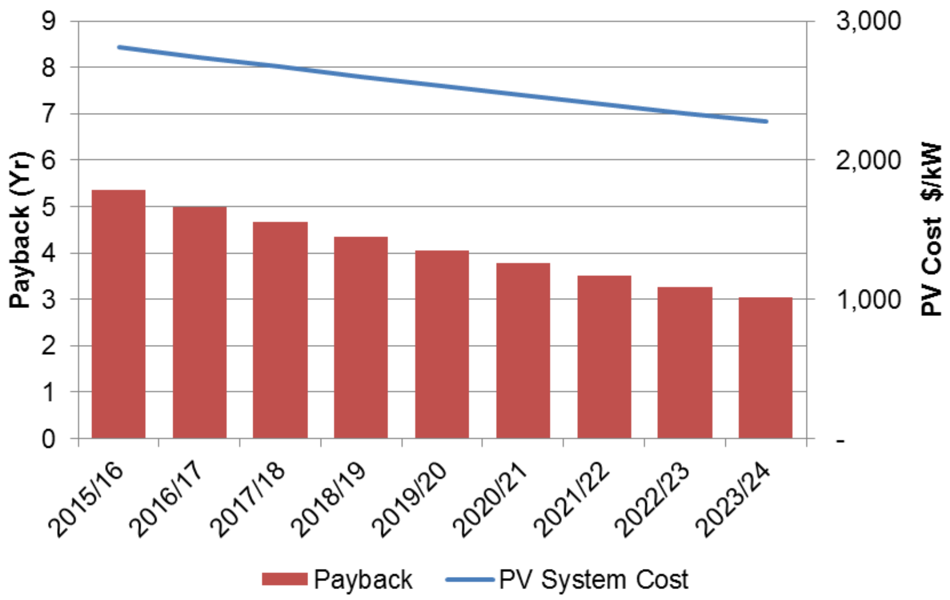
These projections have been updated to account for:

- higher installation rates observed in 2013-14 than previously projected;
- updated PV costs (installed) that are slightly lower than previously used; and
- a declining contribution of rooftop PV to MD as the time of MD moves later in the evening.

The Commission notes that the current 1:1 feed-in tariff (FiT) is not the result of a Government policy but rather a scheme implemented in 2001 by PWC to reflect the initiative for renewable technologies. The value of the FiT is not mandated or regulated by Government or the Commission, but is currently a decision for Jacana Energy. For the 2013-14 Review, the Commission has assumed that the FiT remains the same over the outlook period. However the Commission notes that the FiT was inherited by Jacana Energy following structural separation of PWC and the ongoing level of the FiT will be a matter for Jacana Energy to determine in consultation with its shareholding Minister[13].

From a customer perspective, the economics of installing rooftop PV is the same in all the three power systems. This economics is shown in the figure below, which shows PV installation cost and the payback period for installations undertaken over the study period. Moving forward Figure 4.1 shows declining rooftop PV installation costs and a declining payback period.

Figure 4.1: Rooftop PV Costs (Installed) and Economic Payback Period



Source: The Commission

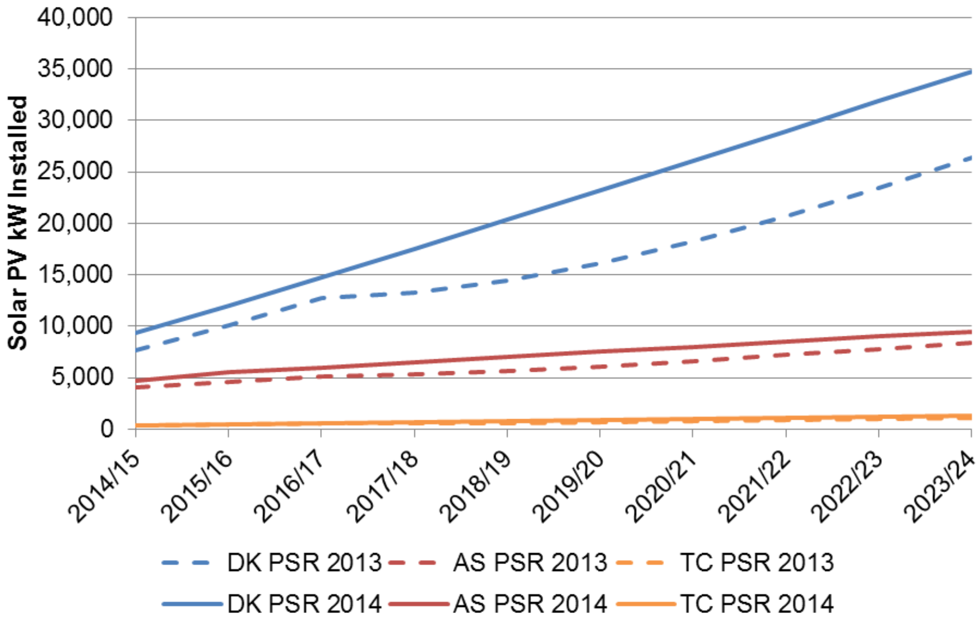
The updated rooftop PV projections, together with the projections contained in the 2012-13 Review are shown in Figure 4.2 below. This shows the level of rooftop PV installation in each of the three power systems is expected to increase uniformly over the next ten years. The projected level of

12 Section 4.6

13 Jacana Energy, Public Hearing Transcript, Committee on the Northern Territory's Energy Future, 28 November 2014

rooftop PV installation (and that contained in the 2012-13 Review) is shown in the figure below. This near uniform level of installation is due to a slightly increasing installation rate on a decreasing amount on dwellings that do have rooftop PV.

Figure 4.2: Projected Rooftop PV Installation



Source: The Commission

The percentage of dwelling with rooftop PV increases over the 2014-15 to 2022-23 period is as follows:

- Darwin-Katherine increases from 8.5 per cent to 24.4 per cent;
- Alice Springs increasing from 21.4 per cent to 35.6 per cent; and
- Tennant Creek increasing from 9.8 per cent to 26.4 per cent.

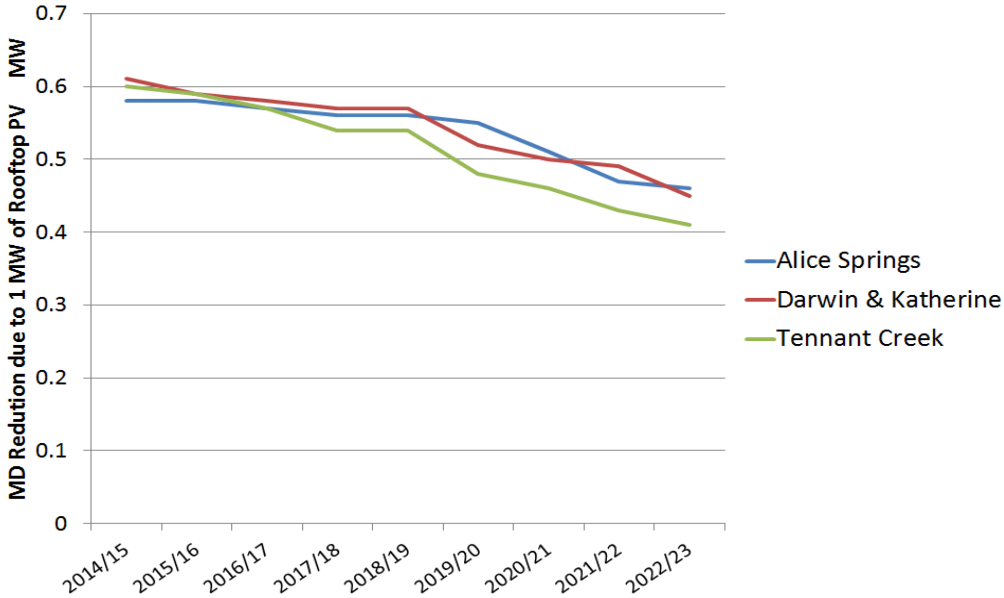
The corresponding ratio of reduction in summer MD (MW) associated with the capacity (MW) of rooftop PV installed is only slightly different in each of the power systems, being roughly about 0.6 in 2015 and decreasing to below 0.5 by 2021[14]. The contribution of rooftop PV to summer MD is shown in Figure 4.3 below.

Alice Springs is projected to become winter peaking by 2022 after which further rooftop PV installations would not influence the annual MD.

Additional explanation and detail of the rooftop PV projections is presented in Appendix C.

[14] In the 2013-14 NMP, PWC quote the contribution of rooftop PV to the reduction of maximum demand as 0.611 for Darwin-Katherine and 0.595 for Alice Springs. These numbers are very close the assessment by the Commission for 2015.

Figure 4.3: Reduction in MD due to 1 MW of Rooftop PV



Source: The Commission

4.4 System-Wide P50 MD Projections

This section presents the system wide MD projections developed by PWC and the Commission for the Darwin-Katherine, Alice Springs and Tennant Creek power systems. Both projections were developed based on a daily maximum temperature that has a 50 per cent probability of being exceeded over summer and expected spot loads (as assessed by PWC). The projections are shown in the Table 4.2 below.

Table 4.2: PWC and the Commission System-Wide P50 MD Projections (MW)

Year	PWC			Commission		
	Darwin-Katherine	Alice Springs	Tennant Creek	Darwin-Katherine	Alice Springs	Tennant Creek
2014-15	310.3	62.0	7.2	298.67	54.57	7.17
2015-16	314.5	62.1	7.2	303.25	55	7.31
2016-17	320.7	62.2	7.2	308.25	55.43	7.44
2017-18	327.4	62.5	7.3	313.15	55.93	7.57
2018-19	333.7	62.8	7.3	317.78	56.37	7.71
2019-20	339.9	63.0	7.3	323.61	56.92	7.84
2020-21	346.1	63.1	7.4	328.81	57.66	7.97
2021-22	352.3	63.2	7.4	333.68	58.43	8.1
2022-23	358.7	63.3	7.4	339.7	59.01	8.24
2023-24	365.1	63.4	7.5	345.67	59.69	8.37

The key difference between the PWC and Commission's projections for Darwin-Katherine is that the Commission's projections commence about 20 MW lower (in 2014-15). The Commission's approach uses maximum temperature as an explanatory variable in the model, whereas PWC's approach weather-corrects demand prior to the least squares regression.

The approach by the Commission reflects the preference not to use the demand/temperature sensitivity of 3.2 per cent MW per degree C (that is taken over a temperature range of 27 to 37^{o}C that is wider than that associated with high demands) while PWC considered the sensitivity consistent with observed MD. The slopes of the PWC and the Commission projections are very similar.

For Darwin-Katherine, PWC forecasts an average of 1.8 per cent growth (6.1 MW) per annum for system wide MD and the Commission's forecast an average of 1.6 per cent (5.2 MW) per annum over the review period.

For Alice Springs, PWC forecasts a relatively flat average of 0.2 per cent (0.2 MW) per annum and the Commission forecasts an average 1 per cent (0.6 MW) for the same review period. For Tennant Creek, PWC forecasts a relatively flat average of 0.5 per cent (0.03 MW) and the Commission forecasts a relatively flat average at 1.7 per cent (0.1 MW) for the review period.

P10 MD were also developed and these are presented in Appendix D.

For both PWC and the Commission, the P10 MD projections averaged about 9 MW higher than the P50 projections.

4.4.1 Comment on System Load Factor

The 2012-13 Review recommended that system load factor be monitored. As for the previous Review there was no evidence of load factor deteriorating. This is supported by the growth in rooftop PV, which averages a greater level of output at the time of maximum demand (about 45 per cent) compared to overall (about 25 per cent). This is also consistent with a gradual move to having the power systems become winter-peaking.

4.5 Zone Substation MD Projections

This section presents the ZSS MD projections developed by PWC and the Commission for the Darwin-Katherine, Alice Springs and Tennant Creek power systems. Both projections were developed based on a temperature that has a 50 per cent probability of being exceeded over summer and expected spot loads (as assessed by PWC). The projections are presented in the sub-sections that follow.

4.5.1 Darwin-Katherine ZSS projections

The P50 ZSS MD projections for Darwin-Katherine are shown in Figures 4.4 and 4.5. The difference in the ZSS projections (PWC less the Commission) is shown in Figure 4.6.

Figure 4.4: PWC ZSS P50 Projections: Darwin-Katherine (MVA)

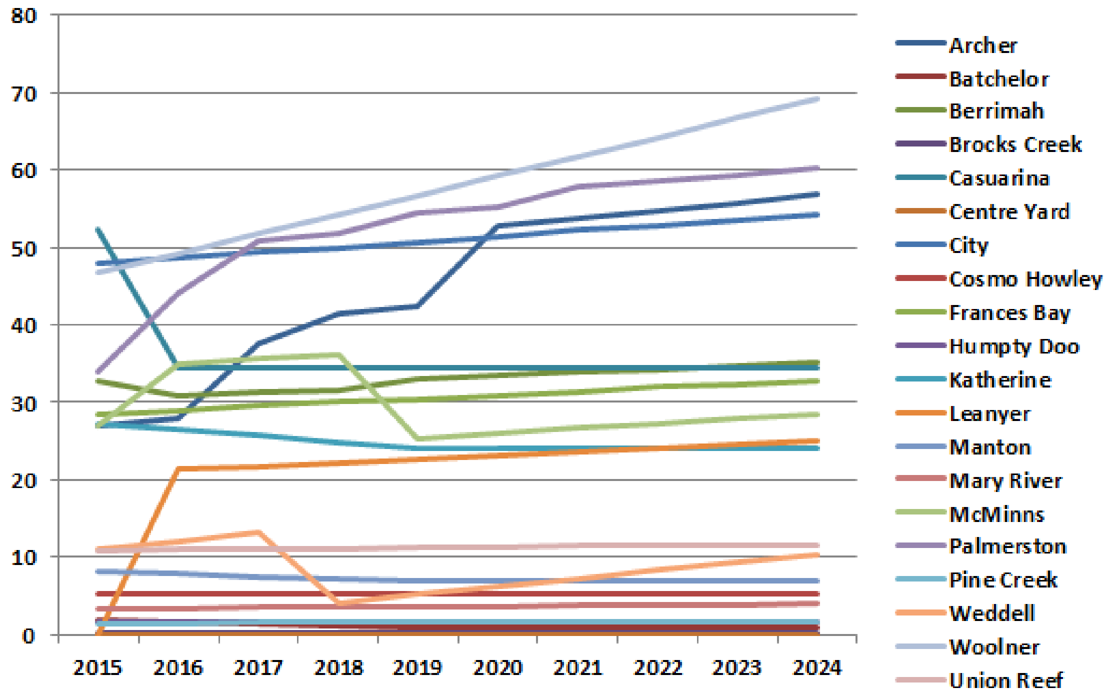
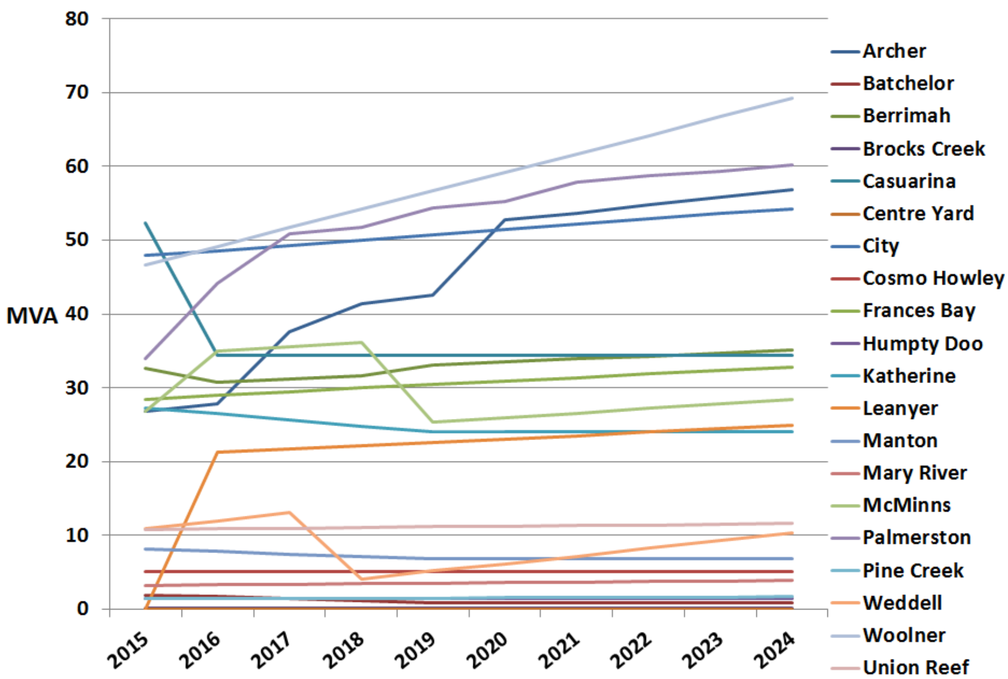
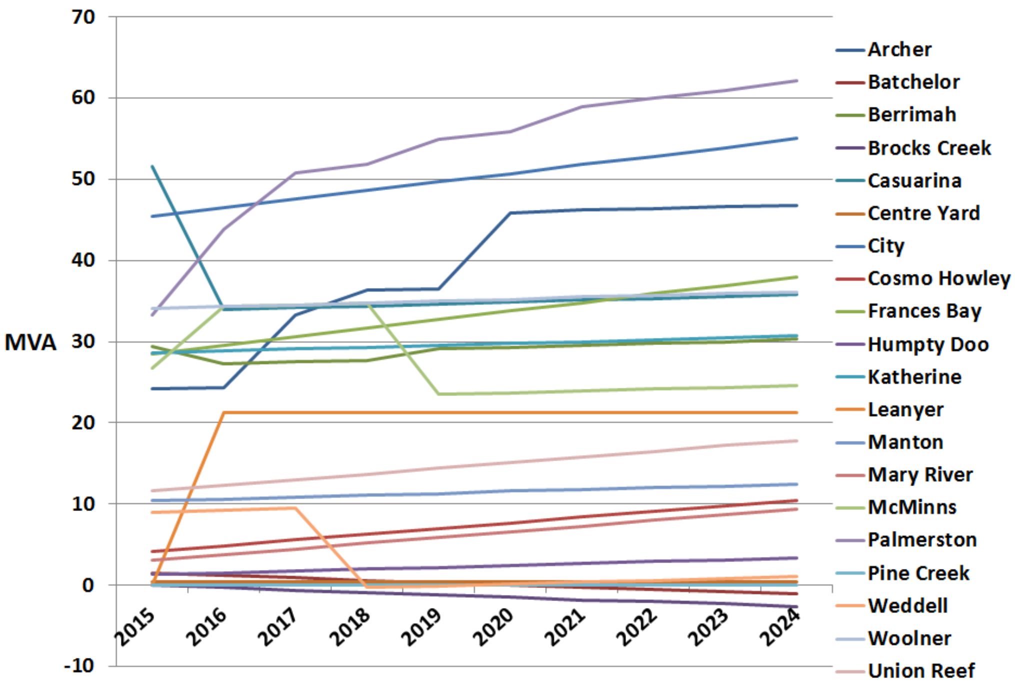


Figure 4.5: The Commission ZSS P50 Projections: Darwin-Katherine (MVA)



Source: PWC and the Commission

Figure 4.6: PWC less the Commission ZSS P50 Projections: Darwin-Katherine (MVA)



Source: PWC and the Commission

The differences are scattered within a 5 MW range by 2020 in all but Woolner. The projection of Woolner between PWC and Maren Jacob is significantly different and the reasons for this are noted below.

For Darwin-Katherine, PWC forecasts an average of 3.1 per cent growth per annum for total non-coincident ZSS MD and the Commission forecasts an average of 2.5 per cent per annum over the review period. Both forecasts include an average forecast of 6 to 7 per cent in 2015-16 and 2016-17, reducing in both 2017-18 and 2018-19, increasing again in 2019-20 before evening out around 1.5 to 2 per cent for the remainder of the review period to 2024.

The Commission and PWC total non-coincident ZSS MD forecasts for Alice Springs are similar except for the treatment of Sadadeen (discussed below) and the ZSS MD growth over the review period for Tennant Creek is as for the system-wide Tennant Creek forecast.

Comments on Woolner ZSS Projection

The approaches by PWC and the Commission to Woolner ZSS, which should be read in conjunction with to the respective projection approaches presented in Appendix A, had the following differences:

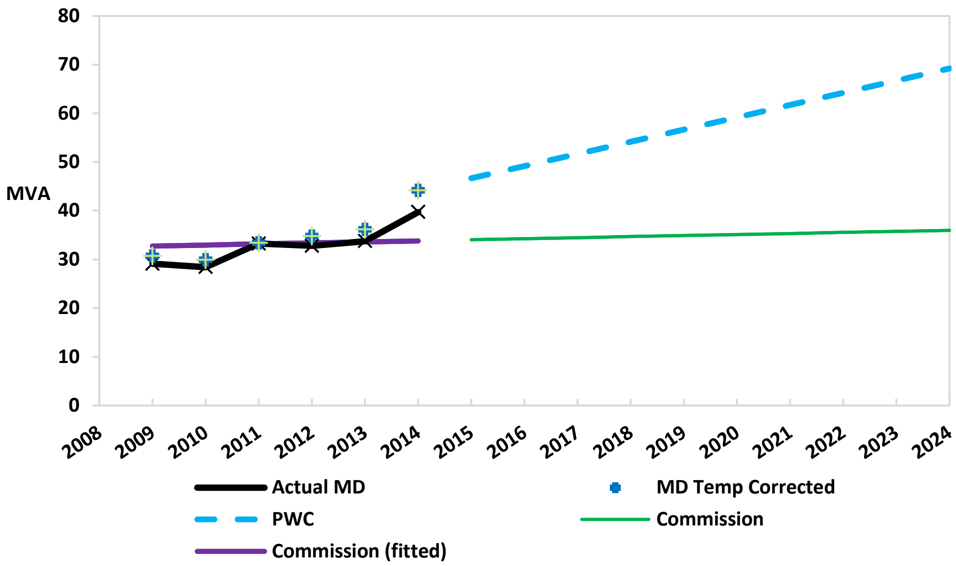
- PWC used weather-corrected demands in the projection while the Commission had temperature as an explanatory variable. The Commission regression model had temperature less sensitive then the sensitivity used by PWC (which weather-corrected the ‘raw’ 2014 figure of 39.7 MW to 44.2 MW due to a temperature adjustment of 32.4°C compared with 35.9°C); and
- PWC extrapolated from the last observation while the Commission projection was based on regression model outcomes.

Both PWC and the Commission did not use the 2008 observation as load had been shifted from Woolner in 2009 (and did not use 2008 data for Casuarina and Berrimah).

The difference in the two projections is illustrated in Figure 4.7, which shows the PWC projection almost double that of the Commission's projection by 2024 (69.2 MW compared with 36.1 MW).

Both the Commission and PWC appreciate the uncertainty in the MD projections of this ZSS, and recognise that demand growth needs to be carefully monitored. The Commission recommends that PWC closely monitors demand growth at Woolner ZSS.

Figure 4.7: Woolner - Historical MDs and PWC and Commission Projections (MVA)



Source: PWC and the Commission

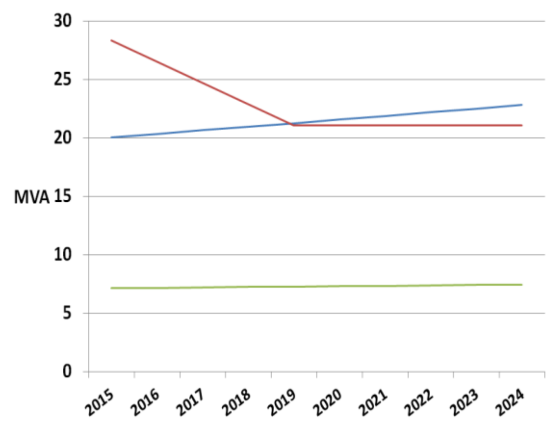
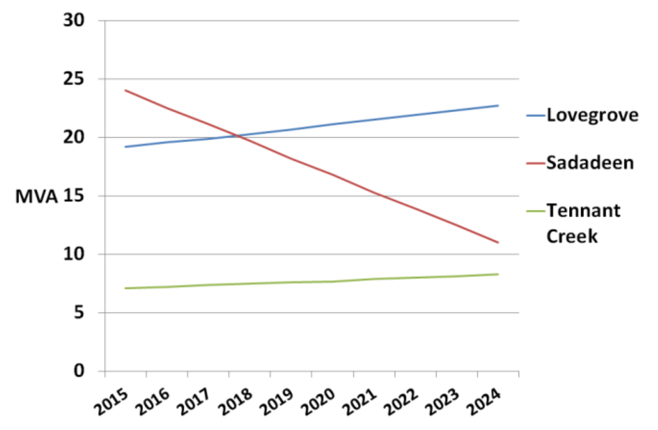
4.5.2 Alice Springs and Tennant Creek ZSS Projections

The P50 ZSS projections for Alice Springs (which has the ZSS's Sadadeen and Lovegrove) and Tennant Creek power systems are shown in Figure 4.8.

For the Alice Springs ZSS, the Commission and PWC's projections are very close except for Sadadeen where PWC took the position that the trending decline would cease in 2019 (as there were no known reasons that supported the load at Sadadeen continuing to reduce or that demand shifting from Sadadeen to Lovegrove). The Commission did not have any information on this, but appreciated the issue and considers PWC's approach to be reasonable.

Tennant Creek demand is projected to remain flat over the review period.

Figure 4.8: Alice Springs and Tennant Creek ZSS MD P50 Projections (MVA)

PWC Projection	The Commission Projection
	

Source: PWC and the Commission

4.5.3 Reconciliation of ZSS with System-Wide Projections

PWC has also developed system-wide MD (on a P50 basis) from the ZSS for each of the three power systems. The purpose of this is to compare the results with the system-wide MD projections (noting the different methodologies used to develop the respective MD). The key uncertainty in such comparison is the diversity of ZSS MD.

5. Generation Reliability

One of the roles of the annual Power System Review is the transparent reporting and projection of generation reliability. With this objective, the 2012-13 Review:

- explained the concepts of power system reliability and security;
- introduced indices that express generating reliability and presented the industry standards of generating reliability, including that used in the NEM and the WA WEM;
- presented results of modelling that demonstrated an indicative optimum economic level of generation reliability in each of the Territory power systems;
- articulated the value associated with reliability-based planning; and
- provided recommendations on the future use of reliability assessment and reporting in the future.

This chapter builds on the material presented in the 2012-13 Review by:

- reviewing the reliability standard for each of the Territory power systems;
- reviewing the generating reliability performance over the past 12 months;
- presenting issues particular to the manner the Territory power systems are operated and how these should be included in reliability assessments; and
- developing and interpreting generation reserve margin standards in a similar manner as used by AEMO.

Generation Reliability

Reliability is considered to encompass adequacy and security.

Reliability is a measure of the ability of the power system to deliver electricity within accepted standards and in the amount desired, for the period of time intended, under the operating conditions intended.

Adequacy relates to the existence of sufficient facilities within the system to satisfy the consumer load demand at all times; taking into account scheduled/unscheduled outages.

Security relates to the ability of the electric systems to respond to sudden disturbances arising within that system, such as electric short circuits.

5.1 Generator Reliability Standard

Consistent with previous Power System Reviews[15], this year's report applies a benchmark of a reliable system a loss of load probability (LOLP) of one day in ten years (or 0.027 per cent). This benchmark is closely consistent with an EUE of 0.002 per cent standard used in the NEM and the WA WEM.

[15] This was reported in the 2011-12 and 2012-13 Power System Reviews.

Based on a Value of Customer Reliability (VCR) of $30 000/MWh[16] the optimal reliability levels in the Territory power systems expressed as EUE and LOLP were in the order of[17]:

- Darwin-Katherine: LOLP (days/year) 0.15 or EUE 0.006 per cent;
- Alice Springs: LOLP (days/year) 0.12 or EUE 0.005 per cent.

The modelling confirmed that the adopted reliability standard expressed as an LOLP of 0.1 day/year was consistent with the economics of power supply in the Territory. Consequently the generation reliability standard was taken to be an EUE of 0.002 per cent.

5.2 Review of 2013-14 Generating Reliability

It is common practice to review the performance and reliability of power systems after each year. The approach used in the NEM (see box below) is representative of industry best practice and is the approach recommended and used in this review.

Annual Review of Generation Reliability in the NEM

The approach used in the NEM is specified by the AEMC Reliability Panel as follows:[18]

- performance against this Reliability Standard for Generation and Bulk Transmission should be considered using the actual observed levels of annual EUE for the most recent financial year; and

- plant performance and demand characteristics that occurred in that financial year should be assessed to determine whether there are any underlying changes occurring.

In doing this, the standards also state that this Reliability Standard:

- includes unserved energy associated with single credible contingencies on a generating unit, delays to the construction or commissioning of new generating units, and ‘acts of God’, but

- excludes unserved energy associated with power system security incidents that result from multiple or non-credible contingencies or industrial action.

Power system incident reports identify the cause and date of events that resulted in under-frequency load shedding (UFLS). A list of the events associated with generator outages are shown in Appendix E.

During 2013-14 there was one System Black incident in the Darwin-Katherine power system and one System Black incident in the Tennant Creek power system. The Darwin-Katherine System Black was not associated with generator failure and is excluded from this analysis (although the Commission notes that the duration of the System Black was exacerbated by generation-related issues). The Tennant Creek System Black incident was associated with generator outages but is being treated separately.

16 This is less than that used in the NEM of $41,000 per MWh in 2013.

17 In undertaking the analysis, approximations were made and the specific issues of spinning reserve and associated costs were not explicitly accounted for. The impact of spinning reserve costs not accounted for would be to lower the optimum reliability standard.

18 Reliability Standards to apply from 1 July 2012.

For each incident, the duration of the event and load shed was based on the UFLS classification[19] and the reported duration of each event.

Table 5.2 presents for each of the three power systems, the number of generator outage events that resulted in load shedding, the average amount of load shed and average time to restore demand per incident and, from this, the total amount of load shedding that occurred reported as MWh and as a percentage of annual demand. Noting that estimates were required in relation to the time to restore load and the amount of demand shed each event, compared to the standard of 0.002 per cent of EUE. Darwin-Katherine was twice the standard, Alice Springs three times the standard, and Tennant Creek 50 per cent above the standard. In addition, the number of events was significantly higher than the LOLP standard of 0.1 day/year.

Table 5.1: Summary of Generator Outages resulting in Load Shedding for 2013-14

Power System	Number of load Shedding Event	LOLP Standard	Estimated Average Load Shed per Event MW	Estimated Average Event Duration Hours	Estimated Load Shed MWh	Estimated %EUE
Darwin-Katherine	11	0.1	18	0.33	63.4	0.004%
Alice Springs	3	0.1	0.5	0.5	12.8	0.006%
Tennant Creek[20]	1	0.1	1	1	1	0.003%

Table 5.2: Generator outage events resulting in a System Black

Power System	Date	Description
Tennant Creek	27 November 2013	Tennant Creek generators tripped. Addressed in Section 3.3
Darwin-Katherine	12 March 2014	Not generation related. Addressed in Section 3.3

Darwin-Katherine

The review has shown that while the EUE is close to the 0.002 per cent standard, the LOLP criterion of 0.1 day/year was significantly exceeded (11 days had generation related load shedding). This is inconsistent with the finding of the 2012-13 Power System Review, which found that these standards (LOLP 0.1 days/year and EUE 0.002 per cent) closely correspond (as they do in the NEM). The Commission concludes that generation reliability declined significantly in 2013-14.

The reason for the apparent anomaly in the number of days that had generation-related load shedding compared to the level of unserved energy, is that the load shedding events were not due to insufficient generation capacity. Instead they were related to the dynamic response of some

19 Such as Stage 1.

20 For Tennant Creek including the amount unserved energy associated with the System Black would significantly increase the EUE per cent. For example, a System Black for six hours would result in a level of unserved energy of 0.075 per cent, which is about 35 times more than the 0.002 per cent standard.

generator units and the 25 MW spinning reserve standard that can result in short load shedding events on the outage of a single generator unit (at times when there is sufficient generation capacity).

Note: This is not evidence that the spinning reserve policy is not economically appropriate. Such evidence requires both the costs and benefits to be considered.

On the basis of the current criteria, the Darwin- Katherine system did not satisfy the reliability standard during 2013-14.

Alice Springs and Tennant Creek

Alice Springs performed better than the Darwin-Katherine system as there were fewer generation-related load shedding events. However the same comments that are made for Darwin-Katherine also apply to Alice Springs.

Tennant Creek had a System Black incident and this is still being investigated by PWC System Control. The size of the power system and single supply system suggests a reliability standard is required that recognises its configuration.

5.3 Classification of Load Shedding Events

The assessment of future power system reliability is by definition normally associated with the 'technical capability' of the power system to provide the highest level of reliability it is capable of providing. This means having all generators not on maintenance (planned or forced) available to be used if necessary. This can mean higher operating costs if some generators are required to operate at partial load.

Large power systems such as the NEM are operated with sufficient spinning reserve[21]and load relief to halt the drop in frequency associated with unforeseen trips of generator units. When assessing generation reliability in the NEM, this is the normal assumption made by AEMO.

This is not the current situation in the Territory power systems, which have low dynamic response of some generators and lower spinning reserve levels. The Commission notes:

- The Darwin-Katherine power system has generator units (CIPS units 8 and 9, and the two Weddell generator units) that cannot respond to frequency drops and the current 25 MW spinning reserve requirement is lower than the largest generator units.
- A loss of a generator unit greater than 25 MW can result in (under frequency) load shedding irrespective of whether there are peaking gas generators available but not operating.
- Dynamic power system studies[22] have shown that under-frequency load shedding should not occur in the Darwin-Katherine power system for the tripping of a single generator unit in peak demand time under the current 25 MW spinning reserve policy. However, the results from the dynamic power system studies do not accord with observations from system incidents as per the investigations undertaken by Evans and Peck (now Advisian) in October 2014 of 14 generation-related UFLS incidents which calls into question the accuracy of the dynamic models.

[21] In the NEM spinning reserve is referred to as contingency reserve and is comprised of fast, slow and delayed (raise and lower) services.

[22] Report titles "Spinning Reserve Analysis – Frequency Response and Economic Dispatch Analysis" by SKM dated 21 January 2014

- Alice Springs is similar to the Darwin-Katherine system in that the power system remains stable for tripping of any one generator unit, but that load shedding can occur.
- Due to the small size of the Tennant Creek power system load shedding is expected on the tripping of a generating unit.

Reliability assessment in the Territory power systems needs to separately account for supply reliability associated with the dynamic response capability of generators, system stability to generator unit tripping, and the manner each of the power systems is operated.

Accordingly, two modes or classification of generation-related load shedding were identified:

- Insufficient generation capacity, including ramping response, to satisfy customer demand. This is termed ***generation capacity reliability***[23]. It represents the technical capability of the generation system to satisfy demand. Load shedding associated with generation capacity shortages can be lengthy and severe.
- Generator dynamic response and generator operating regime (in particular, spinning reserve). This has been termed ***generator response reliability***. As observed in 2013-14, this is characterised by short and more frequent load shedding events than that associated with generation capacity shortages.

It is recommended that the issue of generator adequacy reliability and generator response reliability be separately considered and have separate reliability criteria.

The criterion for generation adequacy reliability has been established as an LOLP of 0.1day/year or an EUE of 0.002 per cent. This was found to be consistent with a Value of Customer Reliability (VCR) in the order of $30 000/MWh.

It is likely that the value customers place on 5 to 10 minute outages (associated with generator response reliability) is different to that associated with generation capacity shortages, which would be expected to be longer and more severe. A suitable index for generator response reliability (where load is retuned quickly) may relate to the expected number of events per year. In this regard, a suitable index would be LOLF, which specifies the maximum number of load shedding events per year that do not relate to capacity shortages.

5.4 Generator Capacity Reliability – Minimum Reserve Margin

Generator reserve margins are associated with having sufficient installed generator capacity to meet load peaks.

In the NEM, AEMO on a regular basis determine the amount of installed capacity (needed in each NEM jurisdiction) relative to a one in ten years MD level (P10) that would provide for the reliability standard to be met moving forward. AEMO refer to this as the Minimum Reserve Level (MRL). MRLs provide a very simple and useful basis on which to monitor future generation reliability associated with having sufficient generator capacity to satisfy load peaks.

The 2011-12 Review introduced this concept and presented a graph that compared the amount of installed generation capacity to the P10 MD forecast plus 20 per cent[24].

[23] This is related to generation adequacy, which is usually associated with security.

[24] The 2011-12 Power System Review stated “In keeping with the Commission’s aim to move the Review to NEM style reporting where practical, Chart 4.12 is included, which is similar to the presentation in the ESOO. In this case MRL of 20 per cent has been added to the load forecast. This presentation

On this basis MRLs have been developed for the Territory power system to provide an LOLP of one day in ten years due generation adequacy. The assessment was undertaken through simulation modelling and the results are shown in Table 5.3. These are used in the outlook of generation reliability presented in section 6.

Table 5.3: Assessed Territory Power System MRLs

Power System	**MRL**[1]
Darwin-Katherine	30 MW
Alice Springs	13 MW
Tennant Creek	2 MW

[1] This is the level of installed generation capacity above the P10 MD level.

5.5 Generator Response Reliability – Spinning Reserve Standard

The economics of spinning reserve determines the amount of spinning reserve that should be carried. This also determines the reliability standard for what this chapter has labelled generator response reliability. For the purposes of this report the discussion is restricted to the Darwin-Katherine system.

Modelling of the dynamics of the Darwin-Katherine system has shown that increasing the spinning reserve amount from 25 MW to 35 MW would result in an increase in dispatch costs of about $1.8M. This is principally related to generators operating on a lower level of their heat rate curve, and is consistent with the Commission's previous estimates[25].

The amount of load shed in 2013-14 due to generator response reliability was 63.4 MWh (there was sufficient generator capacity in all the load shedding events). On the assumption that increasing the spinning reserve margin to 35 MW would eliminate this load shedding (and it is likely that it would not eliminate all of it), the cost per MWh of avoided load shedding would be close to $29 000/MWh.

The Commission understands PWC System Control is undertaking a separate review and report on the economics of spinning reserve.

demonstrates that a 20 per cent MRL is exceeded in every year considered except for 2019-20, where the MRL is only just not achieved."

25 50 MW of generation operating is a reduced heat rate of 0.5 GJ/MWh and a cost of gas at $8.5/GJ.

6. Generation Adequacy and Reliability Outlook

This chapter presents an assessment of generation adequacy for each of the Territory power systems over the next 10 years. This is undertaken using two approaches:

- N-X: This has been the traditional approach in past power system reviews; and
- Meeting the reliability standard. This is presented in terms of modelling results and use of the developed MRLs.

The two approaches yield similar results.

6.1 Generator Adequacy N-X Outlook

PWC's Capacity Investment Planning Strategy[26] (Draft 30 November 2013) outlines the method by which an assessment of capacity adequacy should be made. The following criteria are applied by PWC in planning generation adequacy in each region:

Table 6.1: Generation planning criteria

Power System	**N-X Standard**
Darwin-Katherine	N –3[27]
Alice Springs	N – 2
Tennant Creek	N – 1 (gas) N (diesel)

It should be noted that this N-X criterion does not represent a real-time spinning reserve operation, merely an indication of a margin between installed capacity and the need for load shedding based on the largest X units being unavailable. The assessment is a simple calculation of MD versus installed capacity less the X largest units.

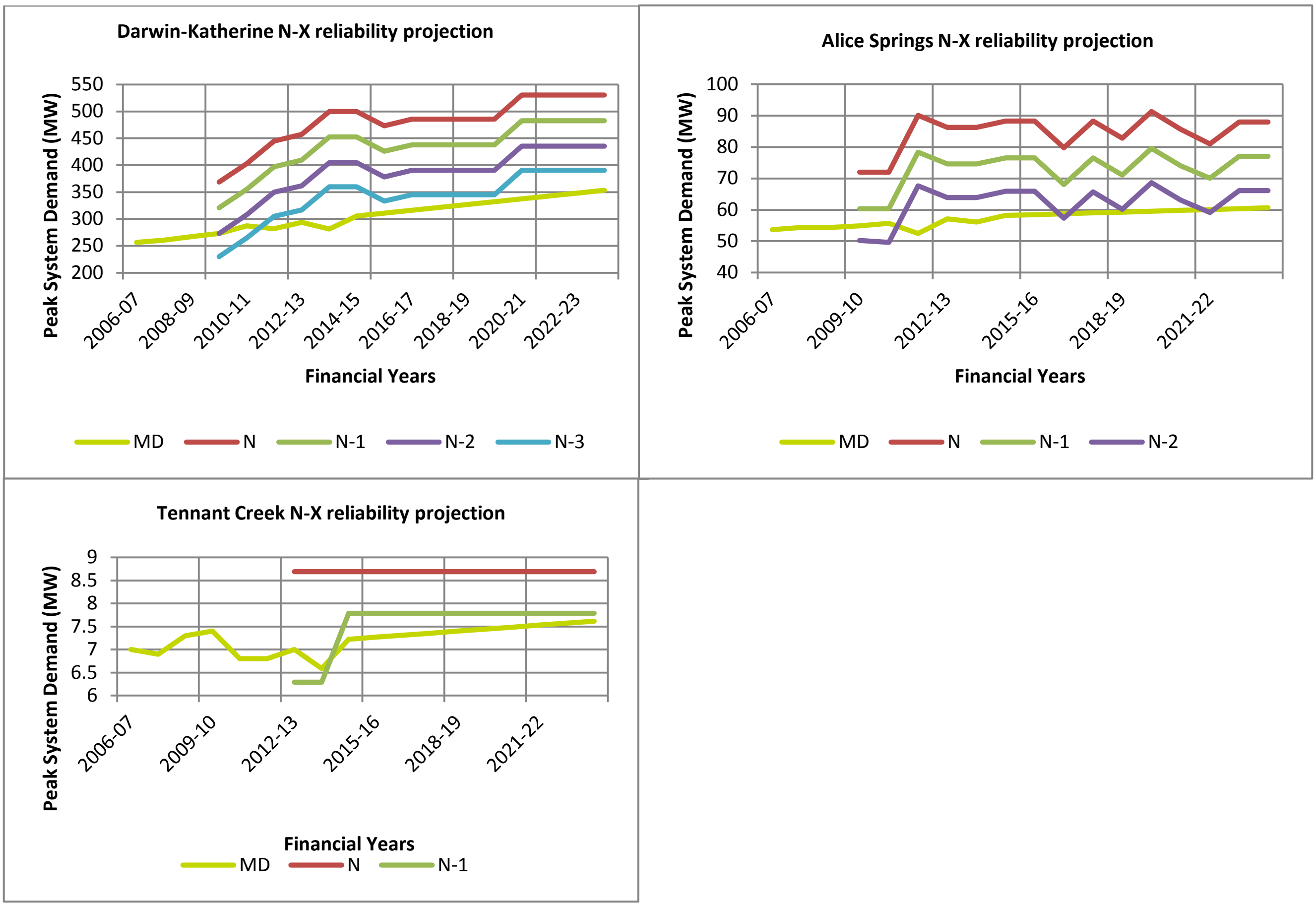
In practice this allows one planned and one forced outage to occur in an N-2 system without the need for long-term load shedding.

Prolonging the N-3 criterion for Darwin-Katherine will lead to further investment in generating plant. Territory Generation advises that the reinstatement of the N-2 planning criteria is planned for 2018-19 following completion of the life extension project. The transparency of major plant outage plans is, in general, not sufficient for the Commission to have confidence in the planning for reliability.

[26] PWC Capacity Investment Planning Strategy, Draft 30 November 2013

[27] Territory Generation (and previously PWC) has advised that this is a temporary measure to allow for CIPS generation set 1 to 6 life extension to occur without affecting adequacy due to expire by 2018-19.

Figure 6.1: N-X generation reliability



Source: The Commission

Darwin-Katherine meets the current N-3 criterion across the 10 year projection. There may be scope to delay additional generation in the region beyond 2020-21 since MD continues to trend almost 50 MW below the N-2 level even without additional investment.

Alice Springs almost achieves N-2 but is not strictly compliant across the projection. This should be able to be managed through better alignment between Owen Springs machine commissioning and Ron Goodin machine retirements.

Tennant Creek remains compliant across the 10-year projection.

In comparison to 2012-13, all margins (except Alice Springs) increased as detailed in Table 6.2.

Tennant Creek can almost meet its standard without reliance on diesel generation (assuming that loss of gas supply is not considered).

Table 6.2: N-X margins for 2013-14

Region	Criterion	Margin 2013-14		Margin 2012-13	
		MW	as per cent of peak demand	MW	as per cent of peak demand
Darwin-Katherine	N-3	78.7	28.0	38	9.7
	N-2	123.7	44.0	83	25.2
Alice Springs	N-2	7.7	13.8	10.8	20.3
Tennant Creek	N-1 (gas)	- 0.3	- 4.6	- 2	- 30[28]

Source: The Commission

6.2 Generation Reliability Outlook

The section presents the outlooks on what have been termed generator capacity reliability and generator response reliability for each of the Territory power systems.

Generator response reliability is assessed through modelling the Darwin-Katherine system with spinning reserves limited to 25 MW and excluding unserved energy associated with capacity shortages. The modelling was considered approximate only as generator unit response dynamics was estimated.

6.2.1 Generator Capacity Reliability

Figure 6.2 presents the outlook for generator capacity reliability through:

- a comparison of installed generator capacity compared to the P10 MD plus the MRL (left side of the figure); and
- the results of modelling[29] capacity reliability expressed as EUE per cent each year (right side of the figure).

The results show that all systems have more capacity than required by the MRL and that the projected level of EUE per cent is well below the target of 0.002 per cent: (that corresponds to an LOLP of less than 0.1 day/year):

- The pattern of EUE per cent in the Darwin-Katherine system increases slightly as demand grows and reduces when new generation enters. Much of this shedding is due to ramping constraints on generators.
- The Alice Springs and Tennant Creek power systems have virtually no load shedding due to sufficient installed capacity.

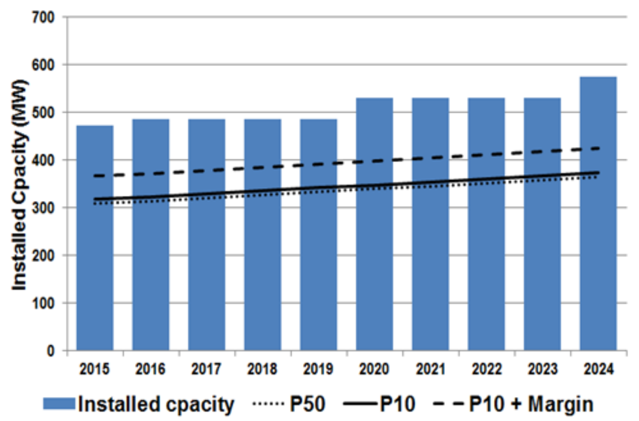
[28] Diesel generation required to meet system peak at N – 1

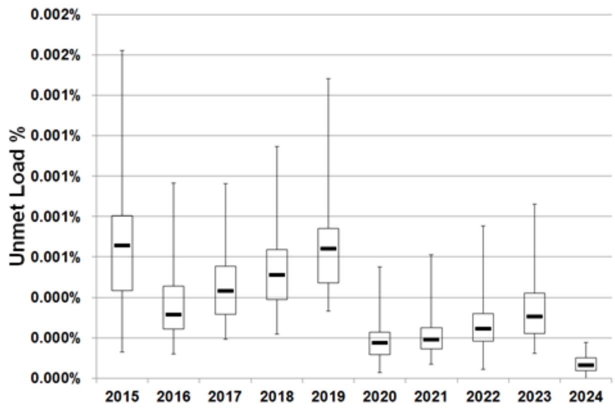
[29] The modelling was undertaken on 5-minute time steps in order to capture load shedding due to ramping constraints.

Figure 6.2: Outlook for Generation Capacity Reliability

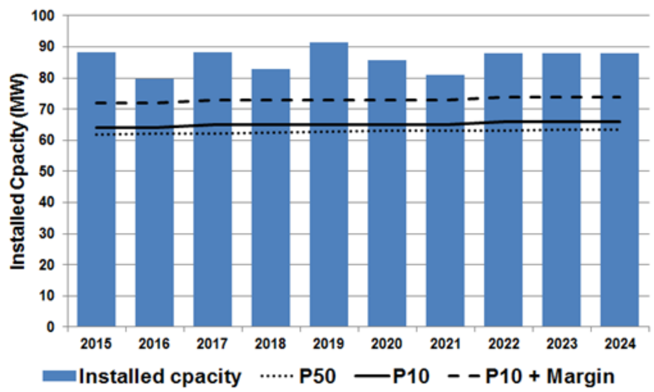
Installed Capacity, MD, MD + MRL	Projected EUE%

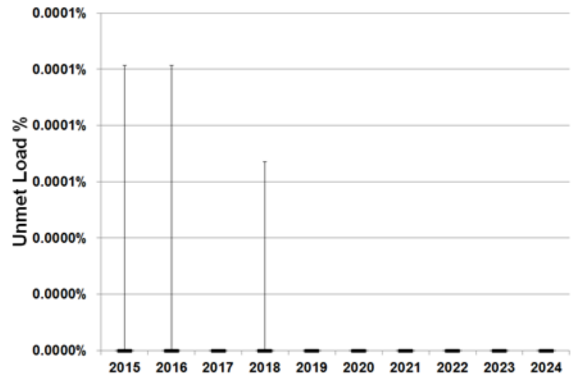
Darwin-Katherine



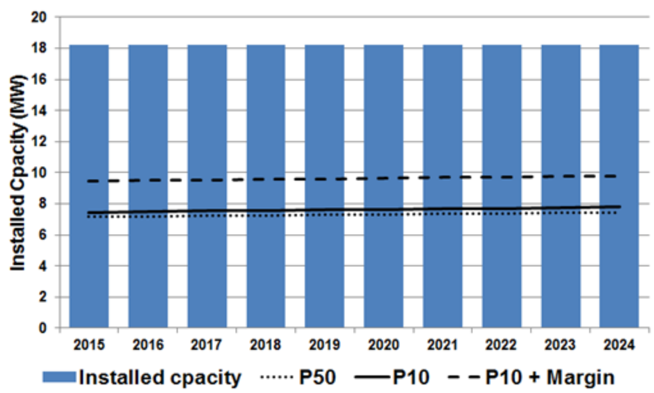


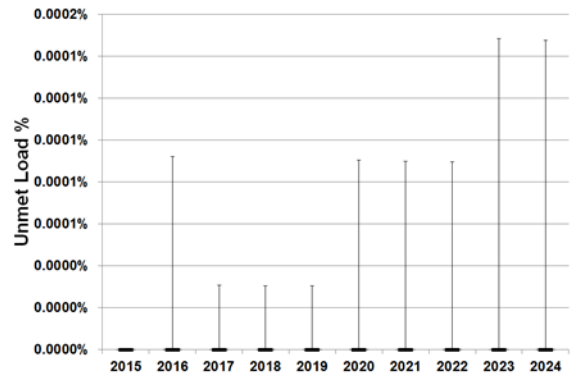
Alice Springs





Tennant Creek





Source: The Commission

6.2.2 Generator Response Reliability – Darwin-Katherine

The discussion of generator response reliability is restricted to the Darwin-Katherine system.

The assessment of generator response reliability is more complex than capacity reliability as assumptions are required in relation to how generators are operated and spinning reserve maintained, and the level of load shedding that would occur on the loss of a generator unit.

For the purpose of this analysis it was assumed that Stage 1 load shedding would occur on the unexpected loss of a CIPS generation units 8 or 9 or one of the Weddell generator units 65 per cent of the time.

The reliability profile of these units is a forced outage rate of 3 per cent (corresponding to 10 days out of service due to breakdown per year) and an expected time of outage of five days per outage. This translates to about two outages per generator per year, eight trips in total and five load shedding events. It would be expected that these would be restricted to about 20 MW of load shedding and that restoration would be within 30 minutes.

Modelling was undertaken based on the assumptions described above that support the estimated average number of load shedding events per year.

PWC System Control is investigating the economics of its spinning reserve policy and from this an economic level of expected load shedding expressed via a suitable index would be an outcome.

7. Generation Performance

7.1 Spinning Reserve

In the 2012-13 Review, the Commission made comment on the level of spinning reserve provided for the Darwin-Katherine network and noted that PWC's review of spinning reserve was yet to be completed. The Commission understands that the spinning reserve review is ongoing.

In the 2012-13 Review, the Commission made the following recommendation:

" It is recommended that PWC complete the review being conducted by SKM and ensure that the following information is available for next year's Review:

- value of customer reliability used in spinning reserve analysis and a robust analysis of how that value has been selected
- new spinning reserve targets for each of the networks
- extent to which the system can be expected to remain secure during multiple contingency events
- analysis of the improvement/decrease of reliability expected due to any change of the spinning reserve targets
- number of hours during the previous year during which the target spinning reserve margins were not achieved. "

With the exception of the last bullet point this information has not been provided to the Commission and it is understood that the "value of customer reliability" being used may be significantly lower than could be reasonably expected.

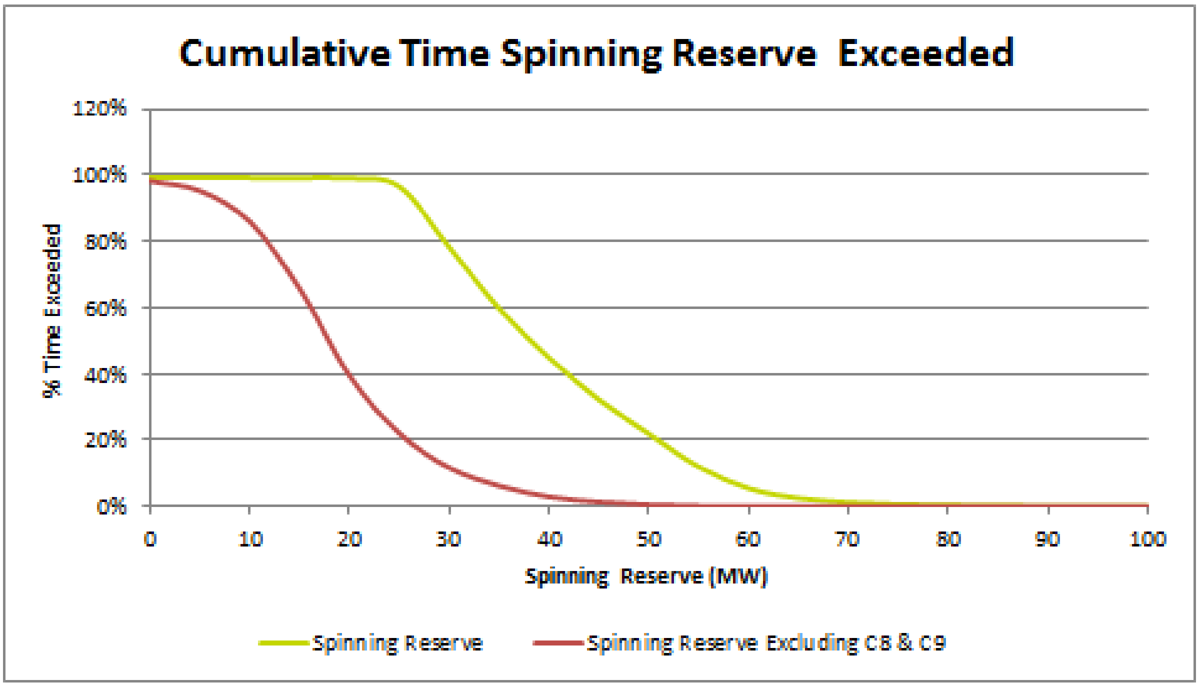
The Commission understands one reason for the delay in the spinning reserve review is that the dynamic power system model being used for the Darwin-Katherine system is not sufficiently accurate to give meaningful predictions. The urgency of development and improvement of this model was also noted in the Commission's 2012-13 Review.

Completion of the power system model and consequently the spinning reserve review (and implementation of any recommendations) should be a high priority for Territory Generation, PWC Networks and PWC System Control.

The actual spinning reserve achieved during the 2013-14 year was 25 MW or more for 96.5 per cent of the time. However, achieving this level of spinning reserve was highly reliant on the CIPS generation units 8 and 9. These generation units (like all aero derivative gas turbines) are able to react quickly to very small frequency changes but have little response or even a reduction of output for large frequency reductions[30]. If the spare capacity of generation units 8 and 9 are ignored then the system had 13 MW of spinning reserve or more 75 per cent of the time. The following chart shows the proportion of time that each level of spinning reserve was available, both with and without generation units 8 and 9.

[30] The Impact of Hydroelectric Power and Other Forms of Generation on Grid Frequency Stability for the WECC Region by; Deepak Aswani, Roger Clarke-Johnson and Gerald Runyan, American Governor Company, Amherst, WI, USA

Figure 7.1: Cumulative Time Spinning Reserve Exceeded



Source: The Commission

The Commission recommends that Territory Generation consider operating the CIPS generation units 8 and 9 at an output just below rating. This would allow the generation units to provide their rapid output for small frequency changes without curtailing any 'practical' spinning reserve from these generation units. Further spinning reserve would then need to be provided using the older industrial gas turbines. In implementing this recommendation Territory Generation should also consider the load at which generation units 8 and 9 have maximum thermal efficiency.

7.1.1 Incident report review

In 2012, the Commission approved amendments to the System Control Technical Code to include incident reporting provisions in the Code. The objectives of introducing incident reporting was to formalise investigation and reporting on major power system incidents, to inform the implementation of preventative measures and the response to adverse events.

There are a number of outstanding final major incident reports due to be provided by PWC System Control to the Commission in accordance with the System Control Technical Code. For the 2013-14 Review period, major incident reports were required for 23 reportable incidents.

Of the 23 reportable incidents, the Commission directed PWC System Control to engage an independent expert to undertake an investigation and prepare the final report in relation to nine reportable incidents that involved load shedding as a result of a generation trip. PWC System Control engaged Advisian to investigate and report on a total of 14 incidents, 11 of which were in the 2013-14 Review period. PWC provided final major incident reports for 10 incidents and two are still outstanding (one incident is generation related and other network related). The Commission notes that 2013-14 was a considerably busy period for PWC with structural separation, 2014 Network Price Determination and the actions that followed the 12 March System Black, nevertheless, incident investigation and reporting is a critical part of power system planning and the timing of these reports must be addressed as a matter of priority. It is understood PWC System Control is engaging additional resources to ensure it complies with its incident reporting obligations.

The Commission undertook a number of additional reviews, including:

1. Special Technical Audit of PWC and Territory Generation – 16 January 2015

2. Independent Investigations into the 12 March 2014 Darwin-Katherine System Black

These reports were completed with technical advice provided by Parsons Brinkerhoff and Advisian, respectively.

The detailed findings and recommendations of these reports are not duplicated in this Review, instead a few important conclusions are included.

Special Technical Audit

The Special Technical Audit examined the degree to which the system control, generation licence and the network licences were being complied with. The audit was conducted in mid to late 2014. The auditor also considered the level of likely compliance immediately prior to the March 2014 System Black incident. The report noted a number of non-compliant and part-compliant issues for PWC and Territory Generation. The audit also noted that both PWC and Territory Generation were non-compliant with the licence requirement to maintain an adequate compliance process. The Commission understands that PWC and Territory Generation have addressed, or are in the process of addressing, the part and non-compliant issues. A subsequent audit of PWC specific to its compliance framework will be conducted in mid-2015. Further details on the findings of the technical audit are provided at Appendix F.

Independent Investigations into the 12 March 2014 Darwin-Katherine System Black

In March 2014, the Commission undertook an investigation into the 12 March 2014 System Black incident following receipt of a request and Terms of Reference from the Treasurer. The Commission received technical advice from Advisian and CQ Partners. The Commission also received advice during the review from AEMO.

The Commission found that the root cause of the incident was the action taken by PWC in response to a malfunctioning of a circuit breaker. It was a switching procedure developed by PWC to isolate the malfunctioning circuit breaker to carry out repairs that caused the protection to trip the Channel Island to Hudson Creek transmission line and subsequently disconnected generating units at CIPS, WPS, Pine Creek and Katherine power stations. Generation-related issues at CIPS and WPS further prolonged the duration of the System Black.

The Commission made various recommendations concerning action in response to its key findings in the investigation report. Following the System Black, PWC appointed AECOM as the independent project management office (PMO) to implement the recommendations outlined in the PWC's reports of the incident, the Commission's report and similar System Black incident reports dating back to 2010. It understood that across the reports, the PMO was responsible for implementing 103 recommendations. Although outside of the review period, the Commission notes that as at March 2015, PWC had implemented all but 10 of the recommendations, and these are due for completion by the end of July 2015. The Commission notes the progress made to date but highlights the importance of the remaining recommendations, which include implementation of system islanding (a recommendation that dates back to 2010), review of UFLS processes and a review of the secure system guidelines.

Independent Investigation of Power System Reportable Incidents

In August 2014 and in accordance with the System Control Technical Code, the Commission directed System Control engage an independent expert to undertake an investigation and prepare a final report to the Commission in relation to power system incidents in the Darwin-Katherine power that involved UFLS following failure of a single generation asset. Advisian was engaged by PWC and undertook an investigation into 14 separate incidents.

The Commission notes a recurring theme in the report of generators in the Darwin-Katherine region not able to increase their output by an amount close to their assumed 'reserve' with sufficient speed to avoid load shedding. This means (for example) if the system is carrying 25 MW of spinning reserve then tripping of a machine generating less than 25 MW can result in a need to shed load. This effect seems to be particularly pronounced for the newer CIPS generations units 8 and which do not provide as much output as expected either in the immediate (transient) period or the sustained period.

The Commission recommends that PWC System Control and Territory Generation undertake the following actions with urgency:

- investigate why the machine output does not increase rapidly in response to a fall of system frequency;
- take corrective action to make the generators increase load in response to falling system frequency at the maximum safe rate;
- correct the performance of the power system models of the generators so that system performance can be predicted with confidence;
- confirm the optimum tuning of the generator governors and voltage regulators. Determine if there is some benefit to be gained by implementing power system stabilisers on the newer generation units; and
- finalise the spinning reserve review and implement its findings.

7.2 Availability of Existing Generators

7.2.1 Asset Management Plan Review

The Commission reviewed the following relevant documents as part of the 2012-13 Review:

1. Generation – Asset Management Strategy – 6 June 2013 – Draft
2. PWC Generation North – Asset Management Plan High Voltage Generators – Draft
3. Life Extension Study, Phase III – A life extension scenario and associated costs – 6 July 2012 – KEMA.

The Commission has not received new copies of these or similar documents for the 2013-14 Review and understands that no significant further development of these documents has occurred. However, the Commission has been assured that Territory Generation has greatly strengthened its intent to implement these existing plans and that detailed asset strategy planning is underway. The Commission will seek evidence of demonstrable progress during the 2014-15 year.

The following sections refer to Territory Generation as the corporation is now responsible for generation in the relevant power systems. However, the Commission notes for the 2013-14 Review period, PWC was responsible for generation in the relevant power systems.

7.2.2 Availability Outlook

Territory Generation operates the Darwin-Katherine network on an N-3 capacity-planning basis. Territory Generation's definition of N-3 is very different to the accepted meaning of N-3 used by other utilities. From the previous 2012-13 Review, the Commission understands N-3 is intended to represent the following scenario:

- N generation units in service to service the load;
- one machine in service to provide spinning reserve;
- one machine out of service for routine maintenance; and
- one machine unavailable for service (long term) due to major maintenance activity such as the CIPS life extension project.

Based on this arrangement it is quite conceivable that a forced outage of one machine could lead to a scenario where it is not possible to provide any spinning reserve until the machine undergoing routine maintenance can be returned to service.

Territory Generation has provided predictions of machine availability. Territory Generation has predicted that at CIPS each of the nine machines will be available 92 per cent of the time in each of the coming 10 years. These predictions are split according to 2 per cent forced outages and 6 per cent planned outages.

Assuming that one machine is out of service for planned maintenance, the likelihood of a certain number of generation units available at any one time has been calculated from these values:

Table 7.1: Probability of CIPS generation units being available for service

Generation units available (6+1 required[31])	Probability of precisely this any available	Probability of this many or more available
8	85.1%	85.1%
7	13.9%	99.0%
6	1.0%	99.96%
5	0.04%	99.999%

The future availability used by Territory Generation does not seem to be based on any significant evidence and does not match the values provided for the 2012-13 Review.

[31] +1 represents the need to provide some spinning reserve.

Table 7.2: CIPS generation units actual vs. predicted availability

Machine	2012-2013 Actual Availability	2013-14 Actual Availability	2014-2015 Predicted availability
Unit 1 GE Frame 6 combustion turbine (gas or diesel) 31.6 MW capacity	98.1%	97.3%	92%
Unit 2 GE Frame 6 combustion turbine (gas or diesel) 31.6 MW capacity	0.0%	67.4%	92%
Unit 3 GE Frame 6 combustion turbine (gas or diesel) 31.6 MW capacity	95.6%	100%	92%
Unit 4 GE Frame 6 combustion turbine (gas or diesel) 31.6 MW capacity	99.4%	77.3%	92%
Unit 5 GE Frame 6 combustion turbine (gas or diesel) 31.6 MW capacity	85.4%	59.7%	92%
Unit 6 Mitsubishi Steam Turbine (waste heat) 32 MW capacity	98.8%	72.5%	92%
Unit 7 GE LM6000 combustion turbine (gas or diesel) 36 MW capacity	85.1%	95.2%	92%
Unit 8 Rolls Royce Trent 60 combustion turbine (gas or diesel) 42 MW capacity	87.1%	95.5%	92%
Unit 9 Rolls Royce Trent 60 combustion turbine (gas or diesel) 42 MW capacity	66.5%	92.5%	92%

Source: PWC Standards of Service Report 2013-14

The historic availability values for Territory Generation's generation units are highly volatile, with no discernible pattern. Typically machine availability should follow one of three basic patterns:

1. increasing availability for relatively new plant;
2. constant availability for mid-life plant; or
3. reducing availability for end of life plant.

One possible explanation for the Territory Generation generation units failing to follow one of these patterns is that the mean time between failures of the generation units is following the expected pattern and the mean time to repair is highly volatile due to some external influence. The mean time to repair could be influenced by many factors including perceived urgency of repair, availability of the other generation units, the season, network load, availability of repair staff, or available funding.

In the absence of any pattern to the machine availability, it is not possible for the Commission to verify Territory Generation's assertion that each machine will have an availability of 92 per cent, but rather this seems highly unlikely or at least the variation around this number seems unpredictable.

The Commission recommends the reliability of generating units be estimated based on planned maintenance activities on an annual basis in addition to an allowance for unplanned outages. This would give some validity to the year-by-year projections and aid in the assessment of adequacy.

The Commission recommends that Territory Generation move to a probabilistic approach to determining the available capacity. The N-X approach is only applicable to systems where each individual component has very high availability (greater than 98-99 per cent) and this assumption is not applicable to Territory Generation's generation units.

7.3 Standards of Service Indicators

The following data is based on the PWC Standards of Service Report 2013-14 and previous reports for historical context. Figures 7.1 and 7.2 show the SAIDI and SAIFI results for the past six years relative to the agreed minimum standard (AMS).

Darwin-Katherine

The Commission observed in the 2012-13 Review, that the SAIDI measure for each of the regions was returning to trend. The data for Tennant Creek and Alice Springs continues this trend to some extent.

The Darwin region data is skewed by a couple of large events (namely the 12 March 2014 System Black and unplanned outages due to failure of CIPS generation units 8 and 9 and the Weddell units). Ignoring this event, the index for the rest of the year is adequate. This leads the Commission to conclude that system restart and contingency management systems were not adequate for that event.

The Commission concludes that:

1. SAIDI has not shown any improvement across a six year period but remains within the AMS, ignoring abnormal events such as the 12 March 2014 System Black incident;
2. SAIFI has remained low in 2013-14; and
3. with SAIFI low but SAIDI not improving, this suggests that events, when they occur, are of longer duration and so planning for recovery from contingencies appears to be lacking.

Although the 12 March 2014 System Black incident is excluded for the purposes of SAIDI, the Commission notes that the duration of the System Black was exacerbated due to generation-related issues.

The generation-related SAIDI and SAIFI measures for Katherine are zero (in the standards of service report), which may be a result of any system outages being attributed to the Darwin region.

Alice Springs

The Alice Springs generating SAIDI remains poor, although still within the AMS. The Commission observes that the major generation incidents in the Alice Springs region are due to secondary control system failures. These systems should include redundancy to allow ordered shutdowns or continued operation in accordance with good electricity industry practice. Territory Generation should consider a review of the subsystem reliability as a contributing factor to the verging on poor reliability of these units.

Tennant Creek

The Tennant Creek generation SAIDI and SAIFI remain acceptable despite some significant events during the 2013-14 period.

Figure 7.2: 4 Region SAIDIs

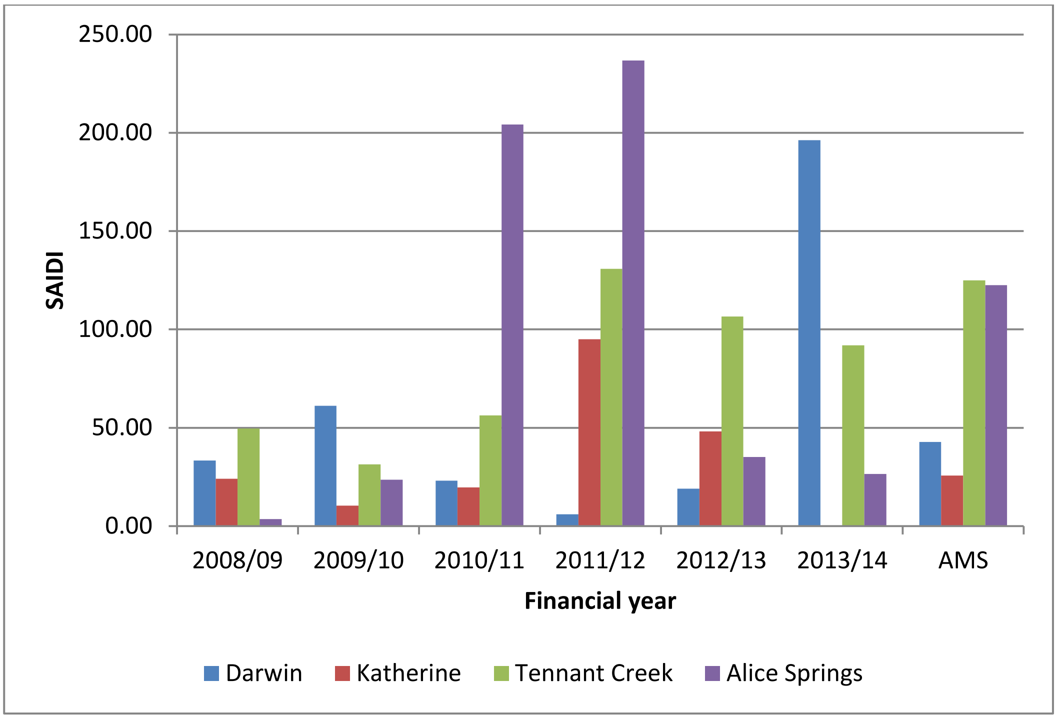
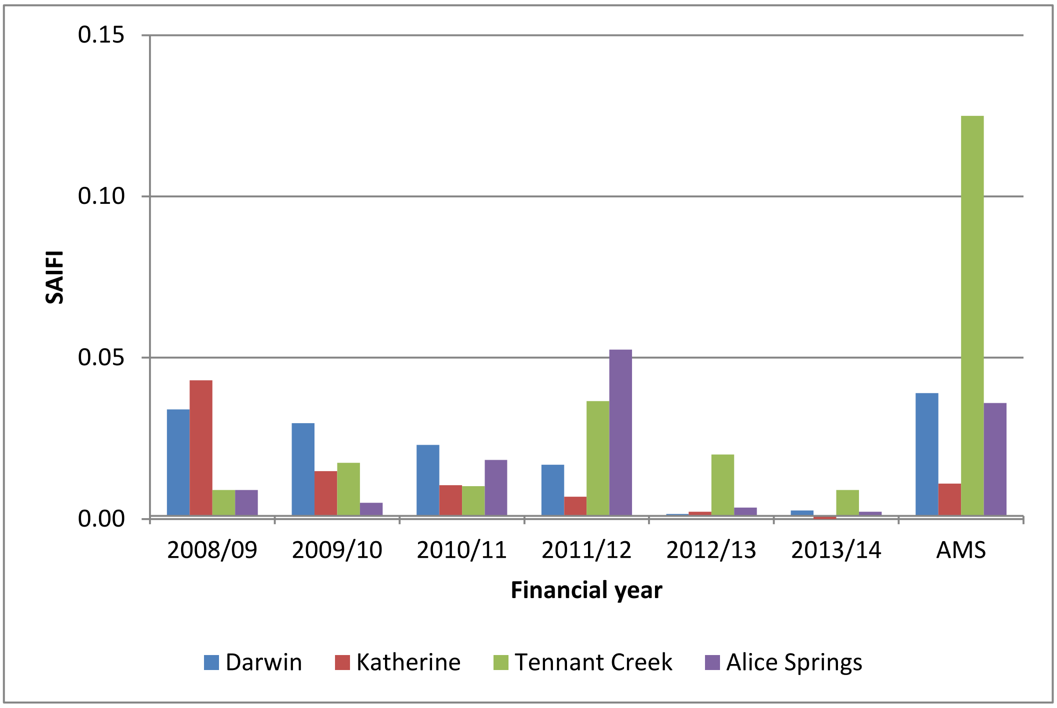


Figure 7.3: 4 Region SAIFIs



Source: PWC Standards of Service Report 2013-14

7.4 New or Proposed Generators

The PWC document, Capacity Investment Planning Strategy – Draft, approved 18 November 2013, was reviewed by the Commission as part of the 2012-13 Review. No additional information was provided for the 2013-14 Review.

7.5 Progress against Key Findings from the 2012-13 Power System Review

The following findings come from the 2011-12 Review and still need to be addressed by PWC and Territory Generation.

Continued development of electrical models, particularly in the Darwin-Katherine and Alice Springs systems, to identify both steady and transient stability issues must be addressed in order to fully realise the reliability benefits achievable from the significant investment in new generation in the systems. This work should specifically identify and document any deficiencies in current generator technical standards or network configuration that may be contributing to the transient stability issues in the systems, and develop a plan to redress them.

At the time of the 2012-13 Review there had been little demonstrable progress on this item but progress was considered imminent as part of the spinning reserve review being completed by PWC. The completion of the spinning reserve review needs to be finalised as a matter of priority.

Consistent with the above approach, finalise a comprehensive, and consistent with industry practice, policy on spinning reserve to be carried in each of the systems, with the intent of increasing the resilience of the systems to individual generator trips.

From the 2012-13 Review:

"The Commission requested in 2011-12 that PWC finalise a comprehensive, and consistent with industry practice, policy on spinning reserves to be carried in each of the systems, with the intent of increasing the resilience of the systems to individual generator trips. The Commission notes that this recommendation has not been completed, with the assistance of SKM, and that this review should be complete by mid-2014."

At the time of the current review this work remains incomplete.

Improvement of generation reliability at a unit level to reduce the number of Under Frequency Load Shedding (UFLS) events that are occurring across all three systems.

The Commission has not seen any evidence to suggest that there has been a material improvement in this area. The newer units remain the least reliable units and there may be some evidence that the rate of double contingency events is falling.

7.6 Key Findings – Generation Operation and Planning

The practice of routinely shedding load for single contingency events would be unsatisfactory in most electricity networks. It is understood the appropriate level of spinning reserve (and indirectly this load shedding practice) is currently being investigated by System Control. The Commission is keen to be informed of the outcomes of that study and any decisions to revise spinning reserve practices as a result. The Commission will also look at the assumptions of that study including the assumed value of customer reliability. The Commission considers that this should be priority for PWC in 2015-16.

Territory Generation needs to:

- understand why the output of the newer generators does not increase rapidly in response to a fall of system frequency;
- take corrective action to make the generators increase load in response to falling system frequency at the maximum safe rate;
- confirm the optimum tuning of the generator governors and voltage regulators;
- determine if there is some benefit to be gained by implementing power system stabilisers on the newer generation units; and
- consider providing less spinning reserve using the aero derivative gas turbines and more spinning reserve using the industrial gas turbines.

The power system and machine dynamic models need to be updated and proven to be accurate so that system performance can be predicted with confidence. This should include detailed testing of the generation units.

The Commission’s view is that considerable work is required by PWC to improve the timing of the reporting of major incidents. The Commission is aware that PWC is engaging additional resources to address this issue of compliance.

8. Fuel Supply

8.1 Introduction – Scope and Methodology

The scope of this chapter is to:

- review the adequacy of fuel resources and fuel transport for electricity generation for the medium and long term, including discussion of any significant risk to continuity of supply;
- assess the 11 September 2014 supply interruption and make relevant recommendations; and
- review potential developments in the area of fuel resources.

The methodology of the 2013-14 report is consistent with the previous year's report and where circumstances have not changed and details remain relevant, they have been re-stated in this chapter.

8.2 Adequacy of Northern Territory Gas Supply

8.2.1 Territory Generation's Gas Requirement

Territory Generation confirmed its gas usage for 2013-14 from the three main power systems (that is, Darwin-Katherine, Alice Springs and Tennant Creek) was 18.1 PJ (representing a 1.1 per cent increase from the previous year). Eighty-five per cent of gas used in the three main power systems was in the Darwin-Katherine system. PWC's gas sales to other parties and other generation requirements in the Territory resulted in a total 2013-14 gas usage of approximately 21 PJ (annual daily average of 57.5 TJ/d). The Territory's peak 2013-14 daily gas demand was approximately 78 TJ/d.

Territory Generation has forecast a flat to slightly negative growth in gas demand from the three main power systems during the next five years, with increased efficiency from modern generation facilities offsetting small increases in power demand. Increased competition from third party generation providers may also reduce Territory Generation's gas requirement over the medium to long term. PWC's direct gas sales to Territory industrial customers are also under pressure, with the Amadeus basin gas producers seeking to capture market share through sales to industrial customers. The conclusion is that both PWC's and Territory Generation's gas demand growth is under pressure from increasing competitive forces in the Territory.

8.2.2 PWC Gas Supply

PWC has entered into a long-term contract to purchase gas from ENI's offshore Blacktip gas field in the Bonaparte Basin. Refer to Figure 8.1 for the location of ENI's Blacktip field and the Wadeye onshore processing plant. PWC and ENI have entered into a 25 year gas supply arrangement, which commenced in 2009 for the supply of up to 740 PJ of gas, with an initial annual quantity of 22.5 PJ/a and increasing to 37 PJ/a in the last contract year[32]. The maximum gas processing capacity of the Wadeye plant is approximately 110 to 120 TJ/d1. PWC's annual contract quantity for the 2013-14 period is substantially in excess of its actual gas requirements.

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[32] ENI press release, "ENI starts development of Blacktip gas field offshore Australia", 30 June 2006

The annual contract quantities from Blacktip increase over time to allow for market growth in the Territory. These increases in annual quantities are considered in excess of PWC's forecast growth in demand over the medium to long-term, which will increase PWC's take or pay exposure to Blacktip over time. PWC's maximum daily gas demand of approximately 78 TJ/d is also substantially less than the contracted maximum daily supply entitlement from Blacktip of approximately 110 TJ/d. The Territory's daily peak gas demand tends to grow at faster rates compared to the annual demand for gas and should be monitored each year to ensure peak demand is adequately covered.

8.2.3 Gas Transportation Capacity

The transportation capacity of the Bonaparte Pipeline and the Ban Ban Springs to Darwin section of the Amadeus pipeline is approximately 104 TJ/d2. Figure 8.1is a map of the Northern Territory Gas Transportation pipeline infrastructure. PWC has entered into sufficient long-term transportation agreements with the owners of the Bonaparte and Amadeus gas pipelines to transport Blacktip gas to its various power station delivery points in the Territory.

8.3 Security of Gas Supply

8.3.1 Introduction

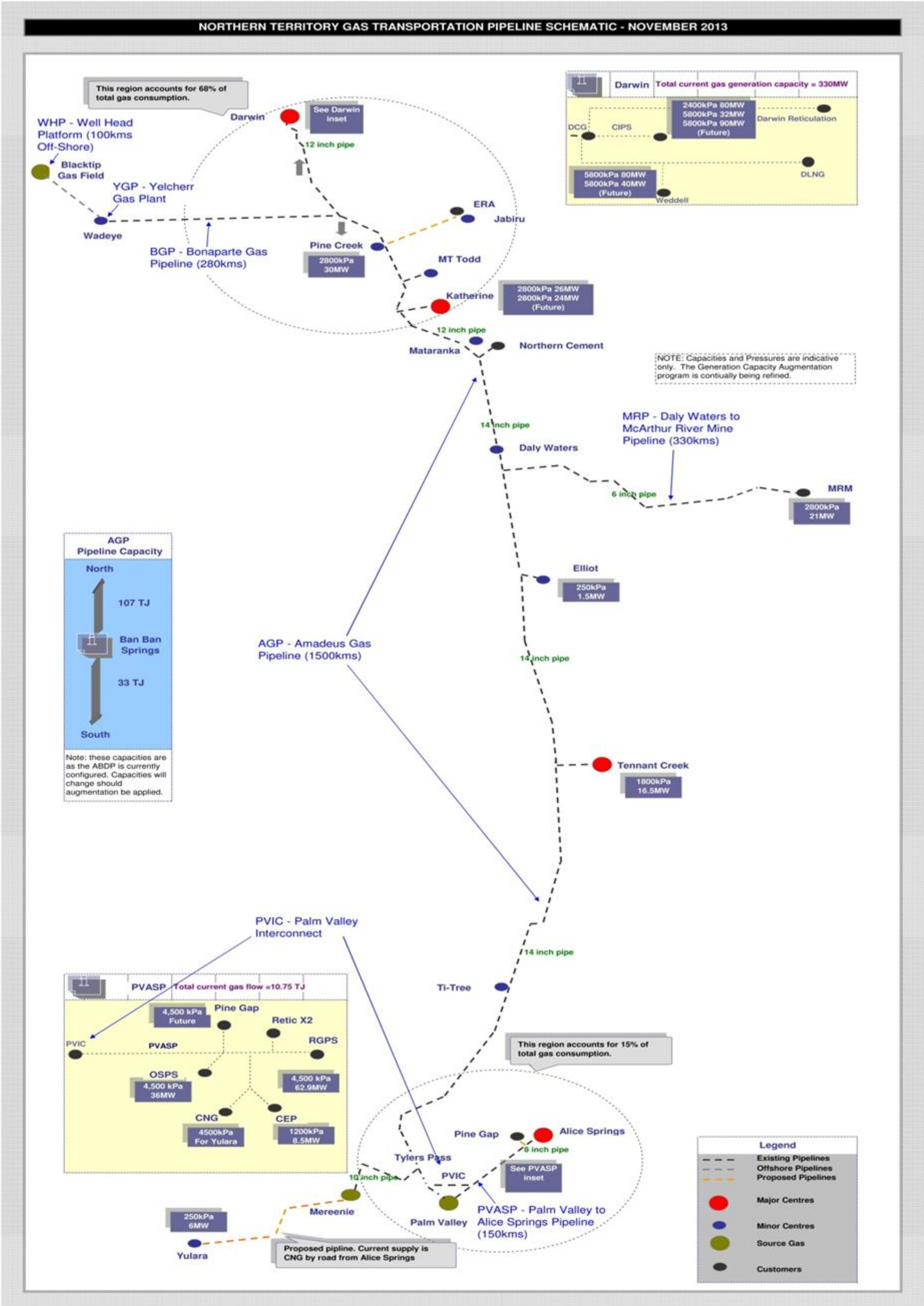
Gas supply to the Territory is assessed to have 'N-1' redundancy. That is, both Blacktip and Darwin LNG can supply 100 per cent of the Territory's gas requirement, should either one of these sources of gas supply be interrupted. It is important to note there are some limitations to the Darwin LNG back-up arrangement, which affects its ability to cover 100 per cent of Territory gas demand (in the event of a complete Blacktip failure), as follows:

- supply is restricted to a maximum amount of 2.5 PJ/a in any calendar year; and
- during periods of peak demand, Darwin LNG's supply to the southern regions of Alice Springs may be restricted by insufficient Amadeus gas pipeline pressure. New southern supply from the Dingo gas field (forecast to commence in 2015) and potential additional supply from Mereenie/Palm Valley is likely to eliminate this risk.

As detailed in section 8.4, pipeline line pack, Amadeus basin gas and diesel back-up generation provides additional energy support to the Territory, however these measures are not capable of replacing 100 per cent of Territory's energy requirement in the event of a simultaneous Blacktip and Darwin LNG outage that extends for a small period, less than a day in the case of the 11 September 2014 incident.

The commencement of the Inpex back-up supply arrangement (in approximately 2017) will increase gas system security to N-2 until 2022. PWC's Darwin LNG back-up arrangement expires in 2022 (unless a new extension agreement can be agreed by the parties).

Figure 8.1: Northern Territory Gas Infrastructure



8.3.2 Blacktip Gas Field

8.3.2.1 Redundancy of Blacktip Infrastructure

The Blacktip gas field consists of two offshore wells with an unmanned and remotely operated wellhead platform. The onshore plant consists of three export compressors, simple separation and dehydration facilities and utilities such as power generation. This type of facility similar to other upstream gas projects in eastern Australia like those in the Otway basin that supply gas to the Victorian domestic market. Generally unmanned offshore facilities will have a lower level of reliability than manned or onshore facilities. The additional time taken to fly out to an unmanned platform and assess the nature of any production issues will increase the time of a supply interruption.

The two development wells provide some level of field deliverability redundancy, given current sales to PWC are essentially from one well, although the productivity of the second well may not have the same capacity of the main producing well. The onshore gas plant at Wadeye has three export compressors, which are required to be fully operational to produce gas at peak production rates. Where a gas plant has an extra unit on standby for each major processing element (that is, compression, dehydration, liquids separation, utilities, etc.), the gas plant is referred to as having full n+1 redundancy. At peak production rates (approx. 110 – 120 TJ/d), the Wadeye facility does not have full redundancy for periods of planned maintenance activity or a trip of major processing elements of the gas plant. Plant utilities such as steam and power are often a source of production issues for a plant such as the Wadeye facility and an interruption to power was the cause of the 11 September 2014 interruption.

PWC's peak-day requirement for gas is approximately 78 TJ/d, which is significantly below the peak capacity of the Blacktip gas plant. The amount of redundant plant capacity (created by current low levels of demand) will decrease over time as the rate of peak-day demand increases. At higher levels of daily gas demand by PWC, there is likely to be an increased reliance on PWC's back-up supply arrangements, as redundant plant capacity may not be available to cover minor (or major) trips to Blacktip gas production. Without full N-1 redundancy on all major elements of plant processing capacity, there is an increased risk of minor or major shortfalls during periods of plant failure coinciding with peak gas demand. Given PWC's strong back-up arrangements, this is not an area of concern but should be noted and may involve a greater level of management of PWC's daily gas supplies in the medium term.

8.3.2.2 Blacktip Planned and Unplanned Maintenance

Typical to other gas sales agreements, there are limits on the duration of planned and unplanned maintenance interruptions of gas supply from Blacktip facilities each contract year. Importantly, there are also restrictions on the number of days in a row for a single interruption. The duration and scale of any Blacktip supply shortfall will determine whether PWC is required to call upon its back-up gas arrangements. The permitted periods of planned and unplanned maintenance and maximum number of days of continuous interruption are well within PWC's back-up capabilities from Darwin LNG.

8.3.2.3 Blacktip Reserves

Gas reserves and well deliverability are critical elements of gas supply security. Field performance should be regularly monitored over time. Blacktip's current 1P[33] reserves are sufficient to satisfy its long-term contractual obligations to PWC. Blacktip is at the early stage of its producing life, having produced for only six years of a 25 year supply term to PWC. It is recommended that reserves, well deliverability and levels of reservoir water production be monitored at regular intervals over the life of the project. While there are no indications of reserve or deliverability issues and ongoing risks seem low given 1P reserves are sufficient to satisfy ENI's contractual obligations to PWC, a major failure of Blacktip reserves/deliverability would be classified as a catastrophic event and have material gas supply and cost implications for the Territory.

8.3.3 Amadeus Basin Gas

8.3.3.1 Mereenie/Palm Valley

The development of the Blacktip field created gas-on-gas competition in the Territory for the first time. The large quantities of Blacktip gas and the unutilised productive capability of the Amadeus gas (albeit not as large as historical rates due to the partial depletion of its gas reserves) has created a long supply market in the Territory. This has created a competitive gas market for Territory customers and put downward price pressure on new gas supply contracts.

Amadeus gas production is currently supplying small quantities of gas to customers in the Territory, although this is expected to increase over the medium term. Large industrial customers (such as McArthur River mine), potential new power generators and mining projects are expected to increase supply from the Amadeus basin. It is estimated there are over 100 PJ of conventional proven and probable tail gas reserves remaining in the Amadeus Basin – most of these in the Mereenie gas field.

This long supply market in the Territory assists security of supply in the event of major interruption from Blacktip. The Amadeus basin does have capabilities to supply additional gas in circumstances of a major failure of Blacktip production, however these additional quantities are not large and not capable of replacing a major supply interruption. There would also be commercial and technical issues that PWC would need to resolve associated with a major re-start of Amadeus gas production.

8.3.3.2 Dingo

In September 2013, PWC entered into a new gas sales agreement to develop the Dingo gas field, located 60km south of Alice Springs. PWC's initial supply tranche is 15.4 PJ over a 10-year term from the Dingo gas field, with options to increase supply up to 31 PJ of gas over a 20-year supply period if sufficient reserves are available[34]. Supply is expected to commence from 2015. Dingo gas will be connected into the pipeline transmission system at Brewer estate, 20km south of Alice Springs. The development of Dingo provides an additional supply option for PWC and will also improve the efficiency of the new Owen Springs Power Station. Dingo gas is "leaner" (that is, it contains lower levels of LPGs) compared to "rich" sale gas from Mereenie. Modern gas engines run more efficiently utilising leaner sales gas compared to rich sales gas streams.

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33 1P reserves denotes proved reserves under the Petroleum Resource Management System (PRMS), developed by the American society of petroleum engineers to classify oil and gas resources. 1P reserves have a 90 per cent confidence level of being produced over the life of the asset.

34 Magellan press release, 12 September 2013.

8.3.4 LNG Back-up Supply

8.3.4.1 Introduction

PWC's back-up supply arrangements with Darwin LNG and Inpex LNG are not considered traditional firm supply agreements, as their LNG production would take precedence over supply to PWC. Given the scale of the LNG operations and the importance of power supply to the Territory, it is unlikely that either Darwin or Inpex LNG would not supply gas to PWC when requested, unless the LNG facility is physically incapable of supplying gas, such as during periods of planned or unplanned maintenance activities.

8.3.4.2 Darwin LNG

PWC has an existing back-up arrangement with Darwin LNG's Wickham Point facility to supply up to 80 TJ/d, with a maximum annual purchase of 2.5 PJ. This arrangement will continue until 2022. Assuming a northern peak demand of 65 TJ/d (Darwin-Katherine region), the existing Darwin LNG back-up arrangement could supply the northern region for five to six weeks (or longer periods during low demand). PWC has previously utilised Darwin LNG back-up supply during periods of planned and unplanned interruption of Blacktip production, although actual rates of supply have been significantly lower than the 80 TJ/d maximum. Other than the 11 September 2014 incident, PWC's Darwin LNG back-up arrangement has proven effective and is currently PWC's main mechanism to manage supply shortfalls from Blacktip. At the time of the 11 September 2014 incident, Darwin LNG was undergoing planned maintenance and therefore not immediately available at the time when supply from Blacktip was interrupted.

The northern region of Darwin-Katherine (where the majority of generation is located) can be supplied using Darwin LNG back-up gas. Pipeline pressures in the Amadeus pipeline may not be sufficient to transport Darwin LNG back-up gas south of Tennant Creek. Where there is a partial supply from Blacktip, Blacktip gas would continue to supply southern demand. Where there is a total loss of Blacktip gas, the southern region would be supplied through a combination of pipeline line pack, Darwin LNG (if pipeline pressure is suitable), Dingo gas and diesel generation. In an extended outage, additional gas from the Amadeus basin could be used to supply additional gas to the southern region.

8.3.4.3 Inpex LNG

PWC has executed an agreement for a second back-up supply with Inpex (developers of the second LNG plant in Darwin). This arrangement will commence upon operation of Inpex's LNG plant in 2017 for a period of 15 years. PWC has a daily entitlement of 100 TJ/d, with a maximum quantity of 3 PJ per annum. This second PWC back-up arrangement will greatly improve security of gas supply to the Territory, not only in duration of northern back-up supply capability (by doubling the period of coverage to at least 13 weeks), but also by managing the circumstance of a simultaneous interruption of gas supply from Blacktip and Darwin LNG.

8.3.5 Gas Transportation

8.3.5.1 Pipeline Failure

Neither the Bonaparte pipeline nor the Amadeus pipeline have operating mid-line pipeline compressor stations. The Amadeus pipeline has a mothballed compressor station at Tennant Creek.

This compressor station is not required to operate to satisfy peak demand, based on the current direction of gas flow and sources of supply. The lack of operating mid-line compressor stations reduces the risk of a transmission interruption.

Pipeline rupture of the Bonaparte or Amadeus pipeline is likely to cause some level of gas interruption to PWC's facilities. The location of the pipeline rupture would determine the extent of gas interruption, however this type of event is rare and even a major rupture is likely to be rectified within 5 to 10 weeks. Minor pipeline leaks are likely to be repaired within 24 hours. The gas supply system does not have full redundancy in the event of a major rupture of the Amadeus gas pipeline and the location of the rupture would impact the ability of supply contingency solutions to cover a transmission failure.

8.3.5.2 Pipeline Line Pack

Spare gas stored in transmission pipelines is referred to as pipeline line pack. The amount of line pack that can be used to supplement gas demand during a shortfall of Blacktip production depends on:

- the prevailing pipeline operating pressure. The quantity of spare pipeline line pack is increased at higher pipeline operating pressures; and.
- pipeline throughput and the amount of spare or unutilised firm transportation capacity. Gas transmission pipelines, which are short or transport gas close to their maximum design capacity, have virtually no spare pipeline line pack. Gas pipelines that are long and have large quantities of unutilised capacity can have material quantities of spare line pack to supplement demand during periods of gas shortfall.

PWC has provided high level estimates of available line pack, which can be taken from the relevant pipeline before generation is restricted:

- Bonaparte gas pipeline – up to 35 TJ;
- Amadeus gas pipeline (Ban Ban Springs to Darwin section) – less than 5 TJ;
- Amadeus gas pipeline (Ban Ban Springs to Alice Springs) – up to 100 TJ; and
- Palm Valley to Alice Springs pipeline – less than 5 TJ.

The quantity of spare pipeline line pack in the Amadeus pipeline from Ban Ban Springs to Alice Springs is highly dependent on the direction of flow in the Amadeus gas pipeline. Currently, the Amadeus Gas pipeline is flowing at low rates from Ban Ban Springs to Alice Springs (that is, southerly gas flow), which provides a material quantity of spare line pack that could be utilised in the southern regions. Only a small amount of spare line pack in the southern section of the Amadeus gas pipeline (that is, the Ban Ban Springs to Alice Springs) could be used to supplement the northern region's gas supply, because of the high delivery pressure requirements of PWC's generating facilities at CIPS.

The northern region has limited spare line pack especially in the section of the Amadeus pipeline from Ban Ban Springs to Darwin because of its short distance and high flow rates. The Bonaparte gas pipeline represents the largest source of spare line pack for the northern region, however at peak demand rates the northern region's spare line pack would maintain Darwin-Katherine generation for less than one day if gas production ceased from Blacktip. The southern regions have access to a greater level of line pack (from the Ban Ban Springs to Alice Springs section) and generation could be sustained for up to several days, depending on the prevailing flow of gas and pipeline pressure. Spare pipeline line pack is considered a small and short-term supplement to the main gas contingency strategy of using back-up supply from Darwin LNG or Inpex LNG.

8.3.6 Diesel Back-up

PWC has a number of facilities that are capable of using diesel as a last resort if no sources of back-up gas or spare line pack are available. Katherine, Tennant Creek, Ron Goodin and Owen Springs power stations have duel fuel (that is, gas and diesel) generation capabilities. CIPS has some gas generators that can be converted to diesel in 24 to 48 hours, if required.

Based on advice from Territory Generation, diesel capacity for the three main power systems are:

- Darwin-Katherine system: 310 MW of diesel generation capacity compared to a peak 2013-14 demand of 309.8 MW, although not all this capacity is available instantaneously and units at CIPS require up to 48 hours to be at full diesel generation capability;
- Alice Springs system: 80.6MW of diesel generation capacity compared to a peak 2013-14 demand of 57.6MW; and
- Tennant Creek system: 11.9 MW of diesel generation capacity compared to a peak 2013-14 demand of 7.6 MW.

PWC has substantial diesel storage capacity at all its dual-fired facilities, although the new diesel tanks at Owen Springs power station have a smaller diesel storage capacity than the tanks at the old Ron Goodin power station. Ron Goodin power station is being phased out by the new Owen Springs power station. The operational inventory of diesel storage varies, depending on the location and availability of back-up gas supply.

Territory Generation has advised the operational target for diesel back-up at CIPS is approximately seven hours of supply. Tennant Creek and Alice Spring systems have higher levels of diesel inventory compared to the Darwin-Katherine system due to the easy availability of Darwin LNG back-up gas in the northern region.

8.3.7 Contingency Analysis – Failure of Blacktip or Gas Transportation

An analysis of the contingency arrangements for a major and minor failure of Blacktip supply and gas transportation capacity is detailed in Table 8.1.

Table 8.1: Gas Contingency Analysis

Incident	Event	Contingency/Outcome
Partial loss of Blacktip supply, less than 10 days.	Minor plant failure or shutdown	• northern supply from Darwin LNG and/or Inpex LNG • southern supply from Blacktip • no impact, within normal contingency
Partial loss of Blacktip supply for more than 5 weeks.	Major failure of plant/equipment requiring extended period of repair.	• northern supply from Darwin LNG and/or Inpex LNG, additional gas maybe required • southern supply from Blacktip • outside normal contingency and may require additional gas purchases from Amadeus/Darwin LNG/Inpex LNG
Full loss of Blacktip supply for less than 10	Significant failure of plant or extended	• northern supply from Darwin LNG and/or Inpex LNG • southern supply from pipeline Darwin LNG/Inpex LNG (subject to sufficient pipeline pressures), northern LNG

days.	maintenance.	back-up, Amadeus gas or diesel. • no impact, within normal contingency, unless Amadeus gas required.
Full loss of Blacktip for more than 5 weeks.	Catastrophic failure of field or plant, reserve failure, fire/explosion.	• northern supply from Darwin LNG or Inpex LNG, additional gas required. • southern supply from additional DarwinLNG/Inpex LNG (subject to sufficient pipeline pressures), Amadeus or diesel • outside normal contingency and requires additional gas purchases from Amadeus/Darwin LNG/Inpex LNG • large additional costs, but gas likely to available to satisfy PWC's full gas requirements.
Pipeline Rupture	Minor Rupture – less than 24 hrs.	• Blacktip, Darwin LNG or Inpex LNG back-up, pipeline line pack where rupture doesn't prevent gas supply • diesel where rupture prevents gas supply • no impact, within normal contingency
Pipeline Rupture	Major Rupture – more than 5 weeks	• Blacktip, Darwin LNG or Inpex LNG back-up, pipeline line pack where rupture doesn't prevent gas supply • diesel where rupture prevents gas supply • possibly outside normal contingency and may require additional gas purchases from Amadeus/Darwin LNG/Inpex LNG.

8.3.8 Key Conclusions – Security of Gas Supply

The key conclusions regarding security of gas supply to the Territory are:

- Northern Territory's gas system security is considered to be N-1, that one major source of gas can fail and be fully covered by supply from an alternate source. A compete Blacktip supply interruption can be fully covered by Darwin LNG (if available and subject to certain conditions);
- ENI's Blacktip field does not have full N-1 redundancy on all elements of field production and plant processing. This increases the Territory's reliance on back-up gas arrangements and alternate sources of energy such as diesel generation;
- Amadeus basin gas and diesel back-up generation provides additional energy support to the Territory, however these measures are not capable of replacing 100 per cent of Territory's energy requirement in the event of a sustained period of simultaneous Blacktip and Darwin LNG outage;
- the addition of the Inpex LNG back-up arrangement from 2017 will materially improve security of gas supply to the Territory, doubling the contingency supply period of up to twelve weeks and increasing gas system security to N-2 until 2022;
- Darwin LNG and Inpex LNG can supply the southern region but is subject to sufficient pressure available to transport gas from Darwin to Alice Springs. Diesel, spare pipeline line pack or new gas from Amadeus would be the alternate options if northern gas were unable to supply all of the southern gas demand; and

- during an event involving a major failure of Blacktip gas supply (that is, greater than five to six weeks with Darwin LNG alone or more than 13 weeks with Darwin LNG and Inpex LNG), existing contingency arrangements would exceed volume caps. Additional gas purchases from Darwin LNG, Inpex LNG and/or Amadeus would be required, subject to parties agreeing to suitable commercial arrangements. These purchases would likely be at a higher cost, however existing infrastructure can provide continuity of gas supply.

8.4 11 September 2014 Supply Interruption

Blacktip (ENI) gas supply was interrupted due to an equipment failure. System Control took measures to reduce load in an attempt to maximise the usage of the advised remaining gas, the measures taken included both voltage and frequency reduction, as well as reducing the minimum required spinning reserve. Territory Generation was also required to change over several generating units to operate on liquid (diesel) fuel (C9, C5, K1, K2).

PWC System Control adopted a rotational load shedding scheme to further reduce load. The scheme involved eight blocks and each block was taken off supply for a duration of approximately one hour. Only seven blocks of the eight were used as ENI restarted production in the evening.

8.4.1 Analysis and Key Recommendations

There was an emergency event on 11 September 2014 which required load shedding as a result of a gas supply failure due to an electrical fault at the Blacktip gas platform. Investigations into the event highlighted a number of areas that require improvement to reduce the likelihood and mitigate the impacts of any future emergency event. The following is a summary of the key recommended actions noted by PWC in its report to the Territory Government following the 11 September event:

(a) review and improve ENI's electrical utilities systems, which supply power to the Blacktip plant and unmanned wellhead platforms. A power interruption to the unmanned wellhead platform was the source of the gas supply interruption;

(b) establishment of formal operational/communication protocols with all stakeholders involved in the gas supply chain to avoid situations where maintenance activities planned by stakeholders clash; and

(c) improve internal PWC and government communications processes to more quickly inform relevant stakeholders of a potential gas supply problem.

The Commission supports the above recommendations, with an expansion of item b) to include an effective emergency response management process to manage hourly gas flows and power generation during an event.

An effective emergency response management process will assist to reduce the scale and impact of the Territory electricity blackouts. The Commission considers the emergency management of the 11 September event was hampered because there was not an effective management process that enabled a free flow of live information between all the key stakeholders, namely ENI, APA/Amadeus pipeline, Darwin LNG, Amadeus gas producers, PWC and Territory Generation. In such circumstances, stakeholders will often make conservative decisions because information is not sufficient to enable parties to make a risk assessment of different scenarios.

Often there is limited information during emergency events, however the role of the emergency management process is to bring all available information to the key stakeholders to facilitate the best decisions. Eastern Australia has operated a successful emergency response process for some time, to manage major gas supply outages at Moomba or Longford.

The key aspects of an effective emergency response process would involve:

- a gas supply interruption from Blacktip or Darwin LNG, that is likely to last longer than an agreed time protocol, would trigger an emergency response. Where Blacktip or Darwin LNG is undergoing planned maintenance activities and the gas system security is operating on ‘n’ (that is, no system redundancy), there should be stricter protocols to initiate an emergency response;
- PWC or ENI (gas producers generally initiate an emergency response in the eastern states) would call an emergency response;
- stakeholders would dial into an emergency teleconference number, including representatives from all gas producers (including Darwin LNG and Amadeus producers);
- PWC or ENI would lead each teleconference and all parties would share the most updated information on items such as:
  - nature of the gas supply interruption and likely recovery times;
  - available line pack and pipeline pressures;
  - supply capabilities from other gas producers (that is, the Amadeus producers, etc.);
  - current electricity demand, diesel generation capabilities and the status of any current or potential blackouts; and
  - any other relevant information.
- teleconferences continue until the emergency response is over, sometimes as frequently as every one to four hours during critical periods.

There is no contractual obligation for parties to participate or share information in the emergency response teleconferences. Parties participate on the basis of goodwill and in the public’s best interests. The focus is on operational and not commercial matters. The commercial issue such as liability and the contractual nature of the event, are not relevant at the time and these matters are addressed subsequent to the emergency response. This emergency response process has operated during east coast gas emergencies. Where the industry has worked together, gas supplies to customers have been maintained during serious events that otherwise would have led to major gas outages. The Commission recommends that a similar process be developed in the Territory to better manage emergency events and minimise electricity interruptions to customers.

8.4.2 Other Items relevant to 11 September Event

A summary of other key items to the 11 September 2014 event:

- if either Blacktip or Darwin LNG schedule planned maintenance activities, there should be heighten focus on gas security issues during these periods, since the gas supply system is operating without full back-up gas cover (that is, on a ‘n’ basis). Where the gas system is operating on ‘n’, it is recommended that preparations be made for the relevant period to reflect the higher level of supply risks, which should include:
  - maximise pipeline line pack by ensuring there is no planned pipeline maintenance that reduces operating pressures along the pipeline and maximise gas flows into the pipeline a few days prior to the event;

- advise all relevant parties of the periods of ‘n’ gas system security to maximise readiness for other energy support, such as diesel generation back-up, pipeline line pack or alternate supply from the Amadeus basin;
- finalise in advance all technical and commercial issues with Santos and Central Petroleum to facilitate a quick ramp-up in production if required from the Amadeus basin, including commercial arrangements for automatic spot gas sales if required; and
- review diesel inventories for all Territory power stations and prevailing capabilities to re-stock storage tanks at short notice.

8.5 Potential Developments in Territory Fuel Resources

There are a number of upstream parties exploring for new oil and gas opportunities in the Northern Territory. Onshore activity tends to be focused on unconventional gas exploration, mostly shale gas opportunities and offshore activity on new conventional resources.

Onshore unconventional developments are more likely to provide new domestic supply opportunities compared to offshore exploration because:

- onshore developments can support small scale initial developments with incremental expansion, while offshore developments require large markets (such as LNG supply) to justify the large capital cost of bringing gas onshore; and
- generally only large producers participate in offshore exploration due to the large costs (these producers tend to focus on big scale LNG projects rather than smaller domestic supply projects).

While an offshore project can supply gas to a Darwin LNG project and domestic supply opportunities concurrently, history has shown that large companies tend to be singularly focused on LNG projects (such as, ConocoPhillips, Inpex experience) and not domestic markets.

The backfill of ConocoPhillips’ Darwin LNG plant after depletion of Bayu-Undan gas reserves around 2022-23 or the potential Darwin LNG plant expansion is a large market opportunity for new sources of Territory gas. ConocoPhillips is currently focusing on the new Browse basin and Timor Sea gas to satisfy its Darwin LNG project, although onshore unconventional gas could also supply this opportunity.

In summary, there are a number of potential new sources of gas supply in the Territory, although all need further exploration and appraisal to establish their technical and commercial viability. Most of these new supply opportunities are from onshore unconventional gas exploration/appraisal, although an offshore tie-back to the existing Blacktip field from other resources in the Bonaparte basin could also provide new domestic supply opportunities.

9. Electricity Networks Adequacy

9.1 Introduction

The Commission has reviewed the method used by PWC to assess the transmission and distribution system network adequacy to meet existing and future demand. The method is primarily documented in the PWC Network Management Plan (NMP) 2013-14 to 2018-19. Where possible the Commission has validated the results provided in the NMP against supporting data provided by PWC.

The Commission has used the following criteria, which is similar to the PWC criteria, for the 2013- 14 Review:

- **Planning and monitoring**. PWC's should have the capacity to measure, plan, operate, maintain and augment the network in order to maintain the adequacy of the system.
- **Existing and future system utilisation** should be low enough to allow for load growth, peak loads and loadings during equipment outages. Conversely utilisation should be high enough to avoid unnecessary augmentation and unnecessary costs to customers. This assessment is made at the following system levels:
    - zone;
    - transmission line;
    - substation;
    - feeders;
    - distribution substation; and
    - LV network.
- **Poorly performing feeders.** PWC should have plans to bring the reliability of any poorly performing feeders up to a satisfactory level.
- **Fault levels**. Electrical equipment is designed to withstand current and associated short-circuit forces in the event of a fault. PWC should have documents that record what current system fault levels are and the design capacity of each installation. They should also have processes to ensure that new and existing equipment capability is not exceeded by the system fault levels.
- **Condition of the asset**. PWC should carry out preventative maintenance, planned corrective maintenance and asset replacements to reduce the probability of unexpected plant failure, at an acceptable cost.
- **Demand management.** PWC should document the alternative strategies considered to meet the system demand. These activities can be different from the traditional methods, which were focused exclusively on upgrade of generation and network capacity to meet a higher system demand. The modern approach adopted by PWC includes considering new tariff structures, power factor correction, load shifting and embedded generation. Collectively these strategies are known as 'non-network solutions'.
- **Security of the system**. The PWC power system should continue to operate under reasonable network contingency conditions. There are some network configurations like radial transmission systems or single transformer ZSS where loss of supply is unavoidable. In these cases, there should be plans in place to restore supply to customers quickly.

- **Reliability of supply**. PWC is required to publish reliability data in their annual 'standards of service' report. This data should show improving reliability over time.

9.2 Planning and Monitoring

PWC provided the Commission with an update of their NMP dated January 2015. This document is an update of the plan that was provided at about the same time last year for the 2012-13 Review. The NMP is not explicitly required to meet PWC's legislated obligations, however it does contain much of the information required by the Commission in an easily accessible form.

PWC's NMP for 2012-13 to 2017-18 was made publicly available on PWC's website and the Commission understands that it is PWC's intention to publish the latest plan in the same way.

Section 1.3 of the latest NMP says:

The Plan's key objectives are to:

- *provide stakeholders with greater transparency of the electricity network's management and operation by documenting Power Networks' mission, the major challenges and management strategies and plans;*
- *satisfy much of the Commission's reporting requirements for the regulated electricity network;*
- *lay the foundation for subsequent regulatory price determinations;*
- *provide a framework for continuously improving the network's technical and economic performance; and*
- *disseminate information on the proposed development of the network over the next five years and beyond, thereby facilitating the development of non-network alternatives to traditional network expansion.*

The NMP demonstrates at a high level that PWC has suitable systems in place to monitor the performance of the network and plan work required to maintain the adequacy of the network. It is particularly noteworthy that since 2009, PWC has moved from reactive maintenance practices to preventative maintenance and is using the MAXIMO asset management software to support this change.

9.3 Transmission Line Utilisation

Transmission assets are operated at 66kV or 132kV in the Darwin-Katherine region. The transmission voltages are lower than in other jurisdictions but the assets fulfil the same functional purpose.

PWC has a program of monitoring the MD on each transmission circuit and predicting the growth of that over the coming 10 years. PWC also calculates what the demand would be in the event of a key circuit being unavailable for service and compare that 'contingency loading' with a higher 'contingency rating'. In the 2012-13 Review, the Commission referred to that higher rating as the 'emergency rating'.

Based on limiting the normal and contingency loadings to approximately 100 per cent, PWC has devised a number of proposed network augmentations. These augmentations are shown on the '10-year master plan'. The Commission considers that over the past few years, PWC has made significant improvements to its 10-year master plan. The Darwin-Katherine system 10-year master plan shows the following key augmentations that address concerns raised in the 2012-13 Review:

- establishment of the Wishart ZSS;

- establishment of a high capacity (120 MVA) 66kV Hudson Creek to Wishart circuit;
- establishing a Palmerston to Archer 66kV circuit; and
- creating a 66kV switching station at Wishart.

These changes are proposed to be implemented as required during the coming six years. The Commission considers that these changes will add considerable flexibility into the operation of the 66kV network in the event that one key circuit is not available for service. However, some of these augmentations are listed as required to avoid potential overloads, under contingency conditions, during the 2015 year making their implementation urgent.

The NMP acknowledges that there is significant uncertainty about the quantity and timing of additional demand at East Arm. If this demand comes to fruition more quickly than PWC expects, it may be difficult to meet demand in the short term. The Commission recommends PWC consider the need to have contingencies in place for the eventuality that load grows rapidly at East Arm.

The ‘normal’ rating and ‘contingency’ rating that PWC has applied in evaluating adequacy of their transmission lines causes some concern to the Commission. The technical rating of an overhead line is determined based on the maximum permissible temperature of the conductor. The maximum permissible conductor temperature is limited either by the temperature above which the conductor is damaged or the conductor stretches so much that the clearance between the conductor and the ground becomes too small. For these reasons it is common in other jurisdictions to have one rating for summer and a second (higher) rating for winter. Conversely, PWC is implicitly assuming that the higher rating is available at the time of MD (likely a hot windless day). The Commission recommends that PWC re-examine this practice and explain their reasoning in detail in next year’s NMP.

The Commission notes that section 4.1.1 of the NMP says: *“In addition, at the discretion of Power Networks, certain high impact but low risk failures such as the failure of a single zone substation High Voltage (HV) busbar, or the failure of both circuits of a double circuit line, shall be considered as second contingency events*.” It seems likely to the Commission that this is being applied to the double circuit 132kV line from Channel Island to Hudson Creek. A double circuit outage of this line will certainly lead to a loss of supply to Darwin city and most likely a System Black of the Darwin-Katherine system.

In the Commission’s view, the loss of this particular line does not currently meet any reasonable criteria to be considered a second contingency event because:

- historically double circuit outages of this line have occurred at least twice in the last five years resulting in System Black;
- while the protection on the 132kV line from Channel Island to Hudson Creek operated according to its design, for the System Black incident, its design could be improved such that it would not operate for a credible, similar future event;
- the circuit breakers at the Hudson Creek end are antiquated and unreliable (the Commission notes there is a program in place to replace these circuit breakers);
- consideration of a double circuit line as two separate circuits requires the two circuits to be electromagnetically segregated as far as is possible. The means providing the best possible lightning protection and tower-earthing systems. The performance of the lightning

protection and earthing systems on this line are thought to be highly deficient and according to section 6.3 of the NMP performance is scheduled to be investigated in 2014-15. Presumably if the performance is found to be unsatisfactory then remedial works will be scheduled for 2015-16 or later. The Commission recommends investigating and correcting the earthing of this line be amongst PWC's highest priorities as this represents a real risk of a System Black; and

- this line would likely suffer severe damage if it was subjected to a high category 3 or low category 4 cyclone.

Once all of the remedial work on the 132kV line from Channel Island to Hudson Creek has been completed it may be reasonable to consider a double circuit failure as a second contingency event. This will only be reasonable after the Elizabeth River crossing has been upgraded to a category 4 cyclone level. This crossing is particularly important because (unlike other parts of the line) the time required to repair this section would be long and during the repair Darwin city could be without adequate supply. In the NEM failure of a double circuit line like this one, it would likely be declared a credible event during lightning storms.

PWC has assessed the adequacy of their transmission circuits based on their thermal capability for a small number of contingency events. PWC acknowledge in the NMP that this assessment is indicative because other considerations such as voltage drop and transient stability can reduce the capability of transmission lines. The Commission's view is that PWC should check these considerations, and report the results of those investigations in the next NMP. This would require an accurate power system model.

9.4 Terminal Station and ZSS Utilisation

In the Territory, substation average utilisation is 38 per cent and is projected to stabilise at about 40 per cent in 2018-19. Under first contingency operation the average utilisation is 57 per cent.

There are a few stations where the first contingency loading exceeds 100 per cent, but the overload is small and provided that PWC promptly executes contingency plans to return loading to an acceptable level then this can be tolerated.

There are many substations where adequate contingency supply can only be achieved by the transfer of load onto nearby substations. This method of achieving contingency supply is within industry best practice. However, this method is less transparent to industry observers and without detailed information on the actual transfers to be completed, it is not possible for the Commission to confirm the assertions in the NMP that adequate transfer capacity is available.

The Commission supports PWC in its initiative to complete an engineering investigation into the impact of cyclic loading factor on transformers, in excess of their nameplate rating for limited periods of time.

Considering the Territory's difficult climatic conditions, it would be prudent to confirm that a cyclic loading factor can be implemented without affecting the transformer service age.

The Commission notes that the yearly average temperature in the Territory exceeds the yearly average temperature specified in AS 60076.1 for power transformers[35] (20 °C), so transformers built

[35] For a definition of 'yearly average temperature' refer to AS 60076.1

to this standard may have a technical rating that is lower than their nameplate rating. The Commission also notes that faults within a transformer are often catastrophic and lead time to procure and install a new transformer, can exceed 12 months.

Table 9.1 provides the contingency utilisation for each substation, before any load is transferred.

Table 9.1: Summary of the substation constraints (N-1 conditions)

Substation	2014-15	2018-19
Archer	89%	140%
Batchelor	No local backup	No local backup
Berrimah	86%	61%
Brocks Creek	No local backup	No local backup
Casuarina	129%	64%
Centre Yard	80%	80%
City Zone	56% (N-1), 112% (N-2)	67% (N-1), 133% (N-2)
Cosmo Howley	69%	69%
Frances Bay	34%	36%
Hudson Creek 132/66kV	96%	109%
Humpty Doo	No local backup	No local backup
Katherine	93%	82%
Leanyer	Na	84%
Manton	No local backup	No local backup
Mary River	No local backup	No local backup
Marrakai	20%	20%
McMinns	85%	94%
Palmerston	89%	143%
Pine Creek Terminal	No local backup	No local backup
Pine Creek 66/11 ZS	86%	86%
Pine Creek 11/22 ZS	No local backup	No local backup
Snell Street	Decommissioned	Decommissioned
Tindal	55%	51%
Weddell	71%	33%
Wishart	No local backup	No local backup
Woolner	81%	98%
Lovegrove22/11	90%	96%
Lovegrove 66/22	69%	71%
Owen Springs	66%	68%
Sadadeen	137%	102%
Tennant Creek	92%	102%

Source: PWC

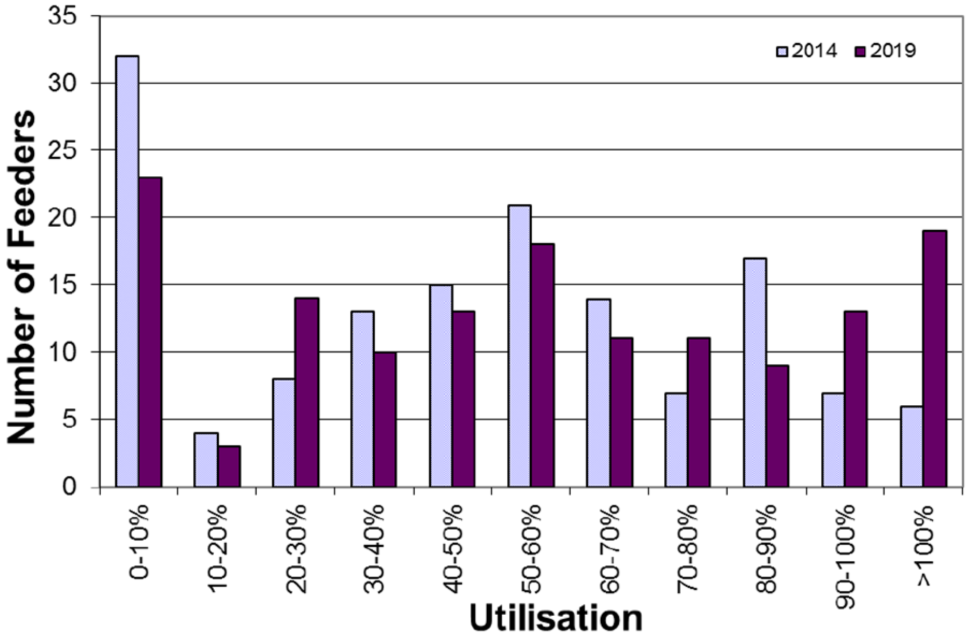
9.5 Feeder Utilisation

The Commission acknowledges that the use of 50 to 55 per cent utilisation target for 11 and 22kV feeders, as utilised by Ergon Energy, is acceptable. PWC has forecast that the average 11kV feeder utilisation will increase from 47 per cent in 2014 to 58 per cent in 2019.

The Commission has not analysed the feeder utilisation data provided for 22kV feeders except to note that the number of 22kV feeders in each utilisation group reduces with increasing utilisation. This is consistent with the Commission's expectation for long rural feeders where the load carrying capability of a feeder is typically governed by voltage drop and not by the thermal rating of the conductor.

The following graph is from PWC's NMP and shows the number of 11kV feeders for each utilisation group.

Figure 9.1: 11kV PWC feeder utilisation



Source: PWC Network Management Plan 2013-14

The utilisation graph is similar to the one presented in last years' NMP with the exception that the number of feeders in the 0-10 per cent category has increased significantly. This is consistent with the recent construction of a number of new ZSS.

There are six 11kV feeders and zero 22kV feeders that exceed 100 per cent utilisation during periods of MD. According to the NMP, work is underway to overcome these overloads. Of greater concern is that the NMP predicts that the number of feeders loaded beyond 100 per cent will rise to 19 and 4, respectively by 2018. The Commission recommends plans be put in place to maintain the number of overloaded circuits at a low level.

9.6 Feeder Performance

PWC and the Commission pay particular attention to the feeders categorised as 'poorly performing feeders'. PWC's Feeder Upgrade Program is an annual program that uses five calendar years of interruption data to analyse outage causes for poorly performing feeders and implement corrective action. The Commission supports this program and reviews SAIDI and SAIFI results annually to validate the effectiveness of PWC upgrade actions.

In the 2011-12 Review, the poorly performing feeder category was defined by referring to the interruption frequency and duration thresholds by regions. The new ESS Code has simplified the performance standards by implementing the SAIDI performance ratio benchmark.

The 2011-12 Review reported 18 feeders that performed as worst performing feeders. Nine of these feeders breached the threshold for two years consecutively and, as per the previous Service Code, were termed as "consecutively worst performing feeder". The 2012-13 Review reported four feeders exceeded the new threshold limit.

The NMP reports that in the 2013-14 year there were no poorly performing feeders as no feeder had breached the threshold for two years consecutively. The Commission notes that this represents a significant improvement in the performance of the worst feeders for at least three consecutive years and is a very good result.

9.7 Incident Report Review

The System Control Technical Code requires PWC to notify the Commission and report to the Commission on certain power system events. The code requires PWC to provide a preliminary fault report for a 'major event' within 14 days and a final report as soon as reasonably practical.

The Commission received the following preliminary reports for major network events for the review period:

- CZ TF2 tripped due to 66kV bushing failure – 6 December 2013
- Pine Creek substation trip – 27 January 2014
- Tennant Creek lightning strike and load shed – 15 February 2014
- Archer ZSS 11kV bus 2 trip – 4 July 2014
- Katherine ZSS feeder trip – 9 July 2014
- Pine Creek ZSS (PKZSS) 132kV circuit breaker (CB) 132PK03 tripped – 11 July 2014
- Humpty Doo ZSS – circuit breaker trips substation – 21 September 2014
- Tennant Creek ZSS (TCZSS) – Stage 1 UFLS – 26 October 2014
- Lovegrove ZSS (LGZSS) – Braitling feeder shed – 16 November 2014
- Pine Creek 132kV switchyard – 66PK01 trip – Pine Creek islanding – 20 November 2014

- Katherine ZSS – Katherine Stage 1 UFLS – 1 December 2014
- Casuarina ZSS (CAZSS) – Transformer 3 trip – 28 November 2014
- Pine Creek ZSS (PKZSS) – 132PK01 trip – 30 November 2014

The Commission has not received final reports for these events except the incidents on 6 December 2013, 15 February 2014 and 26 October 2014. It is acknowledged that most of these events fall outside of the 2013-14 year but the Commission notes concerns that there is a level of non-compliance with reporting requirements under the System Control Technical Code and suggests that the incidents are not being adequately investigated in a timely manner. The Commission considers that it is not reasonable to expect staff to remember the details of events after many weeks or months of delay and any investigation will be ineffective. The Commission also considers that the timing to investigate major incidents should be a concern for the PWC management and board.

The Commission understands that PWC is addressing the outstanding major incident reports and will have the majority of outstanding reports completed by the end of July 2015.

The Commission recommends that PWC reviews its resources and processes for investigating and reporting major incidents and aims to improve the timing of provision of reports to the Commission.

9.8 Reliability

Reliability performance of PWC's network is analysed in two categories:

- transmission network performance; and
- feeder network performance.

PWC has increased expenditure on maintenance and capital projects in recent years. If this expenditure is appropriately targeted on those parts of the network, significantly contributing to system reliability issues, this should result in a progressive improvement in the reliability of the network. Moreover, improvement is evident in the poorly performing feeder category.

Under the ESS Code, licensed utility entities (primarily PWC) are required to report performance against specific indicators and targets for network distribution and transmission. PWC Standards of Service Report for 2013-14 was provided in October 2014. The report is consistent with section 6 of the NMP. The 2013-14 Standards of Service Report provided by PWC applies to the period to 30 June 2014 and prior to structural separation.

9.8.1 Transmission Network Performance

To measure the reliability performance of the PWC transmission network, the key indicators are:

- system average circuit outage duration index (ACOD), which indicates the average duration of circuit outages experienced by the PWC transmission network;
- frequency of system outage index (FCO), which indicates the number of circuit outages experienced by PWC transmission network;
- system average transformer outage duration index (ATOD), which indicates the average duration of circuit outages experienced by the PWC transmission network; and
- frequency of system outage index (FTO), which indicates the number of transformer outages experienced by PWC transmission network.

No transmission system exists in the Alice Springs and Tennant Creek power systems and therefore the performance indicators and targets do not apply.

For the Darwin- Katherine power system, the Commission approved targets to apply for the network regulatory period of 1 July 2014 to 30 June 2019. Although outside the review period is outside of the period for the target, the Commission has made a comparison between actual performance and the target.

The frequency of circuit and transformer outages (FCO and FTO) were above target, however the remaining two performance targets were met (ACOD and ATOD). The Commission notes an improvement from the previous year for all four performance indicators. Refer to Table 9.2 for details of the Darwin-Katherine area results.

Table 9.2: Darwin-Katherine transmission network performance

Transmission performance indicators	2013-14 Target standard	2012-13 Darwin-Katherine adjusted results	2013-14 Darwin-Katherine adjusted results	Target standard met?
Average Circuit Outage Duration (ACOD) (mins)	358.8	227.2	132.1	Yes
Frequency of Circuit Outage (FCO)	49.0	89.0	60.0	No
Average Transformer Outage Duration (ATOD) (mins)	123.3	106.9	55	Yes
Frequency of Transformer Outages (FTO)	0.8	6.0	1	No

Source: PWC Standards of Service Report 2013-14.

PWC did not record any natural events[36] which are allowed to be removed from network transmission reliability indicators in accordance with the ESS Code.

The Commission is generally satisfied with the investigation work completed by PWC to determine the causes of circuit outages and the 2014-15 program to test the earthing on transmission towers which should help to reduce circuit interruptions due to lightning. The Commission recommends that this work focus on the Channel Island to Hudson Creek 132kV lines as a matter of priority.

9.8.2 Feeder Network Performance

To measure the reliability performance of PWC feeders, the key indicators are:

- SAIDI, which indicates the average duration of network and generation-related outages experienced by a customer; and

[36] Clause 4.3 of the Electricity Standards of Service Code allows the removal of natural events identified using the IEEE 2.5 beta method from the adjusted category of its performance indicators.

- SAIFI, which indicates the average number of network and generation-related outages experienced by a customer.

PWC did not record any natural events[37] which are allowed to be removed from network distribution reliability indicators in accordance with the ESS Code. The Commission notes that PWC has provided performance information including the effect of the 12 March 2014 System Black incident and excluding the incident. The Commission considers that it is not appropriate to exclude the outages related to the 12 March System Black incident from SAIFI figures because there are measures within PWC's control that may have prevented the System Black incident. The Commission considers it more justifiable to exclude the impact of the 12 March System Black incident from SAIDI as PWC Networks had little control over the duration of the incident.

PWC met the feeder network SAIDI standard in one out of the four feeder categories. However, if the outages related to the 12 March System Black incident are excluded then the standard was achieved in all four categories. Excluding the System Black incident, the SAIDI figures show significant improvement compared to the previous year. Refer to Table 9.3 and Table 9.4 for details.

Table 9.3: 2013-14 Distribution SAIDI results segmented by feeder category

Feeder categories	SAIDI target standard (minutes)	SAIDI 2012-13 results (minutes)	SAIDI 2013-14 results (minutes)	SAIDI 2013-14 results (minutes) excl. 12 March	Target standard met (2013/14)?
CBD	18.8	1.1	292.1	0.1	No
Urban	136.0	111.0	288.1	52	No
Rural short	496.3	536.9	525.3	229	No
Rural long	2164.9	1108.7	206.4	156	Yes

Source: PWC Standards of Service Report 2013-14.

PWC met the feeder SAIFI standards in three out of the four feeder categories.

Table 9.4: 2013-14 Distribution SAIFI results segmented by feeder category

Feeder categories	SAIFI target standard (minutes)	SAIFI 2012-13 results (minutes)	SAIFI 2013-14 results (minutes)	SAIFI 2013-14 results (minutes) Excl. 12 March	Target standard met?
CBD	0.4	0.03	0.6	0.01	No
Urban	2.5	2.5	1.6	0.9	Yes
Rural Short	8.1	9.1	4.1	3.3	Yes
Rural Long	35.1	12.2	3.4	2.5	Yes

Source: PWC Standards of Service Report 2013-14.

PWC advised that the following activities will be undertaken during 2014-15 to improve the SAIDI and SAIFI performance of the networks:

37 ibid.

- replacement of dated air break switches with remotely controllable gas break switches;
- hardware upgrades such as replacing pin insulators with post insulators and installing fiberglass crossarms;
- installation of animal guards;
- installation of fault indicators to aid rapid fault location; and
- trials of new technologies such as fusesavers.

To assess relative performance of PWC with regulatory expectations elsewhere in Australia, the Commission has compared PWC Networks' 2013-14 performance with the minimum service standards applicable by Ergon. The analysis in Table 9.5 shows PWC feeder performance is improving.

The Commission does note that the Territory's classification of feeders differs to Queensland and that applied by Ergon.

Table 9.5: PWC and Ergon SAIDI and SAIFI comparison

Key Indicator	PWC 2012-13	PWC 2013-14	Ergon Energy Target
Excluding 12 March System Black incident			
SAIDI CBD	1.1	0.1	n/a
SAIDI urban	111	52	146
SAIDI short rural	536	229	406
SAIDI long rural	1 108	156	916
Including 12 March System Black incident			
SAIFI CBD	0.03	0.6	n/a
SAIFI urban	2.5	1.6	1.92
SAIFI short rural	9.1	4.1	3.80
SAIFI long rural	12.2	3.4	7.10

Source: PWC Standards of Service Report 2013-14 and Ergon Minimum Service Standard[38].

9.8.3 SAIDI and SAIFI Historical Comparison

To assess feeder performance, the Commission has compared the latest adjusted SAIDI and SAIFI performance to the performance of the latest five-year period. For this comparison the 12 March 2014 System Black incident was excluded from SAIDI performance and SAIFI performance.

[38] Queensland Department of Energy and Water Resources. Report of Performance against Minimum Service Standards by Energex and Ergon Energy for 2013-14.

Table 9.6: Adjusted (excluding major event days) SAIDI historical results comparison

Key Indicator	2009-10	2010-11	2011-12	2012-13	2013-14 Incl System Black	2013-14 Excl System Black
SAIDI CBD	19.4	166.6	10.4	1.1	292	0.1
SAIDI urban	104	136	67	111	288	52
SAIDI short rural	237	586	256	536	525	229

Source: PWC Standards of Service Report 2013-14.

Table 9.7: Adjusted (excluding major event days) SAIFI historical results comparison

Key Indicator	2009-10	2010-11	2011-12	2012-13	2013-14 Incl. System Black
SAIFI CBD	0.6	1.0	0.4	0.03	0.6
SAIFI urban	2.0	2.6	2.5	2.5	1.6
SAIFI short rural	6.0	9.3	10.4	9.1	4.1
SAIFI long rural	27.0	22.8	46.4	12.2	3.4

Source: PWC Standards of Service Report 2013-14

Historical analysis confirms that the performance for all feeders has improved. For the purpose of this report the Commission has chosen to remove the System Black incident from the SAIDI data but not from the SAIFI data. This is justified on the basis that the cause of the System Black was within PWC Networks control but the duration was exacerbated by generation-related issues.

9.9 Planned and Recent Network Enhancements

PWC is completing or has planned large network projects that reflect the need to address capacity constraints to meet the Territory's growth in demand, replace aging network system assets and improve network reliability and quality of supply. Significant projects recently completed or underway include:

- Snell Street substation replacement with the new Woolner substation (complete);
- City ZSS replacement (commissioning underway);
- Leanyer ZSS (commissioning underway);
- Wishart Modular substation (construction nearly complete);
- Frances Bay 2nd transformer (construction nearly complete);
- Strangways ZSS to replace McMinns (construction under way);
- 22kV switchboard replacement at Tennant Creek, Alice Springs (construction under way);
- Mitchell St Switching Station (delivery phase);

- Improve cyclone performance of Elizabeth River 132kV crossings to category 4 (tender phase for commissioning pre 2015-16 wet season);
- New (3rd) Palmerston to Archer transmission line (development phase – 2017-18)
- 22kV switchboard replacement at Sadadeen, Alice Springs (planning phase);
- New 11kV switchboard at Sadadeen, Alice Springs (planning phase);
- Berrimah ZSS replacement (development phase – beyond five years);
- Replace Casuarina ZSS 66kV switchgear (commitment phase); and
- 132/66kV Terminal Station and transmission lines Weddell-Woolner (long-term planning).

A summary of the major and minor capital project expenditures as proposed by PWC is shown in Table 9.8.

Table 9.8: Forecast capital expenditure ($ million, real $2013-14 with input cost escalation)

Project ($M)	**2014-15**	**2015-16**	**2016-17**	**2017-18**
Total major projects	46.4	25.6	14.0	24.2
Capital items and Essential spares	0.7	0.7	0.7	0.7
Asset Replacement and Upgrade Programs	7.2	6.0	5.9	3.3
HV Cable Replacement Program	1.3	1.5	1.5	1.5
ORMU Replacement Program	2.5	1.3	1.2	1.3
Feeder Upgrade Program	2.4	1.7	1.6	1.5
Customer Augmentation and Network Extension Program	6.5	6.7	6.5	6.5
SCADA and Communication Systems Replacement and Upgrade Program	1.6	1.6	1.6	1.6
Protection Upgrade Program	1.0	1.1	0.9	0.5
Meters/Metering Program	1.1	1.7	2.8	3.1
Customer Connection Program	0.8	0.8	0.8	0.8
Underground Distribution Substation Replacement Program	1.5	0.9	1.4	2.4
Other minor works	1.1	1.1	1.1	1.1
Total Capital Expenditure (Last year's report)	**75.4** (84.7)	**51.8** (74.8)	**41.0** (57.4)	**49.0** (48.4)

Source: PWC Network Management Plan

The last row of the table above (in brackets) shows the total capital expenditure predicted by PWC in the previous version of the NMP as predicted expenditure has been reduced for 2015-16 and 2016-17 and remains consistent for 2017-18.

The Commission supports PWC's large capital project program but notes the following:

- The 2013-14 NMP does not provide adequate details of the different options considered during the planning phase of each project. Future NMPs should provide appropriate detail for the Commission to confirm that PWC has reviewed its investment options.
- Power system reporting should provide comprehensive and authoritative data to assist identification of investment options for the Commission to review. As noted in earlier reviews, the role of the Commission is also to evaluate how PWC is deploying investments to address emerging network constraints.
- The Commission recommends PWC provide more exhaustive detail regarding the options considered, including engineering review, financial and time considerations.
- PWC has identified that the rate of demand increase is expected to slow and consequently the existing 132kV double transmission line back bone from Channel Island to Hudson Creek may not reach its capacity in the N-1 condition by 2021.
- PWC has a preliminary plan that when the line reaches capacity the system may be augmented by a 132kV double circuit line from WPS to Woolner. This would significantly improve the capacity and fault resilience of the entire network. The Commission also understands that the existing 132kV line is cyclone rated category 3 and will be uprated to category 4 only at the Elizabeth River Crossing in 2016-17.

9.10 Progress Against findings from 2012-13 Power System Review

In the 2012-13 Review, the Commission provided a list of recommendations for PWC to address. It is a firm intention of the Commission to monitor the progress of recommendations from all Reviews, to document and investigate the reason for any lack of progress or delays and provide a view as to whether these delays are justified. Progress against the 2012-13 Review recommendations is detailed below:

The Commission recommended that PWC address the following key findings in its 2013-14 reporting.

Capacity concerns

The main capacity concern is related to the transmission line loop between Hudson Creek, Palmerston, McMinns, Weddell and Archer substations. In the event of the loss of the Weddell-McMinns 66kV line or Hudson Creek-Palmerston 66kV line, one line of the 66kV loop will exceed its thermal limit by the year 2014. This scenario will worsen as the load increases in the near future until a new line from Archer or Hudson Creek to Palmerston substation is constructed.

The Commission recommends that PWC consider the most appropriate timing for this project or further consider the option of bringing a 132kV supply into the Palmerston area to ensure security of supply.

Predominance of serious network faults

Genuine transformer faults are usually serious and could have catastrophic effect. Similarly, maloperation of a transformer protection scheme could lead to a capacity shortfall with a risk of overloading the other transformer/s within the substation. The Commission is concerned with the six transformer outages for the 2012-13 period. Similarly, the frequency of transmission line outages (89) within the Darwin-Katherine area is not satisfactory.

Feeder loadings

As good electricity industry practice, it is expected that the overall number of feeders with utilisation above the 80 per cent target be below 10 per cent. The number of 11kV feeders exceeding the utilisation target is above 20 per cent and appears to worsen in the medium term. This data raises concern about the overall planning of the 11kV network and the capacity of the network to supply customers when feeders are out-of-service during a contingency scenario, feeder or substation upgrade.

Alignment with NEM planning

Improvements in aligning the NMP with the requirements of the NER have been made in comparison with the 2011-12 report. The Commission is aware that PWC needs time to establish the systems and processes required to meet these reporting requirements, however there are still critical areas of reporting that need attention, including:

- changes from the previous year's reporting;
- options analysis to fully document the major strategies and plans in the yearly report;
- power factor at peak load;
- detail of the expected commissioning month of each specific major project; and
- fault level details at each substation.

Significant progress seems to have been made in the areas of:

- the transmission line loop between Hudson Creek, Palmerston, McMinns, Weddell and Archer substations;
- network reliability (excluding the System Black incident); and
- feeder loadings.

There has been no improvement or even a negative change to the documentation provided to the Commission.

The Commission notes that less data was available for this review, including a lack of a final incident report for major reportable system incidents. The Commission is also concerned with the finding from the technical audit that PWC was non-compliant with its obligation to maintain an appropriate compliance process and procedures.

Structural separation and resourcing constraints provide some justification for these issues but nevertheless they must be addressed by PWC as a matter of priority.

The Commission notes comments from PWC that its lack of appropriate compliance process and procedures for its regulatory obligations was a low risk. The Commission disagrees with this conclusion.

10. Customer Service Review

10.1 Structure of this Year's Review

This is the first financial year for which the ESS Code has operated for the full period. PWC prepared Standards of Service Reports in both 2012-13 and 2013-14. For 2012-13, PWC was only required to report in accordance with the ESS Code on a best endeavours basis as the Code only commenced halfway through that year. The 2013-14 report differs slightly from the previous report and provides more detailed data in some respects overcoming some shortcomings from the partial reporting in the 2012-13 year.

The key measures and structure of this year's review of customer service performance reflect the ESS Code released 1 December 2012.

The relevant schedules of the ESS Code relating to customer service performance are:

- Schedule 2 – Network Services Performance Indicators; and
- Schedule 3 – Retail Services Performance Indicators.

Specifically, the PWC data provides:

- Network Indicators – which includes 'Quality' (in turn includes Quality of Supply and Complaints); and
- Customer Service Indicators.

Some of the performance reporting is either not fully consistent with the ESS Code, or it is not clear whether the measures are constructed in a manner that is fully consistent with the ESS Code. In the latter case, the ambiguity in interpretation is noted and where it was deemed appropriate, assumptions have been made and noted.

10.2 PWC Network Services Performance

10.2.1 Reconnections and New Connections

Performance of reconnections and new connections for 2013-14

The ESS Code outlines the following indicators for measuring of performance relating to connections and reconnections[39]:

- the percentage and total number of new connections, in the CBD area or urban areas, not undertaken within five business days, excluding connections to new subdivisions where minor extensions or augmentation is required (this measure included in the PWC Standards of Service Report 2013-14);
- the percentage and total number of new connections in rural areas not undertaken within 10 business days excluding connections to new subdivisions where minor extensions or

[39] Schedule 2, 1.8.2 (a), ESS Code, Northern Territory of Australia, 2013.

augmentation is required (this measure included in the PWC Standards of Service Report 2013-14); and

- the number and average length of time taken to provide new connections in urban areas to new subdivisions where minor extensions or augmentation is required (this measure included in the PWC Standards of Service Report 2013-14).

PWC's performance relating to reconnections and new connections for 2013-14 is provided in the tables 10.1 and 10.2.

Table 10.1: Connections and reconnections performance

Performance Measure	Total number		Percentage of total not undertaken within timeframe	
	2013-14	2012-13	2013-14	2012-13
Re-connections not undertaken within 24 hours	14 790	11 060	0.07%	1%
New connections not undertaken in the CBD/urban areas within five days (excluding where minor extensions or augmentation is required)	51	518	3.85%	5.2%
New connections not undertaken in the rural areas within 10 days (excluding where minor extensions or augmentation is required)	15	255	3.84%	1.7%

Table 10.2: New Connections in urban areas

Performance Measure	Total		Avg. Time (weeks)	
	2013-14	**2012-13**	**2013-14**	**2012-13**
New Connections in urban areas to new subdivisions	109	120	12.5	14

Source: PWC Standards of Service Code 2013-14

Progress on performance of reconnections and new connections

The number of reconnections undertaken in 2013-14 is significantly higher (34 per cent) than for the previous period and the fraction of those connections falling outside the benchmarks has decreased for all but rural areas.

Performance for new connections to subdivisions shows slight improvement from the previous year.

The Commission will continue to monitor progress in this area.

10.2.2 Quality of Supply Issues

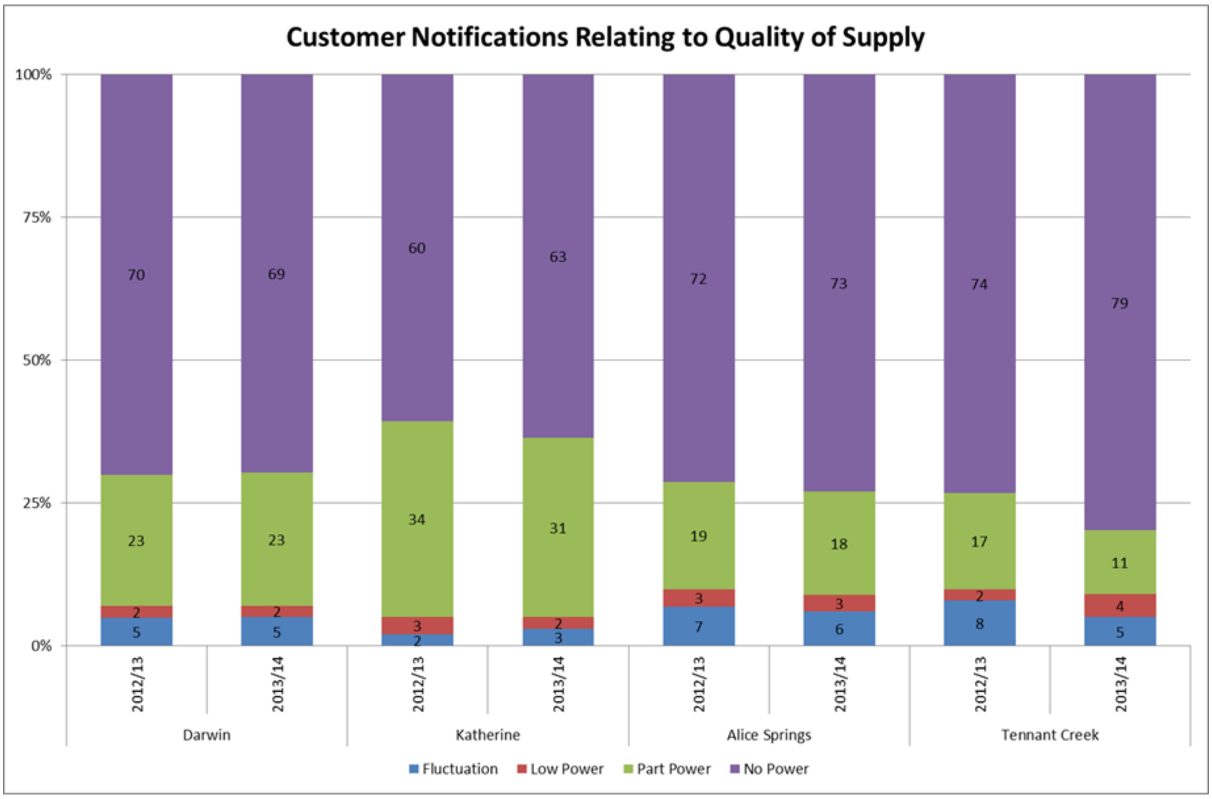
Quality of supply performance for 2013-14

The reporting requirements for complaints relating to network quality of supply are outlined within schedule 2, 1.8.4 (a) (ii) of the ESS Code as 'the percentage and total number of complaints associated with the transmission network and distribution network quality of supply issues'.

The number of complaints increased significantly in Darwin and Alice Springs. The ratio of the types of complaints shows very little variation between the two years with the predominant issue being 'No Power'.

The percentage of complaints relating to PWC's quality of supply performance, by region, is summarised in the Figure 10.1.

Figure 10.1: Customer notifications relating to quality of supply



The number of complaints relating to quality of supply is summarised in the following Table 10.3.

Table 10.3: Number of customer notifications relating to quality of supply

	Darwin	Katherine	Alice Springs	Tennant Creek	3-region total
2012-13	3 748	615	474	131	4 968
2013-14	4 906	561	590	141	6 198
Change on 2012-13 levels	31%	-9%	24%	8%	25%

The Commission found in the 2012-13 Review that the level of customer notifications relating to quality of supply was outside industry benchmarks. This remains to be the case.

The increase in customer notifications concerns the Commission. It is not clear to the Commission if these customer notifications are verified. The Commission can only conclude from the Standards of Service report that more customers are unhappy with the quality of supply. This may or may not indicate a decrease in the quality of supply but could also be attributable to greater customer awareness and higher customer expectations particularly following recent significant tariff increases in May 2013 (20 per cent), January 2014 (5 per cent) and January 2015 (per cent).

The Commission recommends the measurement and routine analysis of power quality data through the network as a method of determining the actual network performance. This data can then be used to understand the customer notification data in context.

10.2.3 Network Related Activities Complaints

The reporting requirements for complaints regarding network-related activities are outlined within schedule 2, 1.8.4 (a) (i) of the ESS Code as *'the percentage and total number of complaints associated with transmission network and distribution network-related activities segmented into complaint categories'*.

PWC provided the following data relating to network-related activities complaints. The category breakdown differs from the 2012-13 Review and PWC's last Standards of Service Report.

Table 10.4: Customer complaints due to network related activities

	Network Related Activities									
	Metering		**Reliability**		**Damage to property/graffiti**		**Other**		**Total**	
	Total	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**	**2013-14**	**2012-13**
Darwin	15	12	41	33	13	11	54	44	123	66
Katherine			1	50			1	50	2	4
Tennant Creek	1	14	2	29			4	57	7	5
Alice Springs			1	50			1	50	2	1
Total									134	76

Source: PWC Standards of Service Report 2013-14.

Performance relating to retail service complaints is discussed in section 10.3.

Progress on network related activities complaints

Since the categorisation has changed between the 2012-13 and 2013-14 Standards of Service reports, the Commission can only comment on the number of complaints, which has almost doubled. These figures are dominated by the contribution from the Darwin area. The Commission recommends PWC provide a more detailed breakdown of the 'Other' category in subsequent reports as this category represents around half of all complaints.

10.2.4 Written Enquiry Response

PWC reported the number of written enquiries and average response times. This is shown in Table 10.5.

Table 10.5: Average time taken to respond to a customer's written enquiry segmented into regions

Region	**Average time taken to respond to a customer's written enquiry (days)**		**No. of written enquiries receiving a response**	
	2013-14	2012-13	2013-14	2012-13
Darwin	1	3	129	10
Katherine	1	NA	2	0
Alice Springs	1	NA	7	0
Tennant Creek	1	1	3	1

Source: PWC Standards of Service Report 2013-14.

The volume of written complaints has shown a very large increase, particularly in the Darwin region. The rates of response remain reasonable.

10.2.5 Telephone call response

In schedule 2, 1.8.3 (b) the ESS Code specifies that *'Where relevant, and unless the Commission otherwise considers appropriate, the results [of telephone call response] will be a combined total for both PAWC Networks and PAWC Retail'*.

While no telephone call response data has been included in reporting of network services performance, data has been provided in reporting of retail services performance. It is therefore assumed that the reporting of telephone call response relates to network and retail services combined. This is discussed in section 10.3. PWC is required to provide these indicators by the ESS Code.

10.3 PWC Retail Services Performance

10.3.1 Telephone Call Response

In schedule 3, 1.1.5 (a) the ESS Code specifies that performance indicators for phone answering include:

- average time taken to answer the phone;
- percentage and total number of calls not answered within 30 seconds; and
- the percentage and total number of calls abandoned.

The reporting by PWC on this measure is consistent with the ESS Code. It is noted that the percentage of calls not answered within 20 seconds has been changed to the percentage of calls not answered within 30 seconds, which is consistent with ESS Code and industry practice.

Table 10.6: Telephone call answering reporting

	2013-14		**2012-13**	
Average time taken to answer the phone	371 seconds		180 seconds	
Number of calls	245 132		204 033	
	Total	%	Total	%
Calls not answered within 30 seconds of the caller asking to talk to a person	182 868	74.6		
Calls not answered within 20 seconds of the caller asking to talk to a person[40]			124 052	60.8
Calls abandoned	46 575	19	20 365	10

In schedule 3, 1.1.3 (a), the ESS Code also specifies that *'for the purpose of calculating retail services performance indicators for Phone Answering, Complaints and Written Enquiries – only include those customers that are taking (or likely to take less than) 160 megawatt hours of electricity from the distribution network during the reporting period'*. It is not explicitly stated, but assumed, that the PWC data only includes this subset of customers.

As with schedule 3, the ESS Code specifies in schedule 2, 1.1.5 (b) that *'Where relevant, and unless the Commission otherwise considers appropriate, the results [of telephone call response] will be a combined total for both PAWC Networks and PAWC Retail'*.

Progress on telephone call response performance

The reporting benchmark for calls not answered within a time has been extended from 20 seconds to 30 seconds (consistent with industry benchmarks) which makes direct comparison of this criterion between years difficult. The Commission observes that the ratio of abandoned calls has risen and this leads to the conclusion that call answering performance has not improved or at least is not meeting customer expectations.

The Commission notes that this period includes the System Black incident in the Darwin-Katherine region and so may be an outlier in performance. The Commission considers the performance as reported to be a significant concerns and expects PWC and Jacana Energy to work to improve performance in this area.

The Commission's view is that structural separation of PWC and the establishment of Jacana Energy should place greater focus on customer service performance. The Commission welcomes Jacana Energy's focus on this activity and looks forward to improved performance in subsequent reviews.

[40] 20 seconds was used to characterise 2012-13 data

10.3.2 Written Enquiries

Although required by the ESS Code under schedule 3, 1.1.8 (a), PWC has not provided data for written enquiries relating to retail services. The Commission's expectation is such performance will be reported for 2014-15.

Data on written enquiries has been included in the reporting of network services performance and relates to both network and retail services combined.

10.3.3 Retail-Related Complaints

Number of customer complaints for 2013-14

Schedule 3, 1.1.6 of the ESS Code specifies that the performance indicator for complaints as 'is the percentage and total number of complaints associated with retail services segmented into complaint categories'. The ESS Code further specifies in schedule 3, 1.1.3 (a) that *'for the purpose of calculating retail services performance indicators for Phone Answering, Complaints and Written Enquiries – only include those customers that are taking (or likely to take less than) 160 megawatt hours of electricity from the distribution network during the reporting period'*.

Complaints data has been provided by PWC and is segmented into regions as required by the ESS Code.

Table 10.7: Retail related complaints

	Number of Complaints	
	2013-14	2012-13
Darwin	1301	1583
Katherine	53	100
Tennant Creek	17	60
Alice Springs	160	317

Progress on number of customer complaints

The Commission notes the significant decrease in complaints in all regions. It is difficult to draw any conclusions from this data due to two factors:

1. the high level of call (and hence possible complaint) abandonment; and
2. the inconsistency between the new (improved) reporting method and that of previous years' (particularly those years prior to the ESS code).

Table 10.8: Progress on total complaint numbers

	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Darwin	1 781	1830	1 553	1 516	1 649	1 301
Katherine	160	160	146	147	104	53
Alice Springs	318	417	432	385	322	160
Tennant Creek	39	70	89	41	61	17
Total	2 332	2 235	2 477	2 220	2 089	1 531

10.4 Customer Hardship Programs

The requirements for reporting on customer hardship programs are provided in schedule 3, 1.1.7 of the ESS Code. PWC has increased the level of reporting on this criterion in the Standards of Service Report as compared to 2012-13. The level of hardship program penetration can be summarised as shown in Table 10.9.

Table 10.9: Customer hardship program summary

	Darwin	Katherine	Alice Springs	Tennant Creek	Total
Customers who participated in a customer hardship program (Reporting category 1-4)	666	31	166	13	876
The average electricity bill of all customers who were on the customer hardship program, as identified in 1) above. (Reporting category 8)	$1 351.11	$1 620.14	$838.72	$1 204.55	

10.5 Progress against Findings from the 2012-13 Review

The Commission notes only minor improvements in customer service performance and reporting. Telephone response rates in particular continue to decline to the extent that call abandonment rates have doubled. The Commission acknowledges that PWC and Jacana Energy are committed to improving performance in this area and will focus on this for the 2014-15 Review. This performance will be closely monitored for the 2014-15 Review.

10.6 Key Findings

The Commission reiterates the importance of breaking down complaint data across the various entities within the electricity supply industry as this gives the best chance to determine customer satisfaction with the overall quality of electricity supply. It is expected that structural separation will provide additional transparency in this regard.

The Commission is pleased with the continuing improvement or maintenance of standards in the following areas:

- responsiveness to reconnections and new connections; and
- reporting of data required by the ESS.

The Commission is concerned that continued poor performance and/or deterioration in performance in the following areas may be masking performance in other areas:

- telephone call responsiveness; and
- minimal categorisation of complaint or customer issue data.

In general, the telephone call loading poses a significant impost on PWC and Jacana Energy that was not well managed in 2013-14. Jacana Energy has indicated development and planned improvements in this area and the Commission would like to see significant improvement in this area in 2014-15.

The Commission is concerned that the number of calls increased significantly during the 2013-14 year but the number of complaints fell. This leads the Commission to believe that the high call abandonment rate may be reducing the real customer complaint number.

The Commission further asserts that customer complaints should only be one source of data on the effectiveness of managing the electricity supply. This is particularly the case for power quality issues. The Commission is interested in understanding the true technical performance of the networks with respect to power quality to get a more objective measure of power quality.

Appendices

A Generating Units

Darwin-Katherine

A.1.1 Channel Island

Unit	GT 1*	GT 2*	GT 3*	GT 4*	GT 5*	ST 6	GT 7	GT 8	GT 9	House Set 0.900 kW
Make / Model	GE Frame 6	GE Frame 6	GE Frame 6	GE Frame 6	GE Frame 6	Mitsubishi	GE LM6000	Trent 60	Trent 60	Kongsberg KG2
Engine Type	Combustion Turbine	Combustion Turbine	Combustion Turbine	Combustion Turbine	Combustion Turbine	Steam Turbine	Combustion Turbine	Combustion Turbine	Combustion Turbine	Combustion Turbine
Fuel Type	Gas or Diesel	Gas or Diesel	Gas or Diesel	Gas or Diesel	Gas or Diesel	Waste Heat	Gas	Gas or Diesel	Gas or Diesel	Diesel
MW GMC RATING	31.6	31.6	31.6	31.6	31.6	32	36	42	42	
N-1 FIRM GMC	31.6	31.6	31.6	31.6	0	16	36	42	42	
N-2 FIRM GMC	31.6	31.6	31.6	0	0	0	36	42	42	
Date Commissioned	1986	1986	1986	1986	1986	1987	2000	2011	2011	1986

* PWC has advised that generation units 1 – 5 (GE Frame 6) have been converted to gas only but can be retro-fitted to use diesel within 24 to 48 hours.

A.1.2 Weddell

Unit	Set 1	Set 2	Set 3
Make / Model	GE LM6000 PD	GE LM6000 PD	GE LM6000 PD
Engine Type	Combustion Turbine	Combustion Turbine	Combustion Turbine
Fuel Type	Gas	Gas	Gas
MW GMC RATING	43	43	43
N-1 FIRM GMC	0	43	43

N-2 FIRM GMC	0	0	43
Date Commissioned	Feb-08	Nov-08	Mar-14

A.1.3 Shoal Bay and Pine Creek PPAs

	Shoal Bay	Pine Creek A			Pine Creek B		
Unit	Set 1	GT 1	GT 2	ST 3	GT 1	GT 2	GT 3
Make / Model	Caterpillar 3516G	Solar Mars	Solar Mars	Peter Brotherhood	Solar Centaur	Solar Centaur	Solar Centaur
Engine Type	Reciprocating Spark Fired	Combustion Turbine	Combustion Turbine	Steam Turbine	Combustion Turbine	Combustion Turbine	Combustion Turbine
Fuel Type	Land Fill Gas	Gas	Gas	Waste Heat	Gas	Gas	Gas
MW GMC RATING	1.1	9.64	9.64	7.31	0	0	0
N-1 FIRM GMC	0	9.64	0	3.655	0	0	0
N-2 FIRM GMC	0	0	0	0	0	0	0
Date Commissioned	Aug-05	Jun-96	Jun-96	Jun-96	1989	1989	1989

A.1.4 Katherine

Unit	GT 1	GT 2	GT 3	GT4
Make / Model	Solar Mars	Solar Mars	Solar Mars	Solar Titan 130
Engine Type	Combustion Turbine	Combustion Turbine	Combustion Turbine	Combustion Turbine
Fuel Type	Gas or Diesel	Gas or Diesel	Gas or Diesel	Gas or Diesel
MW GMC RATING	7.4	7.4	7.4	12.5
N-1 FIRM GMC	7.4	7.4	7.4	0
N-2 FIRM GMC	7.4	7.4	0	0
Date Commissioned	1987	1987	1987	Jul-12

A.2 Tennant Creek

Unit	Set 1	Set 2	Set 3	Set 4	Set 5
Make / Model	Ruston 8ATC	Ruston 8ATC	Ruston 8ATC	Ruston 8ATC	Ruston 8ATC
Engine Type	Reciprocating Diesel	Reciprocating Diesel	Reciprocating Diesel	Reciprocating Diesel	Reciprocating Diesel
Fuel Type	Diesel	Diesel	Diesel	Diesel	Diesel
MW GMC RATING	1.300	1.300	1.300	1.300	1.300
N-1 FIRM GMC	1.300	1.300	1.300	1.300	1.300
N-2 FIRM GMC	1.300	1.300	1.300	1.300	1.300
Date Commissioned					

Unit	Set 10	Set 11	Set 12	Set 13	Set 14	Set 15	Set 16	Set 17
Make / Model	Caterpillar 3516G	Caterpillar 3516G	Caterpillar 3516G	Caterpillar 3516G	Caterpillar 3516G	Solar Taurus	Cummins QSK60	Cummins QSK60
Engine Type	Reciprocating Spark Fired	Reciprocating Spark Fired	Reciprocating Spark Fired	Reciprocating Spark Fired	Reciprocating Spark Fired	Combustion Turbine	Reciprocating Diesel	Reciprocating Diesel
Fuel Type	Gas	Gas	Gas	Gas	Gas	Gas or Diesel	Diesel	Diesel
MW GMC RATING	0.958	0.958	0.958	0.958	0.958	3.900	1.500	0.000
N-1 FIRM GMC	0.958	0.958	0.958	0.958	0.958	0.000	1.500	0.000
N-2 FIRM GMC	0.958	0.958	0.958	0.958	0.958	0.000	0.000	0.000
Date Commissioned	1999	1999	1999	1999	1999	2004	February 2008	December 2010

A.3 Alice Springs

A.3.1 Ron Goodin

Unit	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Set 7	Set 8	Set 9
Make / Model	Mirrlees KVSS12	Mirrlees KVSS12	Mirrlees KV16P Major	Mirrlees KV16P Major	Mirrlees KV16P Major	Pielstick PC2-3 V16 DF	Pielstick PC2-3 V16 DF	Pielstick PC2-3 V16 DF	ASEA GT35C
Engine Type	Reciprocating Diesel	Reciprocating Diesel	Reciprocating Dual Fuel	Reciprocating Dual Fuel	Reciprocating Dual Fuel	Reciprocating Dual Fuel	Reciprocating Dual Fuel	Reciprocating Dual Fuel	Combustion Turbine
Fuel Type	Diesel	Diesel	Diesel and Gas	Diesel and Gas	Diesel and Gas	Diesel and Gas	Diesel and Gas	Diesel and Gas	Gas or Diesel
MW GMC RATING	1.900	1.900	4.200	4.200	4.200	5.500	5.500	5.500	11.700
N-1 FIRM GMC	1.900	1.900	4.200	4.200	4.200	5.500	5.500	5.500	0.000
N-2 FIRM GMC	1.900	1.900	4.200	4.200	4.200	5.500	5.500	0.000	0.000
Date Commissioned	1966	1967	1973	1973	1975	1978	1981	1984	November 1987

Note: Units F, G, J at Ron Goodin Power Station were de-commissioned in 2011.

A.3.2 Owen Springs

Unit	OSPS A (Ex RGPS H set)	OSPS 1	OSPS 2	OSPS 3
Make / Model	Solar Taurus 60	MAN 12V 51/60 DF	MAN 12V 51/60 DF	MAN 12V 51/60 DF
Engine Type	Combustion Turbine	Reciprocating Dual Fuel	Reciprocating Dual Fuel	Reciprocating Dual Fuel
Fuel Type	Gas or Diesel	Dual Fuel	Dual Fuel	Dual Fuel
MW GMC RATING	3.900	10.700	10.700	10.700
N-1 FIRM GMC	3.900	0.000	10.700	10.700
N-2 FIRM GMC	3.900	0.000	0.000	10.700
Date Commissioned	2004	October 2011	October 2011	November 2011

A.3.3 Brewer PPA

Unit	G 1	G 2	G 3	G 4
Make / Model	Waukesha	Waukesha	Waukesha	Waukesha
Engine Type	Reciprocating Spark Fired	Reciprocating Spark Fired	Reciprocating Spark Fired	Reciprocating Spark Fired
Fuel Type	Gas	Gas	Gas	Gas
MW GMC RATING	2.128	2.128	2.128	2.128
N-1 FIRM GMC	2.128	2.128	2.128	0.000
N-2 FIRM GMC	2.128	2.128	0.000	0.000
Date Commissioned	23 December 1996	23 December 1996	23 December 1996	23 December 1996

A.3.4 Uterne PPA

Unit	G 1
Make / Model	SunPower T20 Tracker
Engine Type	Photovoltaic
Fuel Type	PV
MW GMC RATING	0.964
N-1 FIRM GMC	0.000
N-2 FIRM GMC	0.000
Date Commissioned	24 June 2011

B Demand Forecasting Methodologies

PWC and The Commission both developed system wide and ZSS MD forecasts for the Darwin-Katherine, Alice Springs and Tennant Creek power systems. This appendix outlines the approaches used by PWC and the Commission in undertaking these projections.

B.1 PWC

The Network Management Plan 2013/14 to 2018/19 (NMP) presents system wide MD forecasts undertaken by PWC for the three power systems together with a description of the key principles to the approach used. ZSS MD projections are also provided together with a description of the approach used.

System-wide MD Projection Approach

The NMP provides a clear description of the approach used by PWC in undertaking the system wide MD forecasts and this is not reproduced here. However we outline the principles used and the changes to approach from the previous year.

The approach consisted of the following steps:

This approach contains two features that were not part of the previous projection undertaken by PWC:

PWC stated in the NDP (Section 4.5.3)

> Once this influence was removed it was found that a strong correlation exists between these 'No PV' historical MD figures and GSP. In fact the linear relationship has a coefficient of determination of 0.89 indicating a stronger correlation than what exists between the GSP and standard weather MD alone, without the PV adjustment.

Zone Substation Projection Approach

ZSS (or spatial) demand forecasts were developed from data recorded at each of the Zone Substations. The approach to this was described by PWC and is as follows:

A reconciliation of the ZSS MD and system wide MD projections was undertaken as a "check" to the projection. This is done by summing the ZSS MD projections and applying a known diversity factor. The results are not expected to equally align as the system wide projection had GSP as the explanatory variable and had a separate consideration of rooftop PV, as well as the uncertainty in the diversity of ZSS demands at time of MD.

B.2 The Commission

The approaches used by the Commission in projecting system wide and ZSS MDs are outlined below. These were a modification to the approach to the projections undertaken in 2014.

System-wide Projections

The approach by the Commission had similarities to that used by PWC with rooftop PV and spot load being considered separately (that is, removed from the regression model) and the same data range (starting in 2006/07). The rooftop PV projections are presented in Appendix C.

The Commission examined the drivers of overall regional MD for Darwin Katherine system. Econometric analysis was again undertaken examining a number of functional forms and the appropriate explanatory variables.

There was no preferred model as all four functional forms considered (linear, log linear, linear log and double log) provided reasonable explanations of changes in MD. The most appropriate model form determined to be linear-log and this was used.

The explanatory variables considered were Year, GSP, Maximum Temperature on the day of MD, Maximum Temperature on the day preceding the day of MD.

The best estimate of overall change was achieved using the explanatory variables year, GSP, and maximum temperature on the day and the day before. However this had e a small and negative coefficient for GSP, meaning a projected high GSP would result in a lower MD outlook. This suggests that trend growth falls below a constant rate over time.

Given that a negative coefficient for GSP does not correctly represent the impact of GSP on demand, regressions were done removing year and also removing GSP as an explanatory variable in the model.

This resulted in the model used having the explanatory variables Year, Temperature on the day and before the day of MD.

The inclusion of temperature provided only a marginal improvement in the regression. Interestingly, the best estimates in all functional forms were obtained by including both the maximum temperature on the day and for the previous day. The coefficient for the lagged temperature was estimated to be negative which suggests that MD reacts most where there is a large change in temperature from one day to the next.

A comparison of the fit to historical data of the various model forms is shown in Figure 10.2.

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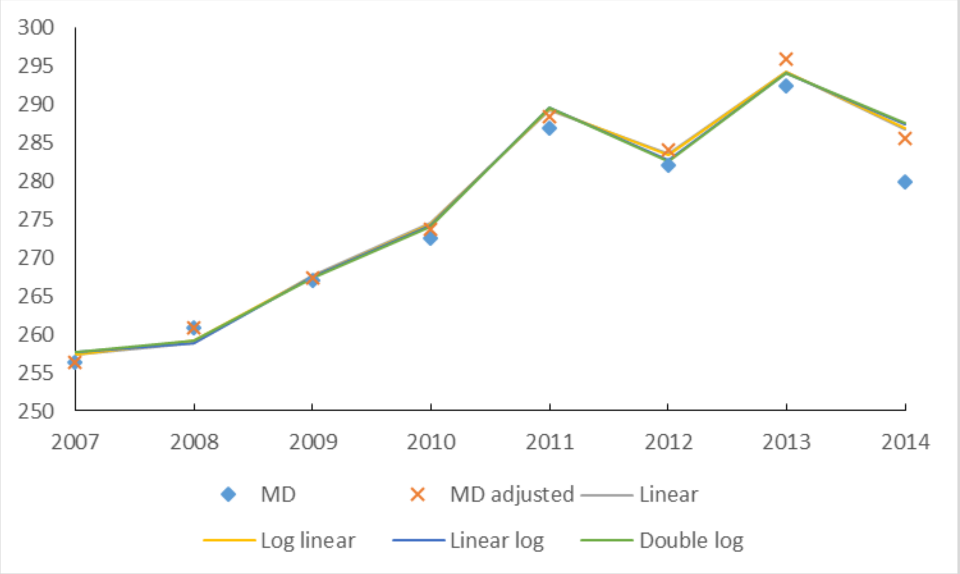
Figure 10.2: Comparison of Statistical Projection Model Forms



Source: The Commission

The interpretation of the small coefficient of temperature in the regression is that there are factors in addition to temperature that result in higher MD than that projected by the regression. The P10 MD was developed from the regression estimate using the P10 maximum temperature and the regression error (1.4 standard deviations).

Zone Substation Projections

The approach used by the Commission (for the Darwin-Katherine and Alice Spring systems) was based on the following:

- Includes unserved energy associated with single credible contingencies on a generating unit, delays to the construction or commissioning of new generating units, and 'acts of God', but
- Excludes unserved energy associated with power system security incidents that results from multiple or non-credible contingencies or industrial action.
- Undertaking a linear regression of maximum daily demand versus maximum daily temperature for all working days in the November to March period excluding 25 December to 15 January (termed the "wet season'). This together with the long-term distribution of historical wet season maximum temperatures provided for a Standard Weather Maximum Demand (SWMD) to be developed, where the SWMD is the MD that would have a 50 per cent probability of being exceeded in that year'
- Weather correcting the historical MD to the SWMD level;
- Removing spot loads in order that significant "load lumps" were removed from the statistical model;
- Removing rooftop PV from the historical demands as the growth of rooftop PV is influenced by separate factors to that which influence demand and consequently MD growth;
- Developing a least squares linear regression model of "corrected" MD with the explanatory variable Gross State Product (GSP);

- Utilising then rooftop PV projection presented in the 2012/13 Power System Review and adjusting this for more recent data on installation levels;
- Based on an outlook of GSP and using the developed regression model, project future SWMD's exclusive of rooftop PV and spot load changes. Then add back in spot load changes and rooftop PV to obtain the MD outlook (based on a 50 per cent probability of being exceeded);
- The MD outlook based on a 10 per cent probability of being exceeded (P10) was developed from the temperature MD sensitivity established.
- The separate treatment and projection of rooftop;
- The inclusion of the explanatory variable GSP in the regression model and the removal of the explanatory variable year.
- For each ZSS the recorded MD were weather corrected to provide historical SWMDs, and changes to spot loads removed;
- A least-squares linear regression was applied to project the ZSS corrected demands. The 2008 recorded MD are excluded from the regression;
- The projection us taken to commence from the 2014 P50 MD with the slope defined by the least squares;
- The changes to spot loads were added back in to provide the final ZSS MD projection.
- Developing demographic profiles of the individual ZSS through mapping the physical ZSS locations to Australian Bureau of Statistics data on customer type locations;
- "Like" ZSS data was "pooled" in the statistical trend analysis in order to increase the level of confidence in the estimates developed. This provided for a common relationship across the pooled data while allowing individual intercepts for each ZSS;
- Trialling the explanatory variables Gross State Product and population (the latter was found to improve the regression) and different trend models (such as linear-log);
- Using actual MDs rather than temperature corrected MDs and including temperature explanatory variables in the model. The temperature explanatory variables trialled were the maximum temperature two days before, maximum temperature the day before, and the maximum temperature on the day of MD. This approach reflected a lack of confidence in the high ΔMD/Δ temperature sensitivity that had been used (3.2 per cent);
- The 2008 MD figures are used in the regression;
- Removing expected spot loads from the model (that is, the same treatment as used by PWC);
- Using the average of the maximum temperatures that had been recorded on the historical days of MD as the maximum temperature on the day of MD in future years. The forecasts were taken to be on a P50 basis.
- Separately forecast rooftop PV and assess the component of this forecast not contained in the regression developed.

C Rooftop PV Outlook

This appendix supports the rooftop PV projections presented in Chapter 4 of this report with additional details of the analysis and projections.

Tabular results are contained in Appendix D.

C.1 Projection Approach

The uptake of rooftop PV was based on the net economic benefits of installing rooftop PV.

The benefits from installing PV arise from:

- Small Scale Renewable Energy Certificates – these certificates are deemed for the lifetime of the installation and lower the initial capital cost of installation;
- Usage offset (avoided electricity purchase at tariff prices);
- Feed in Tariff – export to the gird when household usage is less than rooftop PV output. The feed in tariff rates is currently set at the purchase tariff but has been assumed to reduce in 2016/17 in line with the other States.

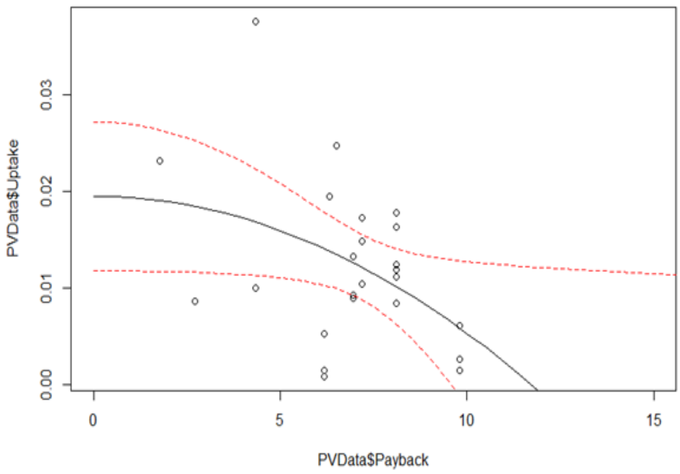
The economics was expressed as the payback period in years for the installation costs to be repaid through reduced electricity purchase costs. A low payback period is highly desirable as this provides more net benefits to the household.

As PV panels have a fixed lifetime there is an assumed upper limit to the payback period (15 years). A payback period greater than 15 years is assumed to have 0 per cent uptake as the cost of installation would outweigh any benefits. In reality the uptake would always be greater than 0 per cent as some people would base their decision on personal/non-economic reasons.

Regression analysis was then used to determine a relationship between the historic payback period and the annual uptake of rooftop PV.

The figure opposite displays the estimated uptake function where uptake is listed as a percentage of the number of households that currently do not have rooftop PV installed.

Payback period Function



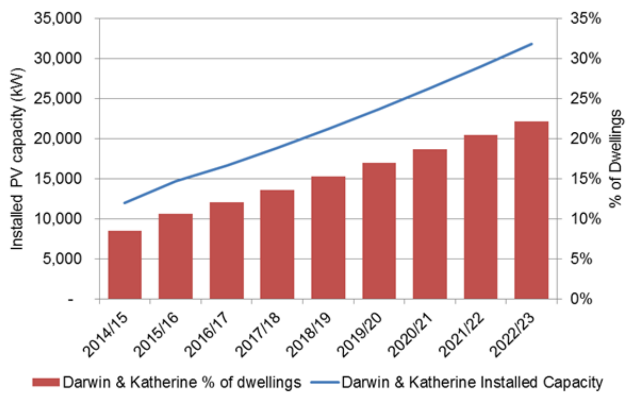
C.2 Rooftop PVP Outlook

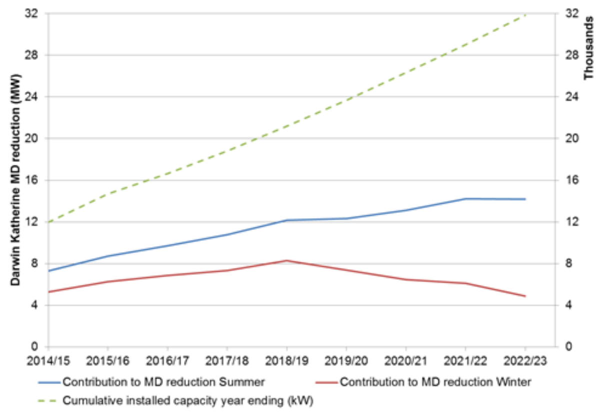
shows for Darwin-Katherine, Alice Spring and Tennant Creek over the outlook period, the projected rooftop PV capacity (expressed as a percentage of dwellings that has rooftop PV installed and the total capacity in kW) and the contribution this rooftop PV has to summer and winter MD (expressed as MW).

Figure 10.3: PV Capacity

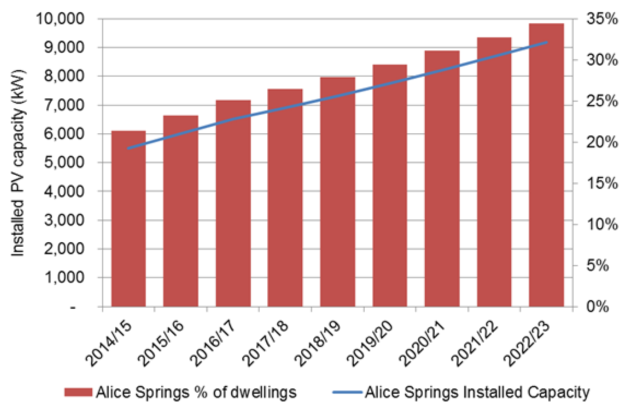
PV Installation- % Dwelling and kWh | **Contribution to MD (summer and winter)**

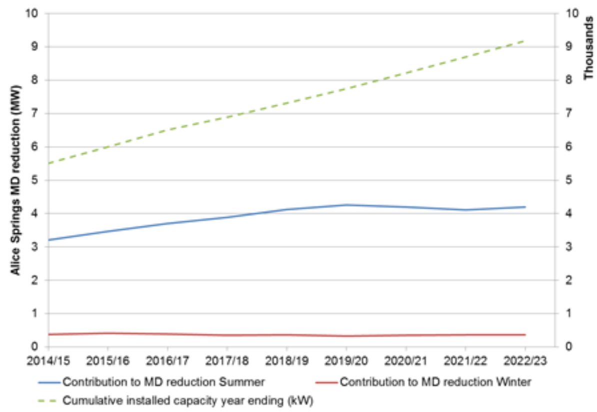
Darwin-Katherine



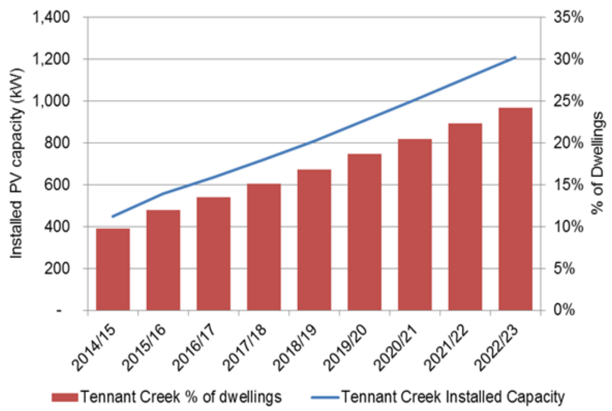


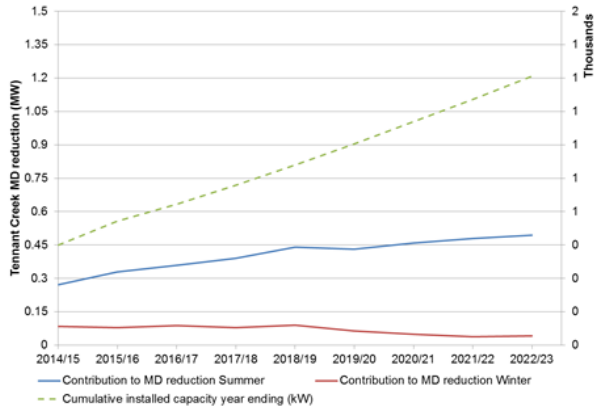
Alice Springs





Tennant Creek





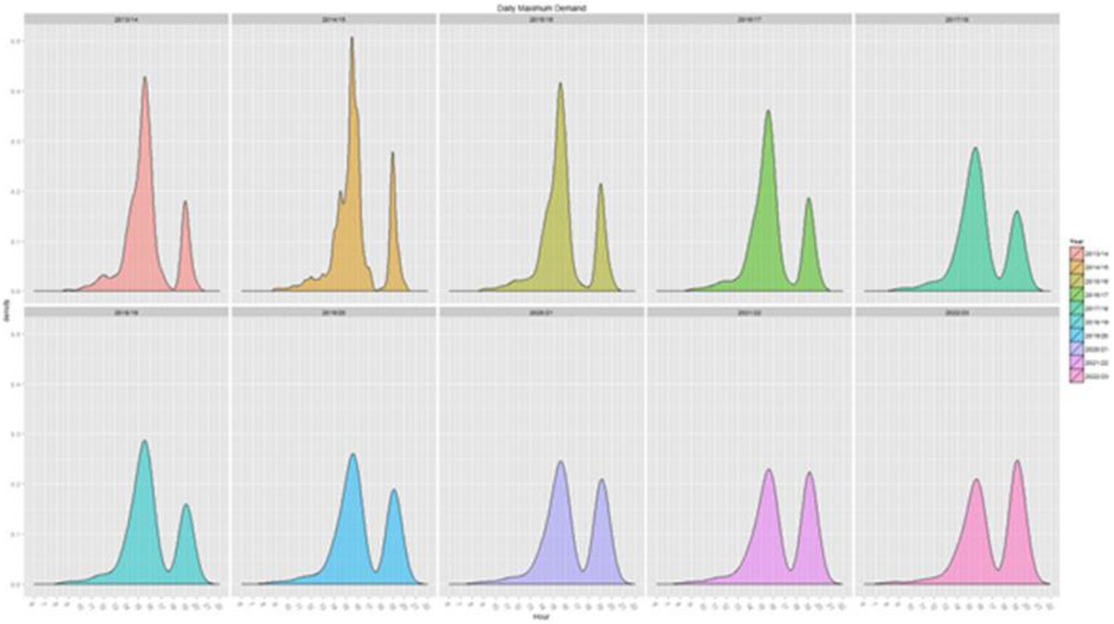
The projections show:

- All three systems increase the number of dwelling by over 13 per cent over the outlook period (about 1.5 per cent per year increase in dwelling with rooftop PV);

- Alice Springs commences with about twice the proportion of dwellings with rooftop PV (at about 20 per cent compared to less than 10 per cent in the other power systems);
- As the amount of rooftop PV increases the contribution of additional rooftop PV to MD begins to decease. This occurs at rooftop PV results in the MD occurring later in the day where the output of rooftop PV is lower.

The movement in MD from daytime to evening is displayed in the Figure 10.4 below for the Darwin-Katherine system. This shows for each year the relative probability of the timing (that is, hour of day) of the MD occurring. A gradual shift in the time of peak demand was observed as rooftop PV increased, until the MD is expected to occur in the evening by 2024. This gradual shift over time is the cause for the lower effectiveness of each new PV system installed later years.

Figure 10.4: Darwin-Katherine: Movement in MD



C.3 References

Key assumption	Source(s)
Historical 1:1 Gross FiT (equal to retail variable tariffs)	• Utilities Commission records • *'Solar Cities Data Analysis Report'*, CSIRO, 10 July 2013
Historical PV installation cost	• *'Forecasting Methodology Information Paper'*, AEMO, 2013 • *'Analysis of Possible Modifications to the Queensland Solar Feed-in Tariff: Report for the Clean Energy Council'*, IES, 22 June 2013 • *'PV in Australia 2011', Australian PV Association, May 2012* • *'PV in Australia 2012', Australian PV Association, May 2013* • *PV in Australia 2013', Australian PV Association, June 2014*
Historical Small-scale Renewable Energy Scheme (SRES) subsidy	• *'Modelling creation of Small-scale Technology Certificates',* ACIL Tasmanian, December 2011 • *'Small-scale technology certificates data modelling for 2013 to 2015',* Green Energy Markets, February 2013 • GEM website, http://greenmarkets.com.au/, last accessed 11/3/2014 • CER website, http://ret.cleanenergyregulator.gov.au/Latest-Updates/2012/December/of-1, last accessed 12/3/2014
Long term average consumer borrowing rate	• *'Analysis of Possible Modifications to the Queensland Solar Feed-in Tariff: Report for the Clean Energy Council'*, IES, 22 June 2013
Household Numbers	• *'Household and Family Projections, Australia, 2006 to 2031', ABS* • *Census 2011, ABS*

D Tabular Results

This chapter provides the graphical quantities shown in Tabular format. This is done in the order the graphs appear in the report. No explanation is provided on the numbers as this is contained in the main body of the report and associated appendices.

D.1 Rooftop PV

Table D.1: Installed Rooftop PV Capacity

	Darwin & Katherine		Alice Springs		Tennant Creek	
	Installed Capacity (kW)	% of dwellings	Installed Capacity	% of dwellings	Installed Capacity	% of dwellings
2014/15	11,973	8.5%	5,506	21.4%	449	9.8%
2015/16	14,700	10.6%	6,004	23.2%	557	12.0%
2016/17	16,636	12.0%	6,510	25.1%	633	13.5%
2017/18	18,811	13.6%	6,898	26.5%	718	15.1%
2018/19	21,174	15.2%	7,314	27.9%	809	16.8%
2019/20	23,685	16.9%	7,750	29.5%	904	18.6%
2020/21	26,312	18.7%	8,215	31.1%	1,003	20.5%
2021/22	29,029	20.4%	8,692	32.7%	1,105	22.3%
2022/23	31,815	22.2%	9,176	34.4%	1,208	24.2%

Table D.2: Contribution to MD Summer/Winter (MW) <need half hour data for AS and TC

	Darwin & Katherine		Alice Springs		Tennant Creek	
	Summer	Winter	Summer	Winter	Summer	Winter
2014/15	7.29	5.29	3.21	0.38	0.27	0.08
2015/16	8.71	6.29	3.46	0.41	0.33	0.08
2016/17	9.70	6.87	3.71	0.39	0.36	0.09
2017/18	10.80	7.35	3.89	0.35	0.39	0.08
2018/19	12.16	8.28	4.13	0.37	0.44	0.09
2019/20	12.31	7.37	4.26	0.33	0.43	0.06
2020/21	13.10	6.48	4.19	0.35	0.46	0.05
2021/22	14.21	6.10	4.11	0.37	0.48	0.04
2022/23	14.17	4.89	4.20	0.37	0.49	0.04

D.2 Zone Substation Projections

Table D.3: PWC ZSS MD Projections P50: Darwin - Katherine (MW)

FYE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Archer	26.9	27.9	37.6	41.4	42.5	52.7	53.7	54.8	55.8	56.8
Batchelor	1.9	1.7	1.4	1.2	0.9	0.9	0.9	0.9	0.9	0.9
Berrimah	32.7	30.8	31.2	31.6	33.1	33.5	33.9	34.3	34.7	35.1
Brocks Creek	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Casuarina	52.3	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4	34.4
Centre Yard										
City	47.9	48.6	49.3	50.0	50.7	51.4	52.2	52.9	53.6	54.3
Cosmo Howley	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Frances Bay	28.5	29.0	29.5	30.0	30.4	30.9	31.4	31.9	32.3	32.8
Humpty Doo	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Katherine	27.3	26.5	25.7	24.8	24.0	24.0	24.0	24.0	24.0	24.0
Leanyer		21.3	21.7	22.2	22.6	23.1	23.5	24.0	24.5	24.9
Manton	8.2	7.9	7.5	7.2	6.8	6.8	6.8	6.8	6.8	6.8
Mary River	3.27	3.34	3.41	3.47	3.54	3.61	3.68	3.75	3.82	3.89
McMinns	26.9	35.0	35.6	36.2	25.3	26.0	26.6	27.2	27.9	28.5
Palmerston	34.0	44.2	50.9	51.7	54.4	55.2	57.9	58.7	59.4	60.2
Pine Creek	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7
Weddell	11.0	12.0	13.1	4.1	5.2	6.2	7.2	8.3	9.3	10.4
Woolner	46.7	49.2	51.7	54.2	56.7	59.2	61.7	64.2	66.7	69.2
Union Reef	10.8	10.9	11.0	11.1	11.2	11.3	11.4	11.4	11.5	11.6
Archer	26.9	27.9	37.6	41.4	42.5	52.7	53.7	54.8	55.8	56.8
Wishart Modular	9	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.5	10.7

Table D.4: PWC ZSS MD Projections P50 : Alice Springs and Tennant Creek (MW)

FYE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Lovegrove	20.0	20.3	20.6	21.0	21.3	21.6	21.9	22.2	22.5	22.8
Sadadeen	28.4	26.5	24.7	22.9	21.1	21.1	21.1	21.1	21.1	21.1
Tennant Creek	7.2	7.2	7.2	7.3	7.3	7.3	7.4	7.4	7.4	7.5

Table D.5: Commission ZSS MD Projections P50: Darwin-Katherine (MW)

FYE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Archer	24.6	24.8	33.7	36.7	36.9	46.3	46.5	46.8	47.0	47.2
Batchelor	2.2	1.9	1.6	1.3	1.1	0.8	0.5	0.2	-0.1	-0.4
Berrimah	29.7	27.5	27.7	28.0	29.3	29.6	29.8	30.0	30.2	30.4
Brocks Creek	0.3	0.0	-0.3	-0.6	-0.9	-1.1	-1.4	-1.7	-2.0	-2.3
Casuarina	53.1	35.4	35.6	35.8	36.0	36.3	36.5	36.7	36.9	37.1
Centre Yard	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
City	45.9	47.0	48.0	49.1	50.1	51.2	52.2	53.3	54.3	55.4
Cosmo Howley	5.2	5.9	6.6	7.3	7.9	8.6	9.3	10.0	10.6	11.3
Frances Bay	29.2	30.3	31.3	32.4	33.4	34.5	35.5	36.6	37.6	38.7
Humpty Doo	2.5	2.7	2.9	3.1	3.4	3.6	3.8	4.0	4.2	4.4
Katherine	28.9	29.1	29.4	29.6	29.8	30.0	30.2	30.4	30.6	30.9
Leanyer	0.0	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3	21.3
Manton	10.8	11.0	11.2	11.4	11.6	11.9	12.1	12.3	12.5	12.7
Mary River	4.3	4.9	5.6	6.3	6.9	7.6	8.3	9.0	9.6	10.3
McMinns	26.7	34.3	34.6	34.8	23.5	23.7	23.9	24.1	24.3	24.6
Palmerston	33.4	43.8	50.9	51.9	54.9	55.9	59.0	60.0	61.0	62.0
Pine Creek	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Weddell	9.6	9.8	10.0	0.2	0.4	0.6	0.9	1.1	1.3	1.5
Woolner	34.0	34.2	34.5	34.7	34.9	35.1	35.3	35.5	35.8	36.0
Union Reef	11.7	12.4	13.1	13.7	14.4	15.1	15.8	16.4	17.1	17.8
Wishart Modular *	9	9.2	9.4	9.6	9.8	10.0	10.2	10.4	10.5	10.7

*Not projected by the Commission

Table D.6: Commission ZSS MD Projections P50: Alice Springs and Tennant Creek (MW)

FYE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Lovegrove	19.3	19.7	20.1	20.4	20.8	21.2	21.6	22.0	22.4	22.8
Sadadeen	24.1	22.6	21.2	19.8	18.3	16.9	15.4	14.0	12.6	11.1
Tennant Creek	7.2	7.3	7.4	7.6	7.7	7.8	8.0	8.1	8.2	8.4

D.3 System Maximum Demand Projections

Table D.7: PWC System Wide P50 and P10 MD Projections (MW)

FYE	Darwin Katherine		Alice Springs		Tennant Creek	
	P50	P10	P50	P10	P50	P10
2015	310.3	318.2	62.0	64.0	7.2	7.5
2016	314.5	322.6	62.1	64.0	7.2	7.5
2017	320.7	328.9	62.2	65.0	7.2	7.5
2018	327.4	335.8	62.5	65.0	7.3	7.6
2019	333.7	342.3	62.8	65.0	7.3	7.6
2020	339.9	348.6	63.0	65.0	7.3	7.6
2021	346.1	355.0	63.1	65.0	7.4	7.7
2022	352.3	361.4	63.2	66.0	7.4	7.7
2023	358.7	367.9	63.3	66.0	7.4	7.8
2024	365.1	374.5	63.4	66.0	7.5	7.8

Table D.8: Commission System Wide P50 and P10 MD Projections (MW)

FYE	Darwin Katherine		Alice Springs		Tennant Creek	
	P50	P10	P50	P10	P50	P10
2015	297.9	305.5	61.6	64.0	7.1	7.4
2016	310.3	318.2	62.0	64.0	7.2	7.5
2017	314.5	322.6	62.1	64.0	7.2	7.5
2018	320.7	328.9	62.2	65.0	7.2	7.5
2019	327.4	335.8	62.5	65.0	7.3	7.6
2020	333.7	342.3	62.8	65.0	7.3	7.6
2021	339.9	348.6	63.0	65.0	7.3	7.6
2022	346.1	355.0	63.1	65.0	7.4	7.7
2023	352.3	361.4	63.2	66.0	7.4	7.7
2024	358.7	367.9	63.3	66.0	7.4	7.8

E Generator Related Load Shedding

Table E.1: Darwin-Katherine: Generator Outage Events that resulted in load shedding in 2013-14

Date	Description
08/11/2013	Loss of generator 9 at Channel Island
26/11/2013	Loss of generator 2 at Weddell leading to loss pf 17 MW.
24/01/2014	CIPS generator unit 9 (C9) tripped
01/04/2014	CIPS generator unit 8 (C8) tripped
11/04/2014	WPS Generator Unit 3 tripped.
16/09/2014	W3 Tripped - Wrong setting entered during compliance testing 1
11/04/2014	WPS Generator Unit 1 tripped
16/09/2014	C9 Tripped - Vibration sensor failure
24/06/2014	CIPS generator unit 9 (C9) tripped
02/06/2014	CIPS generator unit 8 (C8) tripped
Under review	CIPS generator unit 8 (C8) tripped

Table E.2: Alice Springs: Generator Outage Events that resulted in load shedding in 2013-14

Date	Description
29/11/2013	Owen Springs generation units tripped caused UFLS 1A and 1B event
02/01/2014	Owen Springs 3 tripped resulting in Stage 1B UFLS event
06/05/2014	Ron Goodin Power Station Set 3 tripped. UFLS Stage 1A and 1B.

Table E.3: Tennant Creek: Generator Outage Events that resulted in load shedding in 2013-14

Date	Description
28/11/2013	Tennant Creek generation units tripped caused station black out
10/12/2013	Unit 10 tripped

F Key Findings – Technical Audit

Special Technical Audit of PWC and Territory Generation – Final Report 16 April 2015

As part of the Commission's independent investigation into the 12 March 2014 System Black incident, the Commission undertook a technical audit of PWC and Territory Generation's compliance with technical obligations of their Network, Generation and System Control licences.

The audit also assessed the appropriateness of PWC's compliance processes and reporting in accordance with good electricity industry requirements.

The following is a summary of audit findings for each licence.

System Control

The focus of the audit of the System Control Licence was on key obligations pertaining to maintaining a secure electricity system, including overall governance arrangements, switching procedures, and the under frequency load shedding schemes, and those obligations for when a secure system cannot be maintained including black start procedures.

The Commission examined 18 obligations contained in the licence and the System Control Technical Code.

The audit findings are set out in Table F.1.

Table F.1 Summary of System Control Licence audit findings

Item	Audit finding	Comment
Establish and maintain a compliance process	Not compliant	Corporate compliance system 'GRACE' currently does not provide the granularity required. Lack of Internal Audit. No active internal compliance program for licence obligations or obligations arising from the System Control Technical Code.
Establishment of operating protocol and arrangements for generation dispatch and to maintain power system security	Part compliant	The service level agreement (SLA) describing the generator dispatch is out of date.
Restoration of a power system shall occur as soon as reasonably practical following any interruption within the power system.	Compliant	
Ensuring the accuracy of technical parameters. Ensuring that the technical parameters of Network equipment and System Participants' equipment comply with the standards set out in the Network Technical Code or as set out in an Access Agreement.	Part compliant	No specific actions undertaken. Considered a responsibility of PWC Networks. Some commissioning tests monitored.
Coordinating the plant maintenance program	Part compliant	Opportunity to undertake a broad review when Annual plans received – not done due to resource constraints.

Item	Audit finding	Comment
The power system security responsibilities of the Power System Controller and System Control	Not compliant	Post-trip management is not always optimally performed. No review of Under Frequency Load Shedding scheme. Late submission of preliminary incident reports.
Power system security – responsibility for maintaining power system security	Not compliant	At times, do not meet all requirements of Secure System Guidelines
Power system security – assess the availability and adequacy of contingency capacity reserves and reactive power reserves	Not compliant	No formal assessment and not escalating these problems to Networks.
Power system Security – Procure adequate black start capacity	Compliant	
Power system Security – Develop a Black System Restart Procedure	Compliant	Had the audit been performed prior to the System Black incident of March 2014, it is likely that PWC would have been found not compliant.
Power system security – Coordinate and direct any rotation of widespread interruption of demand	Part compliant	No procedure
Power system Security- Investigate and review all major power system operational incidents and to initiate action plans	Part compliant	Late submission of incident reports. Lack of tracking of action plan outcomes Had the audit been performed prior to March 2014, it is likely that PWC would have been found not compliant.
Ensure the Network Operator satisfactorily interacts with the Power System Controller	Compliant	
Power system stability – Handling single contingency events	Not compliant	System Dynamic models in developing stage. Hence, a full range of stability studies has not been done.
Maintenance of a secure system	Part compliant	System does not always meet all requirements specified in the system secure guidelines. However, in a contingency event, controllers take action to minimise safety risks.
Maintaining the frequency on islanded regions	Compliant	
Designating black start power stations	Compliant	
Approval of System Black Procedures	Not compliant	No formal approval given

Although there were a number of not-compliant and part-compliant findings, overall the Commission found an adequate level of compliance with the System Control Licence.

Generation

The focus of the audit of the Generation Licence is on key obligations related to the provision of:

- ancillary services, in particular, black start capability;
- the organisation's responsiveness to the directions of the System Controller, and the recommendations of technical audits and investigations performed by or on behalf of the System Controller; and

- the maintenance and operation of its facilities in accordance with good electricity industry practice.

The Commission examined seven obligations contained in the Generation Licence and System Control Technical Code; the audit findings are summarised in Table F.2.

Table F.2: Summary of Generation Licence audit findings

Audit item	Audit finding	Comments
Establish and maintain a compliance process	Not compliant	Corporate system ‘GRACE’ currently does not provide granularity required. No active internal compliance program for licence obligations or obligations arising from the System Control Technical Code.
Develop of black system procedures	Compliant	
Detail of black system procedures	Compliant	
Approve black system procedures	Part compliant	Territory Generation could provide evidence of submission of procedures to System Control for approval, but could not provide evidence that they had been approved.
Amendment of black system procedures	Part compliant	Each document has been reviewed and reissued within the last six months. However, it is unlikely that procedures have been reviewed every three years as required, prior to the System Black incident, so it is likely that PWC (licence holder at the time) would have been non-compliant at that time.
Operations and maintenance of black start equipment in accordance with good electricity industry practice	Part compliant	Territory Generation has inherited PWC’s Corporate Asset Management Manual, together with its own suite of asset management plans and procedures. Territory Generation should prioritise the development of a structured asset management system appropriate to its business in order to manage its assets in accordance with good electricity industry practice.
Implementation of Power System Controller directions	Part compliant	Recommendations of incident investigation not implemented within a reasonable time. Had this matter been audited prior to March 2014, it is most likely that PWC would have been found non-compliant with its licence obligations.

Overall, the Commission found an adequate level of compliance with the Generation Licence.

Networks

The Network Licence audit focused on key obligations relating to maintenance practices, network operation, coordination of voltage control facilities, maintenance forecasts and training of staff.

The Commission examined eight key obligations contained in the licence and the System Control Technical Code. The audit findings are set out in Table F.3.

Table F.3: Summary of Network Licence audit findings

Item	Audit finding	Comment
Establish and maintain a compliance process	Not compliant	Corporate system 'GRACE' currently does not provide granularity required. Lack of internal audit. No active internal compliance program for licence obligations or obligations arising from the Network Technical Code.
Asset Maintenance in accordance with the Network Access Code and the Network Technical Code	Compliant	
Third-Party Access compliant with good electricity industry practice	Part compliant	Access documentation does not capture assessment of all technical compliance obligations. Further coordination with System Control is required.
Network Operation and maintenance practices consistent with good electricity industry practice	Compliant	
System Security – advice to System Control	Compliant	
Voltage Control - adequate reactive power resources are planned, installed and made available	Compliant	
Audit and testing of Reactive Power devices	Compliant	
Preparation of maintenance forecast	Part compliant	Maintenance forecasts submitted to the Power System Controller do not include high voltage distribution. However, System Control does not require the high voltage distribution assets maintenance schedule as the additional data reduces the clarity of the schedule. It may be appropriate to revise the requirements of the Code to align with the actual needs of System Control.

Overall, the Commission found an adequate level of compliance with the Network Licence.

Compliance Process and Procedures

Of particular concern to the Commission was that PWC and Territory Generation were non-compliant with the obligation to establish and maintain a compliance process.

As part of the audit, the Commission requested documented compliance reporting policy, process, and procedures and compared the documents to Australian Standard (AS3806) Compliance Programs as a guide for good practice.

A high level review was undertaken of the policy and procedural documentation, a subsequent review of PWC's compliance monitoring capability was undertaken.

The audit noted that PWC started using the GRACE system (Governance, Risk, Audit, Compliance, Event Management) in March 2012 with the top 20 compliance obligations added in August. The focus of the implementation had been on safety and environment obligations and these appeared adequately covered.

The audit noted that no specific process has been established to ensure that PWC complies with its obligations under its system control and network licences. The Commission noted that many obligations were implicit in the many operational procedures, but no assessment of compliance with procedures was undertaken and not all obligations are covered by a procedure. The Commission's view was that operational procedures alone were insufficient to form a compliance process.

The audit noted that PWC had implemented an internal audit process based on high risk obligations but this had not included an audit of licence requirements or the System Control Technical Code.

The Commission noted that training of staff was managed through a training management system and this system had been in place since 2012.

The Commission reviewed policy and procedural documentation and found basic processes were in place but noted many procedures were high level and lacked an adequate amount of operational information.

The Commission noted a detailed review of PWC's compliance monitoring capability was not possible as PWC did not provide information about its current audit and compliance team. The concluded that, given the 'GRACE' system was introduced in 2012 and it is still not used to manage technical code obligations at an adequate level for compliance and there does not appear to be a manual compliance monitoring process or internal auditing procedure for the technical code obligations, this may indicate lack of sufficient resources towards implementing a compliance monitoring system.

Overall, the Commission found that PWC's compliance process appeared sound, however, some gaps existed as the compliance process had not yet been fully implemented. In particular, gaps were noted in controls, for example an internal audit was being performed on high-risk items but this was insufficient to ensure compliance with licence obligations.

Territory Generation

The Commission noted similar concerns with Territory Generation's current use of the GRACE system (that it had inherited as part of structural separation) to manage its compliance obligations. The Commission found a similar focus on safety and environment obligations and these appeared adequately covered.

The Commission found Territory Generation's use of GRACE did not include individual licence compliance items and hence was insufficient to meet the requirement to ensure that Territory Generation complied with its licence obligations. The Commission also noted that Territory Generation had reviewed its compliance monitoring capability and recently appointed a Manager Audit, Risk, Compliance and Legal, and were to conduct a full review of its legal and regulatory obligations in early 2015.

Next Steps

As a result of the audit findings, the Commission will undertake a further audit of PWC's compliance process and procedures in mid-2015. The Commission will also publish further guidelines in relation to compliance reporting to supplement the Commission's Statement of Approach on Compliance[41] in mid-2015, which will include, among other things, a requirement for annual declarations from the directors of each licence holder that appropriate compliance processes and management controls have been maintained.

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[41] Commission's Statement of Approach on Compliance, January 2012

G Progress against Recommendations from Previous Power System Reviews

The progress against recommendations identified in previous reviews is detailed in the table below:

Table G.1: Progress recommendations from previous reviews

Issue Identified	Progress
Further work be undertaken by PWC to incorporate reliability assessment and monitoring into PWC's planning and reporting processes.	No direct evidence of progress has been provided to the Commission. However, it is expected that implementation of Maximo will have caused reliability and equipment performance to have indirectly become part of PWC maintenance planning.
PWC's approach to weather correction for ZSS and system MD forecasts be reviewed.	This was discussed with PWC in the context of the two projection methodologies that were used in the 2013-14 Review. It is understood that this will be included in a review by PWC of MD forecasting approaches that will follow this Review.
PWC consider the outcomes of its investigation on the appropriate level of spinning reserve (and indirectly this load shedding practice) including amending its spinning reserve practices if necessary.	This work is ongoing and needs to be accelerated.
PWC adopt a stochastic method for planning and assessing future generation adequacy and in so doing adjust and refine the methods of forecasting generating unit availability.	This recommendation is superseded by the recommendation that consideration be given to power system planning post-structural separation of PWC.
PWC further consider bringing a 132kV supply into the Palmerston area to ensure security of supply.	Significant progress has been made to improve the flexibility and capacity of supply to the Palmerston area. The solutions selected by PWC seem adequate and do not include the use of 132kV.
PWC address the predominance of serious network faults and frequency of transmission line outages within the Darwin-Katherine area.	This work is ongoing and there generally seems to have been a reduction of serious network events with the types of events being experienced now more closely matching the events experienced by other electricity distributors. The System Black incident is an obvious exception to this statement.
PWC document plans to expedite feeder load re-allocation to increase the time margin before a forecast over-utilisation.	There is no evidence that PWC have formal plans in place, however the NMP clearly show that the time margin before a forecast over utilisation is increasing.

PWC provide in future review, further details of the poor performing feeders including time to restore the feeder for each outage and specific details of the faulty equipment.	According to the NMP there are no feeders that meet the criteria of “poorly performing”. If there are poorly performing feeders in future years then these details should be reported.
PWC undertake analysis on why SAIDI and SAIFI performance for the Urban feeder category was close to not meeting the target standard (if applied to 2012-13) and PWC review the reasons for this performance in the forthcoming year.	SAIDI has not shown any improvement across a six year period but remains within the AMS, ignoring abnormal events such as the System Black. SAIFI has remained low (good) in 2013-14. With SAIFI low but SAIDI not improving this suggests that events, when they occur, are of longer duration and so planning for recovery from contingencies appears to be lacking. There is no evidence of PWC specifically considering why the urban feeder category is closer to its limit than other categories.
PWC categorise customer complaints separately for Networks and Retail during 2014-15, for its own business purposes particularly given structural separation of PWC Retail will occur on 1 July 2014.	This recommendation should be addressed now that structural separation of PWC has occurred.
PWC perform voltage level studies to confirm the capacity of feeders to supply loads of adjacent feeders during contingency scenarios.	Contingency analysis performed by PWC appears to consider the thermal capability of feeders only and ignores the fact that capacity can be limited by voltage drop. The analysis is too simplistic and remains a concern to the Commission.
PWC provide details of SmartGrids pilot scheme. This project should lead to further steps in the implementation of Smart Grid technology within the Territory.	Generic information on smart grids is provided in section 4.2.5.2 of the network management plan. PWC plans to roll out 1000 interval meters to a selection of customers. If additional “smart grid” work is being completed to the network then this has not been communicated to the Commission.
PWC implement remedial action in instances of voltage complaints due to high loads on the LV line.	The Commission has seen no evidence of an excessive number of complaints due to low voltage.
PWC introduce islanding schemes for generation to minimise the duration of UFLS events.	This recommendation has received additional attention following the System Black incident and is now being progressed and monitored.
The reliability of generating units be estimated based on planned maintenance activities on an	This has not occurred. The PWC availability estimates for all machines are 92 per cent and do not consider past experience with particular machines or planned

annual basis in addition to an allowance for unplanned outages.	maintenance activities.
PWC re-assess the reliability of the Tennant Creek generating units taking into account the substation refurbishment and attendant control gear upgrade.	These upgrades are in progress.
PWC provide more exhaustive detail in regards to the options considered, including engineering review, financial and time considerations in relation to its proposed network projects.	These details have not been provided to the Commission. The Commission recognises that this detailed information may not belong in the network management plan. This information should reside in separate reports and be referenced in the NMP.
Urgent planned replacement of the switchgear at Tennant Creek.	Completed.
PWC consider what action is required to address the increase in number of customer calls and improve the associated level of customer service.	This item remains an issue and is re-raised in this PSR
PWC further consider the character and content of the Network Management Plan to progress alignment with NEM practices.	No significant progress has been made
PWC consider employing effective engineering solutions to improve the performance of network feeders 11PA17 Thorngate and 22TC602 Feeder 6.	According to the NMP these two feeders are no longer poorly performing feeders
PWC provide in future review, further details of the poor performing feeders including time to restore the feeder for each outage and specific details of the faulty equipment.	PWC did not provide these details and the Commission did not request them. However, it is noted that performance of the poorest feeders has improved significantly and this is no longer a major issue.
Carried-over from 2011-12 PSR Recommendations	
Continued development of electrical models, particularly in the Darwin-Katherine and Alice Springs systems, to identify both steady and transient stability issues must be addressed in order to fully realise the	This work is ongoing and needs to be accelerated.

reliability benefits achievable from the significant investment in new generation in the systems. This work should specifically identify and document any deficiencies in current generator technical standards or network configuration that may be contributing to the transient stability issues in the systems, and develop a plan to redress them.	
Improvement of generation reliability at a unit level to reduce the number of UFLS events that are occurring across all three systems.	There has been some progress in this area. In particular the number of "multiple contingency" generation events has decreased.
In relation to the 12 March 2014 System Black (further recommendations were made in the 2012-13 PSR[42])	
A detailed review of PWC's switching processes and procedures including the development, implementation and authorisation of switching procedures be undertaken.	Procedure completed and reviewed by System Control.
A full condition assessment of the 132kV circuit breakers be undertaken as a priority, including a risk assessment of the possibility of future failures of power system security.	PWC undertook replacement of circuit breakers 602 and 603 at Hudson Creek as a priority. Due for completion June 2015.
A review of PWC's Black System Restart Procedure and incorporation of black-start procedures for CIPS and WPS be undertaken to ensure compliance with the SCTC and good electricity industry practice.	Completed June 2014. System Control has implemented a program of annual review of black start procedures.
Development of a documented and authoritative process for the reporting and implementation of recommendations from power system reports.	AECOM was appointed by PWC as the Project Management Office (PMO) to implement recommendations arising from reports on the 12 March 2014 System Black incident and similar System Black incidents across the Territory dating back to 2010.

[42] Further recommendations were made in the Commission's Investigation Report to the Treasurer on the 12 March 2014 System Black Incident that occurred in the Darwin-Katherine Power System.

	The PMO managed the implementation of 103 recommendations and was closed in early 2015 with 10 recommendations outstanding for implementation. PWC advised that the outstanding recommendations will be monitored through PWC's Technical Management Committee. For the 2014-15 PSR, PWC will be required to provide details of its processes for reporting (including to the Board) and implementation of recommendations from power system reports, including system incident reports.