POWER SYSTEM REVIEW

2011-12

April 2013

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Disclaimer

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

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 2012.

The Review contains predictions, estimates and statements that are 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.

Recent issues relating to the supply of gas to Gove Alumina Refinery have not been considered in this Review as they are outside the timeframe of the Review. They will require consideration in future Reviews.

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 of terms

Term	Definition
2.5 beta method	Statistical method developed by the IEEE to identify events that are outside the reasonable control of the network service provider
Act	*Electricity Reform Act*
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AVR	Automatic Voltage Regulator
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
Feeder	Any of the medium-voltage lines used to distribute electric power from a substation to consumers or to smaller substations
GSL Code	Guaranteed Service Levels Code effective from 1 January 2012, sets out a scheme by which the network service provider makes payments to customers when service performance is outside a defined threshold
GWh	Gigawatt hour
IEEE	US Institute of Electrical and Electronics Engineers
kV	Kilovolt
LOLP	Loss of load probability – Probabilistic analysis of the adequacy of generation capacity
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
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. For example, if each generating unit individually has a certain probability of being out of service at a particular time, probabilistic analysis calculates the probability of 1, 2, 3 or more units being out of service at the same time. This approach is also commonly called Monte Carlo analysis, and involves running many simulations of the system to determine the probability of certain outcomes occurring
PWC	Power and Water Corporation
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 for electricity in a particular year, expressed as a percentage of maximum demand.
SAIDI	System Average Interruption Duration Index – The average number of minutes

Term	Definition
	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
TPA Code	The Electricity Networks (Third Party Access) Code
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

Chapter 1

Overview

1.1 The Utilities Commission (the Commission)'s annual Power System Review (the Review) reports on power system performance and capacity in the Northern Territory. The Review provides information and analysis of historical and forecast power system performance, focusing on the previous financial year, and trends over the last five years and on the upcoming ten years.

1.2 This Review reports on actual system and network performance in 2011-12, and forecast system performance in the period 2012-13 to 2021-22. The Review relates to the Darwin-Katherine, Alice Springs and Tennant Creek power systems.

Purpose of the Power System Review

1.3 On an annual basis, the Commission is required by the *Electricity Reform Act* (the Act) to prepare an annual Review that reports on power system performance and capacity in the Territory.[1] The 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.

1.4 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.

1.5 Power system reporting should provide the routine public release of comprehensive and authoritative data to industry participants, prospective participants, customers, regulators and policy makers to:

- support planning and monitoring activities by providing data to assist identification of investment options, and to facilitate coordination of investment actions;

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

- encourage transparent reporting on system planning and performance matters;
- advise on system performance against the price and service expectations of the regulatory bargain; and
- assist in holding electricity businesses accountable for reliability performance outcomes.

1.6 Regular power system reporting should also inform the energy industry, potential investors, policy makers and the community about the performance of the power system by relaying:

- planning information, including demand forecasts, 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.

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

1.8 In December 2012, the Commission released a new Electricity Standards of Service Code[2] which establishes standards of service and performance measures in the electricity supply industry. The new Code will form the basis for monitoring and enforcing compliance with and promotion of improved standards of services for future Reviews.

Key findings

1.9 The 2011-12 Review continues an increased emphasis on conducting an arm's length review of the Territory's power system that was commenced in the 2009-10 and 2010-11 Reviews, in order to provide a robust assessment of the adequacy of the power system, including generation, transmission and distribution networks.

1.10 Regular and comprehensive reporting on power system and distribution network performance and health is a feature of the electricity supply industry throughout Australia. This report makes further progress towards aligning the Territory's reporting framework with that applying in jurisdictions operating in the National Electricity Market (NEM). While recognising that there are structural differences between operations in the Territory and the NEM, it is the Commission's intent to align reporting where practical to do so.

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

1.11 The Commission is aware that electricity businesses need time to establish the systems and processes required to meet reporting requirements. Consequently, the Commission acknowledged from the outset that not all the information requested from electricity industry participants in the Territory, primarily the Power and Water Corporation (PWC), would be available for the 2009-10 Review. The Commission expected PWC to provide a more comprehensive data set for the 2010-11 Review. This was achieved, but the data set was still not complete. For the 2011-12 Review, there is a marked improvement in the quality and comprehensiveness of the data provided, and the Commission expects this trend to continue in future Reviews.

1.12 In particular, PWC has improved its demand forecasting methodology for the 2011-12 Review. PWC has instituted new business processes that provide a more comprehensive approach to forecasts from 2012-13. As a result, the Commission has not generated its own demand forecasts for this Review, but adopted PWC Network's forecast of demand after a reasonableness check. However, the Commission considers PWC's energy forecasts too high, with energy growing faster than demand, contrary to recent experience. The energy forecasts were modified to reflect the demand forecasts and recent trends in load factors.

1.13 As part of its response to the Commission's request for information for this Review, PWC Networks has provided a Draft Annual Network Management Plan that includes information on many of the issues relevant to the Review. This Plan is based on similar reports produced by distribution entities (in particular) in other jurisdictions and represents a significant step forward in PWC's own documentation of the state of its network.

1.14 The PWC network includes both transmission and distribution assets. PWC Network's draft Annual Network Management Plan reports on both categories of assets on a common basis. In future years, the Commission proposes to adopt slightly different reliability/availability reporting standards for transmission assets, consistent with the approach adopted in the NEM.

1.15 In those jurisdictions operating in the NEM, the format of these plans is transitioning to become a requirement under the National Electricity Rules (NER). While the Territory does not operate under the NER, the Commission proposes that PWC will prepare such reports in a similar format. While there has been a significant improvement in the data provided to the Commission for this Review, the Commission considers that the quality improvement of data is still progressing and further improvement is expected for the 2012-13 Review.

Generation adequacy

1.16 The generation supply-demand balance provides an assessment of generation adequacy relative to forecast electricity demand in the Darwin-Katherine, Alice Springs and Tennant Creek systems for the period 2012-13 to 2021-22.

1.17 Currently, a system is deemed to have adequate generation if there is sufficient capacity available to maintain supply despite the loss of the two largest units of generation plant, known as an N-2 event.

1.18 The Commission considers that further work is necessary to identify an optimum level of generation capacity for the Territory's power systems that recognises reliability, performance and cost objectives. The Commission considers that probabilistic analysis of the adequacy of generation capacity is necessary, particularly in the Darwin-Katherine and Alice Springs systems. This is the approach most commonly used in Australia for identifying the potential for capacity constraints and is a more robust measure for generation planning purposes than the N-X methodology. PWC has advised that it plans to commence such analysis in late 2013.

1.19 The Commission considers that further analysis is required to assess actual system availability (ie actual availability of generation sets) to assess the security and reliability (dynamic performance) of the system, with particular focus on forced outage rates and spinning reserves. The Commission notes that PWC (through System Control) has commenced a review of the spinning reserve requirement for all regulated systems.

Generation adequacy – Darwin-Katherine

1.20 The Darwin-Katherine system is expected to have sufficient generation capacity to maintain supply under any credible electricity demand scenario despite the loss of the two largest generation units in the system (an N-2 event) through to the summer of 2019-20, given the commissioning of Weddell Unit 3 in April 2013. The modelling shows that additional capacity may be required in the 2019-20 year, but at present this only requires monitoring.

1.21 It has been assumed that Katherine Power Station Unit 5 will be installed in 2016, but the need for this unit is understood to be related to local issues at Katherine rather than overall capacity requirements on the Darwin-Katherine system.

Generation adequacy – Alice Springs

1.22 The Alice Springs system is expected to have sufficient generation capacity to meet forecast peak demand under any credible electricity demand growth scenario from December 2012-13 to 2021-22 with the additional capacity currently planned at Owen Springs Power Station and the retirement of the reciprocating engines at Ron Goodin Power Station. PWC has advised that the asset retirement plan for Ron Goodin Power Station is reviewed periodically.

1.23 Owen Springs Units 1-3 were commissioned in October-November 2011. However, they effectively did not enter commercial service in 2011-12, as their very low run hours demonstrate. This has contributed to the poor generation reliability at Alice Springs. The Commission understands that the reasons for their inability to operate (network constraints rather than issues with the power station) in 2011-12 have now been largely overcome, and consequently expects a significant increase in reliability of supply for customers in Alice Springs in 2012-13.

1.24 During the period under review PWC is planning to install units 4, 5 and 6 at Owen Springs. The need for these units is driven by the retirement of the reciprocating engine units at Ron Goodin rather than system load growth at Alice Springs. This potentially provides an opportunity to delay their installation by keeping the Ron

Goodin units in service, should resources be needed for other priorities, such as relieving network constraints in the Alice Springs network.

Generation adequacy – Tennant Creek

1.25 The generation supply-demand balance in the Tennant Creek system is adequate for the period to 2021-22.

1.26 With no load growth forecast at Tennant Creek, there is no reason to install new capacity to relieve capacity constraints.

1.27 Should new plant be proposed, it would have to be justified on cost savings and improved generation reliability rather than capacity needs. PWC has advised that the five Ruston diesel engines at Tennant Creek are beyond their economic life and need to be retired in the near future (an augmentation plan in line with capacity of the sets to be retired is to be considered by the PWC Board in 2013).

Fuel supply

1.28 Natural gas is the main fuel for electricity generation in the Darwin-Katherine, Alice Springs and Tennant Creek systems. However, a number of generation units are dual fuel, and able to use liquid fuels (ie diesel) as an alternative fuel source.

1.29 PWC has a range of contingency arrangements to maintain electricity supply in the event of the partial or complete loss of the primary gas supply from the Blacktip gas field, with a contingency supply arrangement with the Darwin Liquefied Natural Gas (DLNG) plant, line pack gas and diesel stocks. These arrangements provide multiple fuel supply contingencies.

1.30 It is understood that PWC is considering a further contingency supply from the Inpex project, which would provide a second gas supply to meet any temporary shortfalls in the supply from the Blacktip gas field.

1.31 Recent issues relating to the supply of gas to Gove Alumina Refinery have not been considered in this Review as they are outside the timeframe of the Review. They will require consideration in future Reviews.

Electricity networks adequacy

1.32 Consistent with the approach taken in previous reviews, for the 2011-12 Review the Commission again requested PWC Networks (as owner/operator of the Darwin-Katherine, Alice Springs and Tennant Creek networks) to provide equivalent information to that routinely reported by transmission and distribution network operators in the NEM.

1.33 The Commission's intention was to identify potential network capacity constraints in the period 2012-13 to 2016-17 including:

- transmission/sub-transmission feeders whose loading might exceed normal rating;
- bulk and zone substations whose loading might exceed normal rating; and
- distribution feeders whose loading might exceed normal rating.

Transmission network adequacy – lines

1.34 While prior Reviews have relied on a high level assessment of capacity and constraints in the Darwin-Katherine system by the Commission's consultants, PWC has now implemented processes to conduct this review and provide the Commission with results. The Commission considers this work essential due to the criticality of the transmission/sub-transmission network to security of supply.

1.35 The analysis indicates that under normal conditions, all lines operate within their ratings. However, under first contingency conditions (N-1) at times of peak load, a number of lines may exceed their normal rating. Under such conditions, the lines may operate at an emergency rating for a short time until switching can be performed in parts of the network to transfer load. Such constraints also necessitate careful planning of maintenance outages to periods away from times of peak load. The most significant immediate issues are on the McMinns – Palmerston 66 kV line that limit the output of Weddell Power station should another line fail. This will be resolved by the completion of a second line from Archer to Woolner in 2013. A similar constraint arises on the Weddell to McMinns line in 2016-17.

Transmission network adequacy – substations

1.36 There are 30 actual or planned bulk and zone substations across the Darwin-Katherine, Alice Springs and Tennant Creek systems, with assessment of substation utilisation possible in both 2012-13 and 2016-17 for all substations. This represents an improvement on the 2010-11 Review where analysis could not be done on all substations.

1.37 With all transformers in service, all zone substations should have sufficient capacity to meet forecast load for 2011-12. Subject to the implementation of planned works, this will also be the case in 2016-17.

1.38 Under N-1 conditions (ie the loss of one transformer), six substations face capacity constraints:

- Archer 66/11 kV: by 2016-17, N-1 utilisation is forecast to reach 105 per cent. Load can be transferred to Palmerston on a temporary basis to relieve this situation;
- Berrimah 66/11 kV: N-1 utilisation in 2012-13 is forecast to reach 109 per cent. An emergency transfer to Casuarina is available to relieve this situation. Berrimah generators are no longer available;
- Katherine 132/22 kV: forecast N-1 utilisation in 2012-13 is 102 per cent, rising to 115 per cent by 2016-17. During N-1 conditions, loading can be managed by changing the level of generation at Katherine Power Station;
- McMinns 66/22 kV: forecast N-1 utilisation in 2016-17 is 138 per cent with one transformer out of service. This arises as a result of the connection of a relatively large non-permanent load. A 10 MVA mobile substation has been placed on site and will be used to supply load in emergency conditions;

- Palmerston 66/11 kV: by 2016-17 forecast N-1 utilisation will reach 119 per cent. Temporary load transfers to Berrimah substation are available to relieve this situation; and
- Ron Goodin 22/11 kV: N-1 utilisation exceeds 100 per cent if all load connected at Ron Goodin is back fed through the 22 kV network. Normally, however, most of the connected load is fed directly from the operating power station. This potential constraint is managed with generation, but will become an increasing issue with the planned phase out of Ron Goodin Power Station.

1.39 The Commission notes that the construction of Woolner substation as a replacement for Snell Street is nearing completion, and the rebuilding of City Zone substation will commence in the near future. Completion of these two projects should significantly reduce the risk of a multiple contingency event driven by the poor condition of Snell Street and City Zone substations.

1.40 The Commission will continue to monitor the loading of transmission substation adequacy and what action is being taken by PWC to address any issues.

Distribution network adequacy

1.41 For previous Reviews, PWC Networks was unable to provide the load flow studies or measurements on the low voltage (11/22 kV) distribution network necessary for an assessment of loading and capacity. The Commission notes that this situation has been remedied for the 2011-12 Review. PWC Networks has identified that, of the 177 feeders in the systems, forecast loads may exceed 100 per cent of rating on seven feeders in 2012-13, rising to 13 in 2016-17. Having now identified these, the Commission expects that PWC will implement plans to reduce feeder loading to within normal ratings as a matter of urgency.

Reliability

1.42 The Commission has examined reliability for 2007-08 to 2011-12 for:

- generation and network performance in the Darwin and Katherine regions (the Darwin-Katherine system), Alice Springs and Tennant Creek systems, using a weighted total average of reliability outcomes for each system; and
- Central Business District (CBD), Urban, Short Rural and Long Rural feeders (for 2009-10 to 2011-12 only), using a weighted total average of feeder reliability for each system.

Generation performance trend

1.43 Territory customers experienced an average of 2.2 generation related outages a year (SAIFI) between 2007-08 and 2011-12. The 2011-12 performance was 0.9 outages a year, less than half of the five year average. Unfortunately, this improvement was not universally spread over each of the systems. While Darwin performance significantly improved, Katherine, Alice Springs and Tennant Creek incurred either their worst or second worst performance in the five year period. The improvement in Darwin is consistent with the Commission's expectation that generation reliability performance

would improve with the commissioning of new generation plant (even though Channel Island Units 8 and 9 were only in operation for half of the year) and the planned major maintenance to existing generation plant. However, the Commission expects PWC to put in place activities to achieve such improvements in all systems and in particular Alice Springs where Owen Springs Power Station has now been commissioned. A report by Sinclair Knight Merz (SKM), commissioned by System Control, reports on system events in Alice Springs and provides a baseline of activities to address these issues in Alice Springs.[3]

1.44 An ongoing issue to be addressed is the level of spinning reserves to be provided across all systems. Both the Commission in previous Reviews and SKM in its report on Alice Springs events have noted that in other jurisdictions the level of spinning reserves is set to support the system in the event of the trip of the highest output unit in operation at any time. The level of spinning reserves determined by PWC, while increasing over recent years, does not meet this criterion. The level of spinning reserves is being reviewed by System Control in line with further probabilistic investigations and a cost benefit analysis.

Network performance trend – feeder performance

1.45 Overall, the minutes off supply (SAIDI) in the Territory due to network outages was the lowest in five years. The main contributor to this outcome was the absence of events in 2011-12 that are normally classified as “exclusions” for the purposes of reliability reporting. Aside from this impact, network minutes off supply in 2011-12 was in line with the five year average. The number of network outages (SAIFI) in 2011-12 were also consistent with the five years average.

1.46 Examining feeder performance by feeder type to identify network performance trend is the accepted approach in Australia. This is the third year this data has been reported in the Territory. In the CBD, Urban and Short Rural categories, feeder performance is generally better in 2011-12 than in 2010-11. There has been a marked deterioration in Long Rural feeder performance in 2011-12 over that achieved in 2009-10 and 2010-11.

1.47 The Commission has compared feeder performance in the Territory for 2011-12 with the minimum performance standards applicable to comparable network categories in Queensland.

1.48 Overall, 2011-12 performance is reasonable in the CBD, Urban and Short Rural categories, particularly in terms of average outage time. Long Rural performance is significantly worse than the regulatory expectations in Queensland. While there are only two Long Rural feeders and some volatility is expected, outages are approaching one per week on average. The Commission considers this performance unreasonable. PWC has initiated corrective action on the feeders involved. The Commission is looking for improved performance from PWC in relation to Long Rural

[3] Sinclair Knight Merz, August 2012, Alice Springs Electricity Network System Black and UFLS Failure Independent Investigation Report.

feeders and will report feeder performance in future Reviews to assess feeder performance achieved in the Territory over time.

Customer service performance

1.49 The customer service performance of PWC Networks and PWC Retail is measured using the following indicators:

- time taken to complete reconnections and new connections;
- number of complaints about quality of electricity supply;
- time taken to answer telephone calls (after the customer has chosen to speak to an operator); and
- number of complaints about PWC Networks and PWC Retail customer service.

Reconnections/connections

1.50 The number of reconnections (ie those typically made when someone moves into an existing residence) occurring within 24 hours is greater than 99.9 per cent.

1.51 The number of connections to a property in a new subdivision in an urban area occurring within five working days is 87.9 per cent, significantly down from 92.1 per cent in 2010-11 and the second worst performance over the five year period.

1.52 The number of connections to a property in a new subdivision in an urban area where minor works are required occurring within 10 weeks is 27 per cent, and while an improvement on the 2010-11 result of 18.4 per cent, the Commission still considers this result unacceptable and will closely monitor in future Reviews this performance and what action PWC is taking to address the issue.

Quality of supply complaints

1.53 In the 2010-11 Review, the reported Quality of Supply complaints equated to 1 425, almost 1.9 per cent of customers. The Commission's advisors, Evans & Peck, considered this extremely high by industry standards. Following this comment, PWC investigated the reason for this abnormally high number. Some protective devices in electricity systems, even though operating within their normal "operating envelope", can result in low voltages on parts of the network until repaired. PWC's statistics have included the reporting of these issues as a "quality of supply" issue, whereas other parts of the industry do not due to the temporary nature of the event[4]. Quality of supply issues are more commonly associated with issues such as inadequate system design or the operation of large loads. PWC has reported that in 2011-12, the number of these types of complaints was only seven. The Commission is working with PWC to resolve these reporting inconsistencies.

[4] The Commission understands that distribution network providers in other jurisdictions include these events in their SAIDI and SAIFI figures from the moment the first customer calls.

Telephone call response times

1.54 The reported percentage of telephone calls to PWC answered within 20 seconds of the customer choosing to speak to a human operator was 60 per cent in 2011-12. This was the second worst performance in five years, but was on a very high volume of calls. The number of calls exceeded 100 000, more than ten per cent higher than in any other year in the five year period. The Commission has not ascertained the reasons for this increase in call volume or whether it is a "one off" rather than a growing trend. This issue will be monitored in future Reviews.

Customer complaints

1.55 PWC received 2 089 electricity service related complaints during 2011-12, the lowest in the five year period.

Response to issues raised in the 2010-11 Review

1.56 In the 2010-11 Review[5], the Commission identified a number of issues that it would focus on in the 2011-12 Review. Table 1.1 summarises the progress that has been made in relation to these issues.

Table 1.1: Issues identified in the 2010-11 Review

Issue Identified	Progress
Increased levels of asset performance information.	See below for details on individual assets.
Provision of load flow studies or measurements on the low voltage (11/22 kV) distribution network necessary for an assessment of loading and capacity.	Analysis has been completed on the sections of the 11/22 kV emanating from zone substations based on measured loads and feeder ratings. Work is continuing on integrating full details of the feeders over their entire length into modelling software to ensure all sections are within rating, even if sections are of a smaller conductor size. PWC is of the view that this is not a widespread issue as feeders are thought to be generally of the same conductor size throughout their length. However, analysis needs to be completed as full feeder details are entered into Geographic Information Systems.
Development of a more robust forecasting methodology for assessing the supply-demand balance and investment needs.	A new forecasting methodology has been developed and implemented. Further refinement may be required as experience with the methodology is gained.
Provision of information on network forecast peak demand and the capacity of transmission/sub-transmission feeders and distribution feeders in order to identify potential network capacity constraints.	System normal and contingency studies have been completed on the transmission and sub-transmission system. See above re 11/22kV network.
Provision of network demand forecast for the Alice Springs network as loading information for the Sadadeen and Ron Goodin substations becomes available.	This information has been provided for Ron Goodin and Sadadeen substations.

[5] 2010-11 Power System Review, Item 1.53

Issue Identified	Progress
Provision of loading or capacity information for distribution substations to identify actual or potential constraints in the distribution network.	This information has not been provided. However, a clarification on the classification of Quality of Supply events has reduced concern that overloading of distribution substations and low voltage distributors may be contributing to quality of supply issues. Notwithstanding, PWC should continue to progress the integration of customer billing data with GIS data to enable utilisation to be assessed at a substation/distributor level.
Improvements in the network's resilience to abnormal natural events as a result of increased capital and maintenance expenditure on the network assets.	Ongoing work required. There were no abnormal natural events in 2011-12 on which to form a view as to whether improvements are delivering benefit.

Commission's focus for the 2012-13 Review

1.57 As part of 2012-13 Review, the Commission would like PWC to focus particular attention to the following issues:

- reduction of the incidence of overloading of 11/22 kV feeders;
- continued development of the 11/22 kV high voltage feeder modelling and reporting to include identification of sections of line that may be of lower rating than the trunk sections and therefore be at risk of overloading even though the trunk sections are adequate;
- assessment of the state of loading of distribution substations and low voltage distributors (lines or cables that emanate from distribution substations) and in particular large distribution substations supplying commercial and/or industrial loads, and multiple residential loads;
- timeliness of customer connections for properties in new subdivisions and action taken by PWC to improve performance;
- plans to address poor reliability performance for Long Rural feeder outages;
- alignment of the contents of the Network Management Plan with the reporting requirements (where applicable) of Schedule 5.8 of the National Electricity Rules, and publicly release the document;
- continued development of electrical models, particularly in the Darwin-Katherine and Alice Springs systems, to identify both steady state and transient stability issues that 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;
- consistent with the above approach, 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;

- 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;
- introduction of Islanding Schemes for generation to minimise the duration of UFLS events;
- use of probabilistic analysis as the primary tool for assessing system adequacy and generation planning purposes; and
- further analysis of the reasons for the falling load factor in the Darwin-Katherine and Alice Springs systems.

1.58 The Commission also intends to place greater emphasis on actual system availability (ie actual availability of generation and networks) to assess the security and reliability (dynamic performance) of the system, with particular focus on voltage stability, forced outage rates and spinning reserves.

1.59 The Commission will also review any incident reports (reportable events) to assess the adequacy of the provision and response of facilities and services, and the appropriateness of actions taken to restore or maintain power system security.

Chapter 2

Introduction

Background to review

2.1 On an annual basis, the Commission is required by the *Electricity Reform Act* (the Act) to prepare an Annual Power System Review (the Review) that reports on power system performance and capacity in the Territory.[6] The Review provides information and analysis of historical and forecast power system performance, focusing on the previous financial year, and on the upcoming ten years.

2.2 The 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.

2.3 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.

2.4 The Commission engaged a consultant, Evans & Peck[7], to assist with the preparation of the 2011-12 Review by providing expert advice on power system planning (including generation, transmission and distribution) and reliability performance.

2.5 The input of all those who have contributed is appreciated, but the views expressed in the Review are those of the Commission, and may not necessarily reflect those of the parties consulted.

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

[7] Evans & Peck (a subsidiary of the WorleyParsons Group) is an infrastructure focused advisory company with experience in economic regulation and pricing, and the planning, construction and operation of energy, water and resources projects and facilities.

Legislative framework

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

- *Power and Water Corporation Act* 2002;
- *Utilities Commission Act* 2001;
- *Electricity Reform Act* 2000; and
- *Electricity Networks (Third Party) Access Act* 2002.

2.7 *The Power and Water Corporation Act* establishes PWC to generate, trade, distribute and supply electricity in the Territory.

2.8 The *Utilities Commission Act* establishes the Commission as part of an economic regulatory framework for the transmission and distribution sector, with the aim of simulating competitive market outcomes and the prevention of the misuse of monopoly power.

2.9 The *Electricity Reform Act* (the Act) provides the legislative framework for the operation of the electricity supply industry in the Territory. The 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.

2.10 The Electricity Networks (Third Party Access) Code (TPA Code)[8] specifies the access regime for persons wishing to access PWC's electricity network. By doing so, the TPA Code provides a 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.

2.11 Under the TPA Code, the Commission is responsible for determining the network conditions and charges, and monitoring and enforcing compliance with the determination. The arrangements for the period 1 July 2009 to 30 June 2014 were determined in March 2009.[9]

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[8] 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.

[9] Utilities Commission, March 2009, Final Determination Networks Pricing: 2009 Regulatory Reset.

Alignment with industry reporting

2.12 Regular and comprehensive reporting on power system, and distribution network performance and health is a feature of the electricity supply industry elsewhere in Australia. While comparisons between organisations can provide valuable benchmarks, trends within PWC over a number of years are considered the most important indicator of performance stability and improvement. As a consequence, the Commission has focused on maintaining consistency in the approach adopted in this Review with that adopted in the 2009-10 and 2010-11 Reviews.

2.13 The Commission notes the increasing competitive interest in the provision of electricity at both the wholesale and retail level in the Territory. This is driving the need for increased transparency in the provision of network and system control services. In the NEM, the Australian Energy Regulator (AER) publishes an annual State of the Energy Market report to provide a high level overview of energy market activity in Australia, and supplement the AER's extensive technical reporting on the energy sector. The Australian Energy Market Operator (AEMO) publishes detailed reports on system planning and the operation of energy markets, notably the National Transmission Network Development Plan, Electricity Statement of Opportunities (ESOO) report and Power System Adequacy report. At the distribution network level, network service providers are currently required under jurisdiction specific obligations to report on distribution planning and performance. This is progressively transitioning to become a requirement under the National Electricity Rules (NER).

2.14 While the Territory does not participate in the NEM, where applicable the Commission intends to continue to transition reporting requirements to be consistent with those of the NEM as they are considered to be good industry practice. These reporting arrangements have developed over the past decade or more, during which time industry participants have built their capacity to provide relevant information. In preparing the 2011-12 Review and while gaps still exist, the Commission acknowledges a continuing improvement in PWC's ability to provide asset performance information and the level of analysis supporting that information, building on gains made during the 2009-10 and 2010-11 Reviews.

2.15 For the purposes of providing information to support this Review, PWC Networks provided a copy of its 2011-12 Draft Network Management Plan. At this stage this plan has not been publicly released but the Commission expects that future versions will be made publicly available. Schedule 5.8 of the NER establishes the information that distribution network service providers will be required to include in their distribution annual planning reports in the future. Table 2.1 compares the overlap between those requirements, and the issues currently covered by PWC Networks in its draft. While there is a good degree of alignment, the Commission expects PWC to further adopt the Schedule 5.8 requirements in future plans.

Table 2.1: NER Schedule 5.8 – PWC Distribution Annual Planning Report Content Comparison

Schedule 5.8 Requirement (Summarised)	Coverage in PWC Draft Network Management Plan 2011-12
Information regarding the Service Provider and its network:	
• Description of network	✓
• Operating Environment	✓
• Number and Types of Assets	✓
• Methodologies used in identifying limitations etc.	✗
• Analysis and explanation of forecasts	✓
Forecasts	
• Description of methodology	✓
• Load Forecasts	
– Transmission/distribution connection points	✓
– Sub-transmission lines	✓
– Zone substations	✓
– Forecasts for future connection points, lines and zone substations	✓
• Reliability forecasts	✗
• A description of factors that may have a material impact on network	
– Fault levels	✗
– Voltage Levels	✗
– Power system security requirements	✗
– Quality of Supply	✗
– Aging and potentially unreliable assets	✓
• Information on system limitations	
○ Sub-transmission lines	✓
○ Zone substations	✓
○ High voltage feeders forecast to be overloaded	✓
• Planned investments under the regulatory investment test	N/A
• A summary of planned investments of $2 million or more relating to:	
– Refurbishment of replacement	✓
– Unforeseen network issues	✓
• Information on Joint Planning with other Transmission operators	N/A[10]
• Information on Joint Planning with other Distribution Operators	N/A
• Information on the performance of the network	
– Reliability measures and standards, performance against them and proposed corrective action	✓
– Quality of supply standards, performance against them and proposed corrective action	✗
• Information on demand management activities	✓
• Information on investments in metering	✗
• A regional development plan consisting of maps showing:	
– Transmission / distribution connection points, sub-transmission lines and zone substations	✓
– Emerging system limitations, including overloaded distribution feeders	✗

✓ **Addressed in detail** ✓ **Addressed at high level** ✗ **Not addressed**

N/A Not applicable in the Territory's context

[10] It is assumed that PWC's transmission assets will also be included the Annual Planning Report.

Chapter 3

Overview of the Northern Territory Power Systems

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

- Darwin-Katherine system;
- Alice Springs system; and
- Tennant Creek system.

3.2 PWC operates the three larger electricity systems and also operates localised generation systems at Borroloola, Elliott, Daly Waters, Timber Creek, Ti Tree, Yulara and Kings Canyon. In addition, there are a large number of remote power systems spread across the Territory.

3.3 Chart 3.1 shows energy infrastructure in the Territory. Darwin and Katherine are linked by a 132 kV transmission line. Darwin, Katherine and Alice Springs have 66 kV transmission systems for the bulk transmission of power within the regions.

3.4 Gas is transported by high pressure pipelines from the Blacktip field in the Timor Sea to power stations in Darwin, Katherine, Alice Springs and Tennant Creek. Backup gas can also be provided from the Darwin Liquefied Natural Gas plant. Key statistics pertaining to the three major systems are provided in Table 3.1.

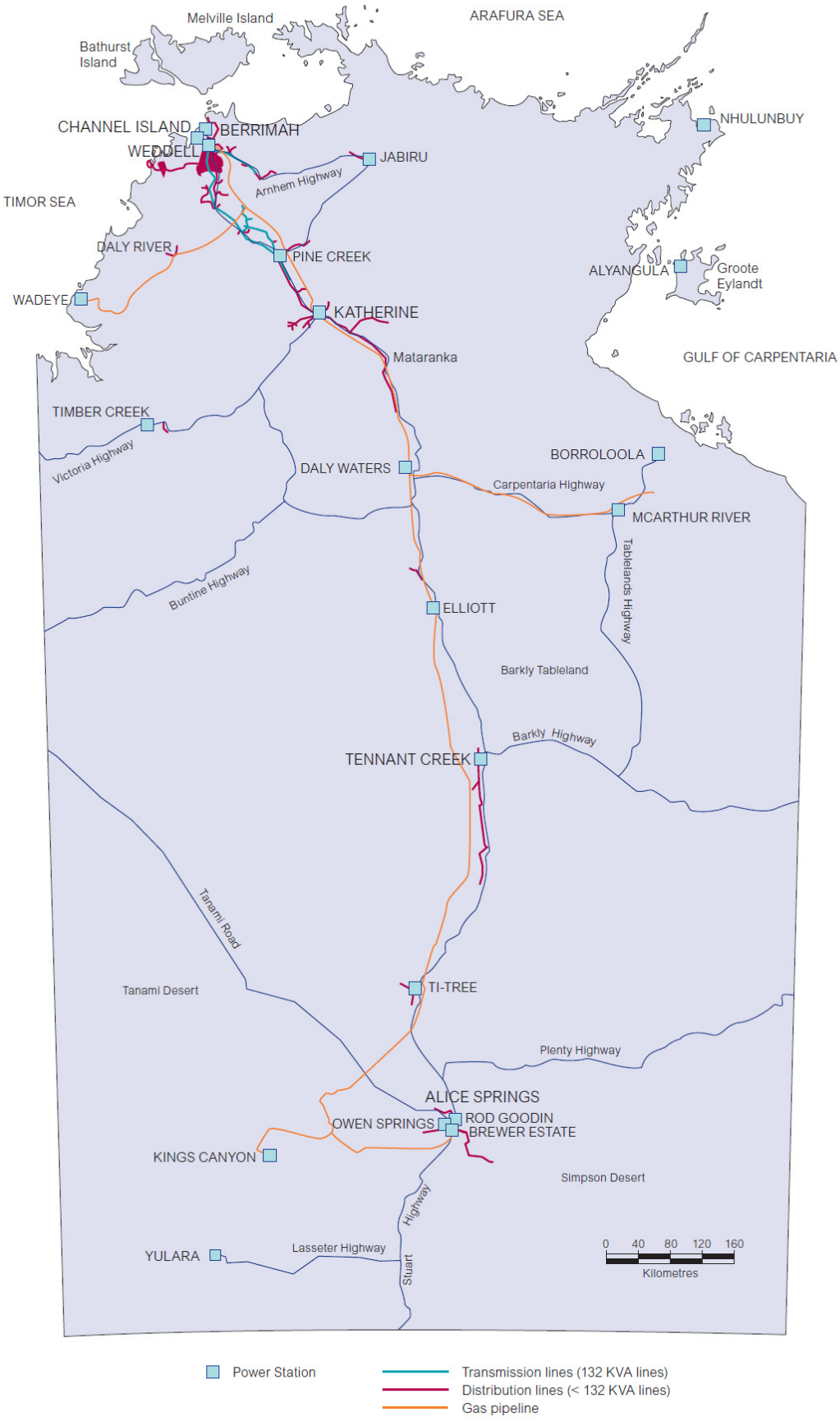
Table 3.1: Key Statistics: Darwin-Katherine, Tennant Creek and Alice Springs power systems

Parameter (as at 30 June 2012)	Darwin-Katherine	Tennant Creek	Alice Springs
Installed generation	445 MW[11]	17 MW	90 MW
Energy delivered (2011-12)	1 512 GWh	31 GWh	226 GWh
Peak demand (2011-12)	282 MW	7 MW	53 MW
Customers	63 012	1 527	11 724
Distribution network length (km)	7 730		
Transmission network length (km)	766		

Source: Power and Water Corporation. Figures rounded to nearest whole number.

[11] Set 4 (12.1 MW) at the Katherine Power Station is not included as it was commissioned in July 2012.

Chart 3.1: Northern Territory energy supply infrastructure.



Source: Power and Water Corporation

3.5 The primary fuel for power generation in Darwin-Katherine, Alice Springs and Tennant Creek is natural gas, with limited use of diesel for backup. Diesel is the main fuel in remote communities. In recent times there has been an increased application of photovoltaic systems in the three main systems, and as a substitute for diesel in remote localities. Retailers operating in the Darwin-Katherine system are subject to the requirements of the Commonwealth's Mandatory Renewable Energy Target Scheme.[12] This scheme operates as two parts:

- Large-scale Renewable Energy Target (LRET); and
- Small-scale Renewable Energy Scheme (SRES).

3.6 The LRET encourages the deployment of large-scale renewable energy projects such as wind farms, while the SRES supports the installation of small-scale systems, including solar panels and solar water heaters. The LRET scheme targets an annual production of 41 million GWh[13] across Australia by 2021 (around 20 per cent of electricity). The target for 2012 is 16.8 million GWh. Retailers are required to purchase renewable energy certificates from eligible generators to offset their liability under the scheme.

3.7 In addition to a number of larger scale commercial installations, there continues to be a steady growth in the number of photovoltaic systems installed by customers. In 2009 there were virtually no so called "rooftop" PVs. In 2010, the number of installations increased to over 1000. PWC's current estimate is that there are now over 2000 rooftop PV installations spread across the three systems. While the majority is in the Darwin-Katherine system, a comparatively high proportion has been installed in Alice Springs.

3.8 The continued development of renewable generation within the Territory reduces the need for retailers to purchase renewable energy certificates created in plants external to the Territory.

Subsequent Developments

3.9 The Commission notes that subsequent events since July 2012 will be addressed in more detail in the 2012-13 Review, including:

- recent issues relating to the supply of gas to the Gove Alumina Refinery will require consideration of the effect on PWC's fuel security in future Reviews;
- Woolner substation will be energised in 2012-13;
- Weddell Power Station Unit 3 is expected to be commissioned in April 2013; and
- a second Weddell – Archer – Woolner 66kV line will be completed in 2013.

Industry participants

3.10 Electricity industry participants licensed to operate in the Darwin-Katherine, Alice Springs and Tennant Creek power systems at 30 June 2012 are listed in Table 3.2.

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[12] A threshold system size of 100 MW applies.
[13] http://www.climatechange.gov.au/en/government/initiatives/renewable-target/fs-enhanced-ret.aspx

Table 3.2: Electricity licence holders at 30 June 2012

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

Source: Utilities Commission.

3.11 PWC generates most electricity for household and business use, operates the electricity transmission/distribution networks and provides retail services to its customers in the Darwin-Katherine, Alice Springs and Tennant Creek power systems.

3.12 PWC is a vertically integrated electricity supplier which also provides water supply and sewerage services. The PWC Generation, Network and Retail units operate as separate businesses with internal transactions between units subject to oversight by the Commission.

3.13 PWC is owned by the Territory Government 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.*

3.14 PWC is also responsible for providing System Control services although these are partly funded through a specific charge approved by the Commission and levied on retailers. As a market develops, it will become important to separate the System Control function from PWC and put in place fully independent 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.[14]

3.15 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 PWC.

3.16 QEnergy and ERM Power Retail have been licensed by the Commission to operate as retailers in the Territory.

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

[14] 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.

Chapter 4

System demand forecasts

4.1 System demand is determined by household, business and industrial electricity consumption patterns, which are influenced by weather, population growth and household formation, economic growth and the development of energy intensive industrial projects. The focus of a system demand forecast is the expectation of maximum or 'peak' demand. Forecasts of peak demand are used to inform decisions about the supply-demand balance and the management of the electricity system in both the short term and long term to ensure a reliable and secure electricity supply:

- the system operator (the System Controller in the Territory) uses peak demand forecasts to determine the generation capacity operating and in reserve that must be available in the short term (eg in the next half hour and over the day) to meet customer energy use; and
- system participants use peak demand forecasts to develop their maintenance programs and to identify generation and network investment needs in the medium to longer term (eg in three years).

4.2 Energy is derived by summing demand over a period of time (eg a month or a year). Energy use drives the amount of fuel that is used in power stations, and forms the basis of calculation of most customers' accounts.

Forecast development

4.3 System demand forecasts for Territory power systems are produced by:

- PWC, which through its System Controller role, develops demand forecasts to ensure there is sufficient generation capacity available to meet demand as part of the day to day operation of the power systems; and
- the Commission, which is required under the Act [s45(1)(a)] to develop forecasts of overall electricity load and generating capacity in consultation with participants in the electricity supply industry.

4.4 PWC Generation, PWC Networks and PWC Retail (and any other generator and retailer operating in the Territory) also require forecasts for business planning purposes. As well as their commercial application in projecting sales and revenues, these forecasts provide an essential input into the scheduling of maintenance, the identification of investment opportunities and the flagging of potential network constraints necessitating upgrades.

4.5 Until recently, PWC has been the sole market generator and sole retailer operating in the Territory, which puts it in a unique situation in Australia of having access to comprehensive information on historical and prospective peak demand and energy

consumption. While still in its infancy, the emergence of competing generators and retailers makes it important that both the System Controller and PWC Networks develop forecasts that reflect all sales transactions in the Territory.

4.6 In the 2009-10 and 2010-11 Reviews, the Commission identified a number of areas for continuing improvement in PWC's forecasting process. The 2010-11 Review noted that:

- a new spatial demand forecasting procedure had been drafted by PWC Networks to underpin PWC's capital and operating expenditure programs by highlighting where network constraints are expected to emerge; and
- from 2012, weather correction of the spatial demand history undertaken by PWC Networks would be made in order to identify the main drivers of peak demand, any changes in these drivers and the factors behind those changes.

4.7 The Commission notes that these improvements have been implemented by PWC Networks in its response to this Review's request for information. As a consequence, the role of Evans & Peck as the Commission's independent advisors has changed from producing independent forecasts to reviewing the suitability of forecasts provided by PWC Networks for adoption by the Commission in discharging its obligations outlined above.

4.8 Forecasts are prepared at three levels:

- a regional level, to inform generation forecasts;
- at a zone substation level, to inform network planning and investment needs; and
- at a high voltage feeder level, again to inform planning and investment needs.

4.9 Consistent with the methodology adopted by PWC, and the approach taken in previous Reviews, the Commission considers that major energy using projects should be considered separately from the forecasting process and treated on a case by case 'contingent' project basis until they become certain. The Commission considers that:

- major projects have varying impacts on energy infrastructure, depending on energy intensity, onshore or offshore locations and the multiplier effects in the local community;
- the Territory's electricity system and distribution networks are relatively small, and a major project can represent a significant percentage of generation capacity;
- these projects may have their own generation capacity, and may not require electricity from the system; and
- there is considerable uncertainty about the timing of projects, due to factors such as global markets, availability of finance and timing of local and national approvals processes.

4.10 Two major projects are factored into the PWC demand forecast scenarios from 2012-13. They are expected to be impacting load from the second quarter 2013. Their full load may not occur at the time of system peak in 2012-13, but needs to be incorporated into the base for 2013-14 and future years.

Review of 2011-12 forecasts

4.11 In the 2010-11 Review, the Commission published forecasts for the period 2011-12 to 2020-21 for the Darwin-Katherine, Alice Springs and Tennant Creek systems. Forecasts were provided by Evans & Peck (these forecasts formed the Commission's Base Forecast) and PWC.

4.12 Table 4.1 compares the actual 2010-11 maximum demand with the Commission's and PWC's forecasts made last year.

Table 4.1: Comparison of Actual (MW) 2010-11

System	2011-12 (Actual) MW	Commission forecast MW	PWC forecast MW
Darwin-Katherine	282.1	297.6	294.2
Alice Springs	52.5	57.4	57.1
Tennant Creek	6.8	7.3	6.9

Source: Power and Water Corporation and Evans & Peck

4.13 Growth in the Darwin-Katherine system has been less than forecast by the Commission and PWC by 15.5 and 12.1 MW respectively. Forecasts are based on P50 temperature conditions. P50 temperatures are likely to be exceeded every two years on average. Peak demand occurred on the 28 November 2011. On that day, the maximum temperature at Darwin Airport was approximately 1.4 degrees less than the P50 value. The temperature sensitivity of the Darwin-Katherine system is approximately 8 MW per degree. On an adjusted basis, the 2011-12 load adjusted to "standard weather" (P50) conditions was 294 MW, in line with the PWC forecast and slightly below the Commission's forecast.

4.14 2011-12 maximum demand in Alice Springs has been some 8 per cent short of both PWC's and Commission's forecast, with the lowest demand in six years being registered. Even after adjustment to reflect mild weather conditions, the maximum demand was well below forecast. This may, in part, be due to significant increases in the number of "roof top" photovoltaic systems being installed in Alice Springs. Such systems manifest themselves as a reduction in load, whereas very large commercial systems (such as that installed at Uterne) are treated as generation rather than being netted off load. Alice Springs has been a participant in the Commonwealth Government's Solar Cities Program[15] since 2008. While this program would be expected to reduce demand growth, it is not yet clear if this fully explains the low level of maximum demand observed in 2011-12. These impacts are discussed further below.

4.15 Actual load Tennant Creek was 1.4 per cent below PWC's forecast, and 7 per cent below the Commission's forecast. On a temperature corrected basis, again reflecting mild temperatures in 2011-12, the maximum demand was estimated at 7.8 MW, above both PWC's and Commission's forecast. Notwithstanding variations from forecast in the short term, the Commission is strongly of the view that weather corrected forecasts

[15] http://www.alicesolarcity.com.au/

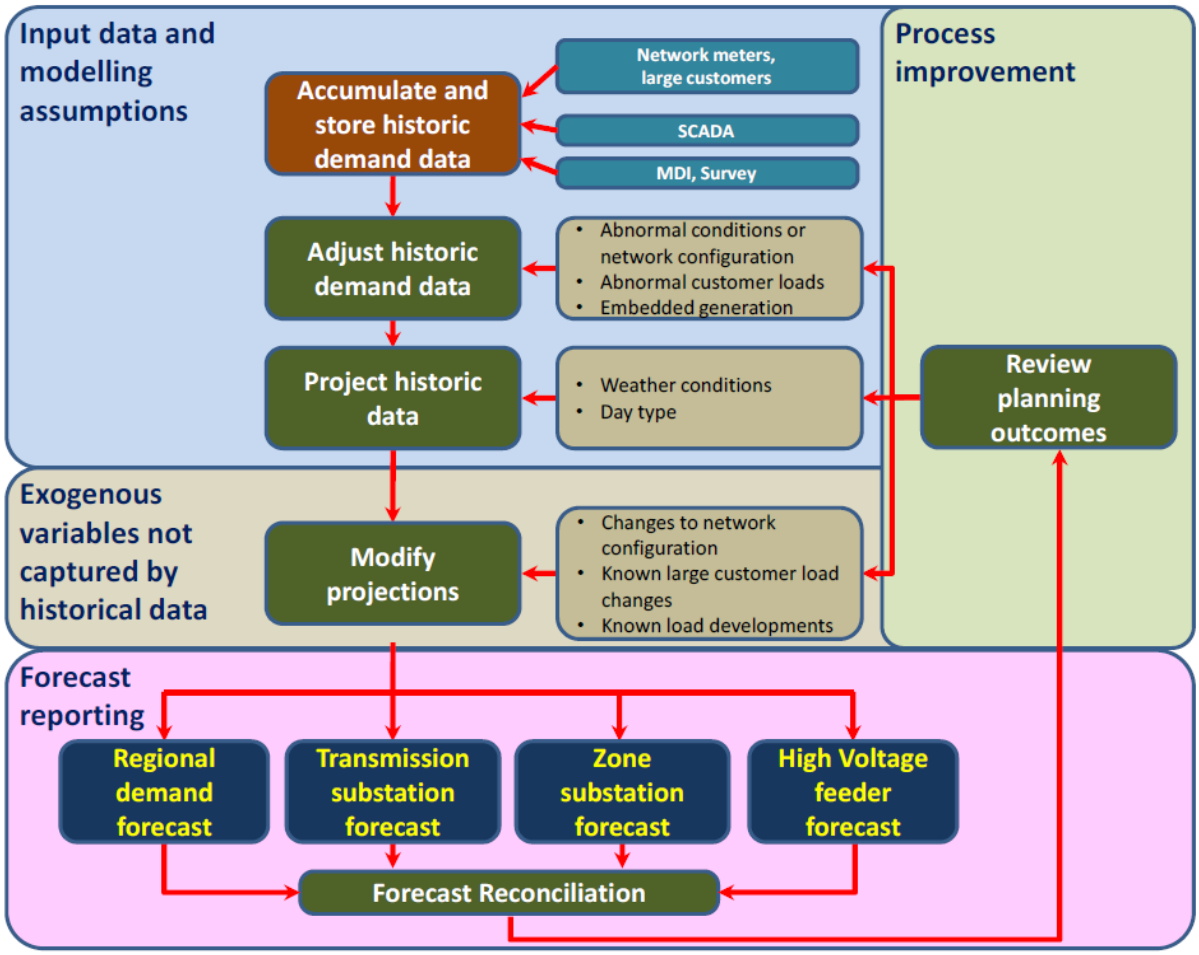
provide a more robust basis for projecting future loads, and therefore provide a better base to plan network and generation expenditure in the medium to long term.

Forecast system demand scenarios

4.16 PWC Networks has produced a series of forecasts for each of the systems. In the last two Reviews, the Commission identified significant deficiencies in PWC's forecasting approach, and adopted its own forecasts (based on advice from Evans & Peck) for the purposes of the Review. As outlined above, many of the deficiencies previously identified such as the lack of weather correction and failure to integrate external economic drivers into the forecast have been addressed by PWC Networks. Consequently the approach taken this year was to examine the suitability of adopting PWC Networks' forecast as the Commission's forecast.

4.17 The revised PWC approach utilises both a "bottom up" analysis and a "top down" review. Bottom up forecasts are based on examining loads at a feeder and substation level. The bottom up process is summarised in Chart 4.1.

Chart 4.1: PWC Networks' "Bottom Up" forecasting process (source PWC's draft Network Management Plan)



Source: Power and Water Corporation

4.18 The forecasts produced by this method are then reviewed from the "top down" in the context of regional factors such as housing approvals, projections of regional economic activity, consumer behaviour and the like which may impact underlying growth. The

result is a consolidated regional forecast for Darwin-Katherine, Alice Springs and Tennant Creek. PWC Networks has produced four forecasts for each system:

- "Base" forecast for "standard" weather conditions (ie one in two year, P50 weather conditions);
- High and Low variations on the Base forecast reflecting changes in economic and other assumptions; and
- a repeat of the "Base" Forecast, but for "P10" weather conditions (ie 1 in 10 year weather scenario). This is used to stress test the system to ensure adequate plant is available to meet extreme weather conditions.

4.19 Key factors influencing current forecast include:

- PWC's knowledge of large loads that may connect to the network. Forecasts may vary depending on whether these loads eventuate, and their timing;
- Territory building approvals for the 12 months ending November 2012 are at their highest level in ten years.[16] Building approvals are considered a leading indicator of new connections. Approvals to the 12 months ended November 2012 were 1800, compared to 1422 at November 2011; and
- Forecasts prepared for the Department of Treasury and Finance by Deloitte Access Economics indicate that over the next five years to 2016-17:
  - population will increase by 1.8 per cent per annum;
  - economic growth will average 4.4 per cent per annum, largely driven by the impacts of the INPEX LNG plant.

4.20 Tempering this growth outlook, will be:

- the potential impact of significant real price increases in regulated retail tariffs that took effect from 1 January 2013; and
- the continued increase in the penetration of PV systems, possibly amplified by real price increases in electricity.

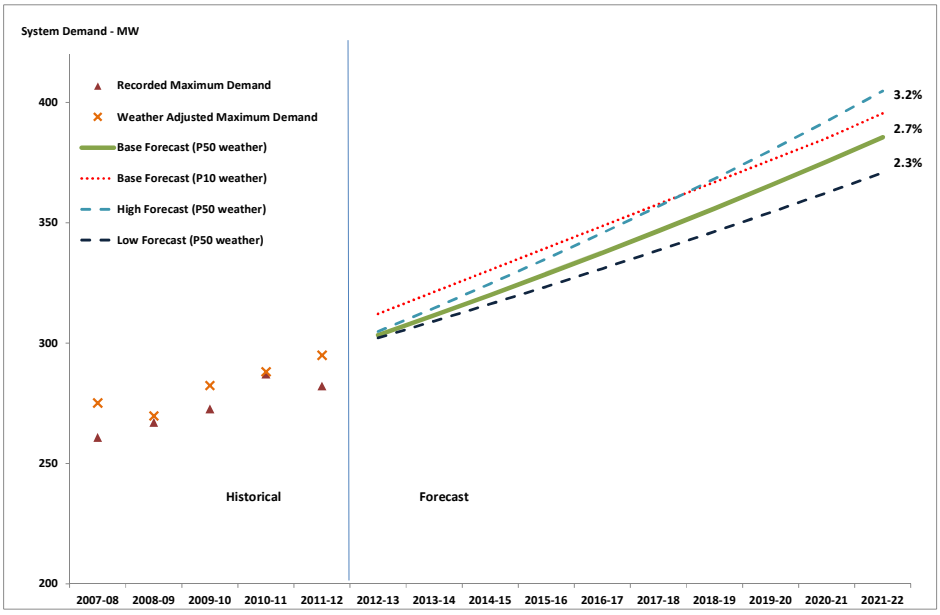
4.21 The net effect is that while strong economic activity in the Territory would normally be expected to put upward pressure on maximum demand forecasts, this is expected to be balanced by the impact of significant real price increases leading to increased energy conservation and potentially acceleration in the rate of installation of rooftop PV systems.

Darwin-Katherine region system forecast

4.22 Annual maximum demand over the last five years, and PWC Networks' ten year forecasts for the Darwin-Katherine system are shown in Chart 4.2.

[16] Derived from ABS Index 8731.0 Building Approvals, Australia TABLE 09. Number of Dwelling Units Approved, Original, States and Territories.

Chart 4.2: Darwin-Katherine annual maximum system demand - Actual 2007-08 to 2011-12 and forecast 2012-13 to 2021-22



Source: Power and Water Corporation and Evans & Peck

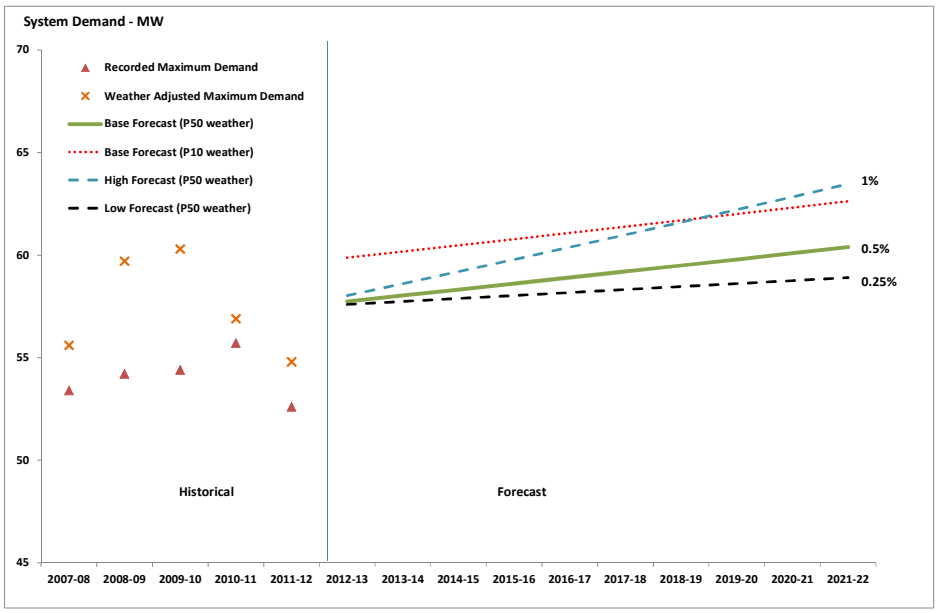
4.23 On a weather adjusted basis, the average growth in maximum demand in the Darwin-Katherine system over the last five years has been 2.6 per cent per annum. PWC Networks' ten year forecast for the Darwin-Katherine system is 2.7 per cent per annum, slightly above the 2.5 per cent previously forecast by PWC, but well below the 3.6 per cent per annum forecast by Evans & Peck and adopted by the Commission for the 2010-11 Review.

4.24 After due consideration of the above and noting PWC's development of more effective forecasting techniques and capability, the Commission has adopted PWC's Base (P50 Weather) forecast for this Review. Table A1 in Appendix B provides details of the Darwin-Katherine forecast for the period 2012-13 to 2021-22.

Alice Springs region system forecast

4.25 Annual maximum demand over the last five years, and PWC Networks' ten year forecasts for the Alice Springs system are shown in Chart 4.3.

Chart 4.3: Alice Springs annual maximum system demand - Actual 2007-08 to 2011-12 and forecast 2012-13 to 2021-22



Source: Power and Water Corporation and Evans & Peck

4.26 The 2011-12 maximum demand in Alice Springs, on both an unadjusted and weather adjusted basis, was considerably down on previous years. On a weather adjusted basis, the growth in maximum demand in the Alice Springs system over the last five years has been virtually zero, with a significant reduction over the last two years. As outlined in Section 4.14 above, Alice Springs has been a participant in the Commonwealth's Solar Cities Program, and there has been strong growth in the installation of rooftop PV systems. PWC Networks' current ten year forecast for the Alice Springs system is 0.5 per cent per annum, well below both the 2.5 per cent previously forecast by PWC for the 2010-11 Review and the 2.0 per cent per annum forecast by Evans & Peck and adopted by the Commission in 2010-11.

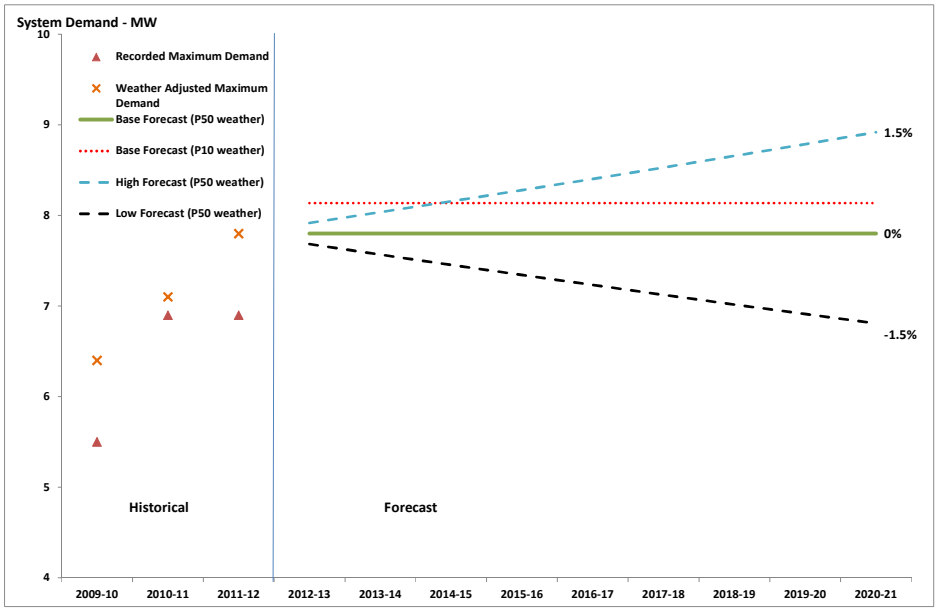
4.27 The high degree volatility in maximum demand over recent years, particularly on a weather corrected basis, increases the difficulty in establishing both the starting point for future forecasts and the rate of growth. It is possible that there has been a significant downward shift in the maximum demand as well as a reduction in underlying growth arising from the Solar Cities Program, and that future forecasts will need to reset the forecast "starting point". However, after due consideration and noting PWC's development of more effective forecasting techniques and capability, the Commission has adopted the Base (P50 Weather) forecast for this Review. Table A2 in Appendix B provides details of the Alice Springs forecast for the period 2012-13 to 2021-22.

Tennant Creek region system forecast

4.28 Annual maximum demand over the last three years[17], and PWC Networks' ten year forecasts for the Tennant Creek system are shown in Chart 4.4.

[17] PWC has advised that earlier data is not available.

Chart 4.4: Tennant Creek annual maximum system demand - Actual 2009-10 to 2011-12 and forecast 2012-13 to 2021-22



Source: Power and Water Corporation and Evans & Peck

4.29 On a weather adjusted basis, the growth in maximum demand in the Tennant Creek over the last three years has been over 10 per cent per annum. However, PWC Networks has advised that this has been influenced by a small number of comparatively large loads. This is not expected to be repeated in future years. PWC Networks' current ten year forecast for the Tennant Creek system is for the maximum demand to remain flat. Zero growth is well below both the 2.5 per cent previously forecast by PWC for the 2010-11 Review and the 1.3 per cent per annum forecast by Evans & Peck and adopted by the Commission in 2010-11.

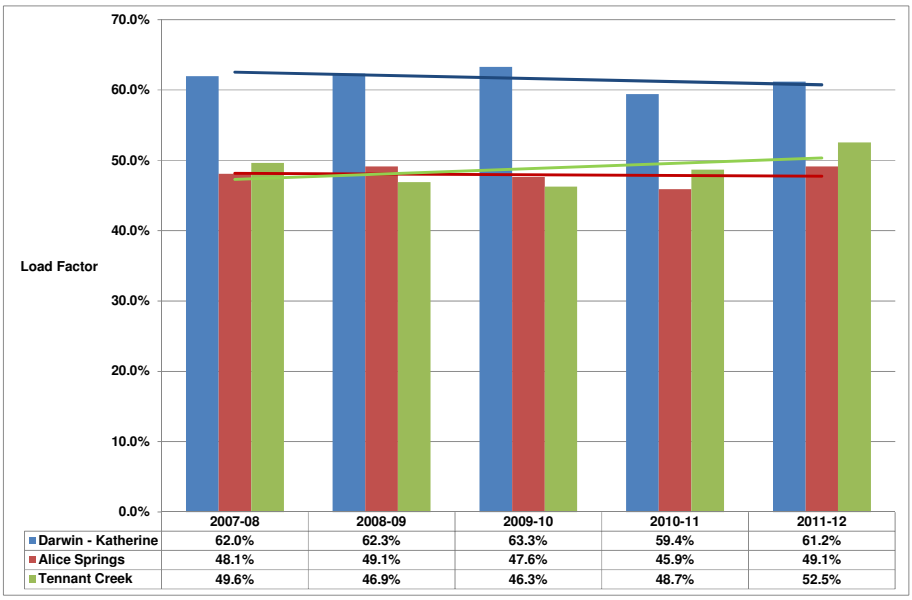
4.30 This is a relatively small system and the volatility in maximum demand increases the difficulty in establishing forecasts. After due consideration of the potential impact of significant real price increases and noting PWC's knowledge of major loads and its development of more effective forecasting techniques and capability, the Commission has adopted the Base (P50 Weather) forecast for this Review. Table A3 in Appendix B provides details of the Tennant Creek forecast for the period 2012-13 to 2021-22.

Energy forecasts

4.31 While peak annual maximum demand on each system relates to only one 60 minute period during the year, energy is the aggregate of all demands across the full year. One measure of the relationship between peak demand and energy is load factor. The load factor is the ratio of average demand over a year to maximum demand. A high load factor is representative of a reasonably flat stable load, whereas a low load factor would tend to represent a peaky volatile load.

4.32 Chart 4.5 presents the trends on load factor in each of the Darwin-Katherine, Alice Springs and Tennant Creek systems from 2006-07 to 2011-12.

Chart 4.5: Trends in load factors for each system over a five year period.



	2007-08	2008-09	2009-10	2010-11	2011-12
Darwin - Katherine	62.0%	62.3%	63.3%	59.4%	61.2%
Alice Springs	48.1%	49.1%	47.6%	45.9%	49.1%
Tennant Creek	49.6%	46.9%	46.3%	48.7%	52.5%

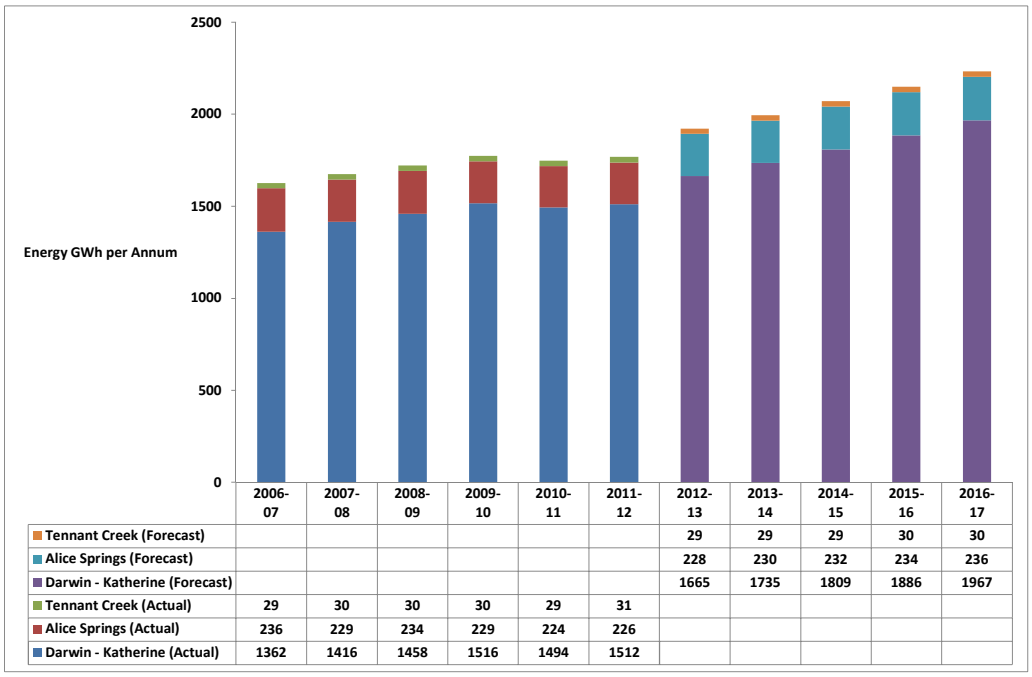
Source: Evans & Peck

4.33 In line with observations in the 2010-11 Review, the load factor trend in both the Darwin-Katherine and Alice Springs systems is downward, whereas the trend has reversed in the Tennant Creek system. The implications of a downward trend, should it continue, is that energy will grow at a lower rate than maximum demand. Deteriorating load factor is often associated with increased community awareness of electricity conservation issues. By way of example, there may be less usage of air conditioning on mild days, but continued use on very hot days. This results in less energy, but the same peak demand. In an industry where many costs are peak demand driven and revenue is recovered from energy sales, this can result in an increase in unit prices.

4.34 The Commission considers further analysis is required to understand the reasons for the falling load factor in the Darwin-Katherine and Alice Springs systems.

4.35 In response to the Commission's request, PWC has provided an energy forecasts for each of the three systems covering the period 2012-13 to 2016-17. These are presented in Chart 4.6.

Chart 4.6: Actual energy 2007-08 to 2011-12 and forecast 2012-13 to 2016-17 (PWC)

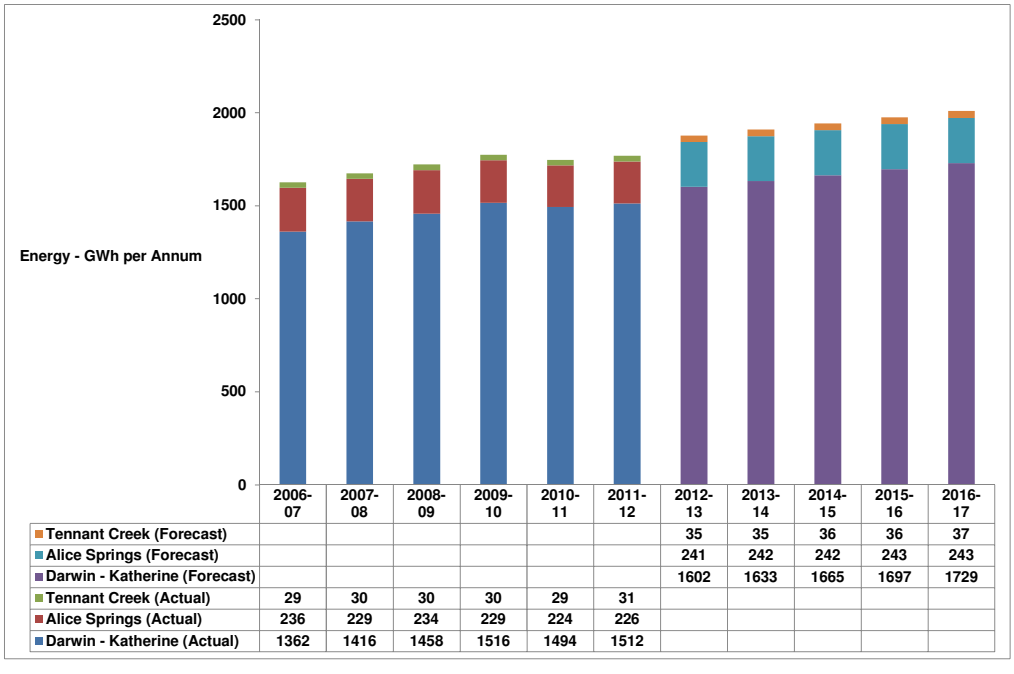


	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Tennant Creek (Forecast)							29	29	29	30	30
Alice Springs (Forecast)							228	230	232	234	236
Darwin - Katherine (Forecast)							1665	1735	1809	1886	1967
Tennant Creek (Actual)	29	30	30	30	29	31					
Alice Springs (Actual)	236	229	234	229	224	226					
Darwin - Katherine (Actual)	1362	1416	1458	1516	1494	1512					

Source: Power and Water Corporation and Evans & Peck

4.36 The growth in total energy in each of the three systems for the five year period 2012-13 to 2016-17 is 4.2 per cent for Darwin-Katherine, and 0.9% for both Alice Springs and Tennant Creek. For Darwin-Katherine, this growth in energy is well above the projected growth in maximum demand. Evans & Peck has produced a separate energy forecast based on PWC Networks' Base (P50 weather) maximum demand forecasts, but taking into account the changing trend in load factor outlined above. This forecast is presented in Chart 4.7.

Chart 4.7: Actual energy 2007-08 to 2011-12 and forecast 2012-13 to 2016-17 (Evans & Peck)



	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
Tennant Creek (Forecast)							35	35	36	36	37
Alice Springs (Forecast)							241	242	242	243	243
Darwin - Katherine (Forecast)							1602	1633	1665	1697	1729
Tennant Creek (Actual)	29	30	30	30	29	31					
Alice Springs (Actual)	236	229	234	229	224	226					
Darwin - Katherine (Actual)	1362	1416	1458	1516	1494	1512					

Source: Evans & Peck

4.37 The overall energy growth rate across Darwin-Katherine system over the five year period 2012-13 to 2016-17 in Evans & Peck's forecast is 1.9 per cent, significantly lower than PWC's forecast of 4.2 per cent. Both forecasts have an increase in 2012-13 over 2011-12, largely driven by weather factors. Similarly the forecast for Alice Springs is 0.3 percent and for Tennant Creek 1.5 per cent. Tennant Creek is the only system showing an increase in load factor.

4.38 In the Commission's view, an energy growth rate in excess of the maximum demand growth rate is contrary to the trend in load factors, and unlikely in the context of factors such as recent significant real price increases with a likely consequent increase in conservation awareness, installation of solar roof top systems and other cost saving measures likely to be adopted by customers. As a result, for its energy forecast, the Commission has adopted Evans & Peck's forecast, as set out in Chart 4.7.

Generation supply balance

4.39 The generation supply-demand balance is an assessment of whether available generation capacity is adequate to meet forecast electricity demand. To make this assessment the Commission has used:

- generation capacity projections for 2012-13 to 2013-14, and advice of generation investment plans for 2014-15 to 2021-22; and
- electricity demand forecasts (P10 on Forecast Trend) for 2012-13 to 2021-22 provided above.

Projected available generation capacity

4.40 Generation capacity projections for the Darwin-Katherine, Alice Springs and Tennant Creek systems for 2012-13 to 2013-14 are provided in the tables below.

4.41 The capacity projections are based on advice by industry participants to the Commission of available capacity, planned generation additions and retirements in the period 2012-13 to 2021-22. Capacity projections for the period 2014-15 to 2021-22 are not reported due to uncertainty about outcomes versus plans. The Commission cautions that the timing of additions and retirements of capacity may vary in response to commercial priorities of electricity industry participants, construction or commissioning delays and changing electricity peak demand forecasts.

Darwin-Katherine system

4.42 Table 4.2 provides the Commission's assessment of generation capacity in the Darwin-Katherine system for 2012-13 to 2013-14. The starting capacity of the Darwin-Katherine system for 2012-13 is 445 MW. Note that this capacity does not include new units which will be added during the year (ie Weddell Unit 3).

Table 4.2: Darwin-Katherine capacity projections (MW) 2010-11 to 2012-13

Year (30 June)	Starting capacity	Retirements	New capacity	Total capacity	Comment
2012-13	445	-	54	499	Plus Weddell Unit 3 (42 MW) Plus Katherine Unit 4 (12 MW)
2013-14		-	-	499	

Source: Power and Water Corporation and Utilities Commission.

4.43 Berrimah Power Station was removed from regular service in 2010-11, reducing the system capacity by 30 MW. The Commission has excluded Berrimah Power Station from the calculation of available generation capacity for 2012-13 on the understanding that one of the units is completely unserviceable, and the second unit has been derated from 15 MW to 10 MW. This capacity is only available for service in an emergency situation.

4.44 New capacity of 54.1 MW is expected to become available in 2012-13 with the commissioning of:

- Katherine Power Station Unit 4 in July 2012, adding 12.1 MW of capacity. This unit was relocated from Ron Goodin Power Station during 2011-12, and was available for service in July 2012; and
- Weddell Power Station Unit 3 (42 MW) in April 2013, nine months later than was advised at the time of preparation of 2010-11 Review.

Alice Springs system

4.45 The starting capacity of the Alice Springs system for 2012-13 is 89 MW.

Table 4.3: Alice Springs capacity projection (MW) 2011-12 to 2013-14

Year (30 June)	Starting capacity	Retirements	New capacity	Total capacity	Comment
2012-13	89	4		85	Less Ron Goodin Unit 1 (2 MW) & Unit 2 (2 MW). Also excludes Uterne capacity as it is not considered firm
2013-14				85	

Source: Power and Water Corporation and Utilities Commission.

4.46 PWC advises that Ron Goodin Units 1 and 2 (3.8 MW total) are to be retired in 2012-13. The Commission has assumed that the units will be decommissioned in January 2013. PWC also advises that it intends to remove from service all reciprocating engine driven generation at Ron Goodin between 2011-12 and 2021-22, leaving only Unit 9 in service. Units 1 and 2 will continue to be available for emergency use.

Tennant Creek system

4.47 The reported starting capacity of the Tennant Creek system for 2011-12 is 17 MW. PWC has advised that the five Ruston diesel engines at Tennant Creek are beyond their economic life and need to be retired in the near future. PWC further advises that

an augmentation plan, taking into account the capacity of the sets to be retired, will be considered by the PWC Board in 2013.

Generation supply-demand balance

4.48 The generation supply-demand balance provides an assessment of generation adequacy relative to forecast electricity demand in the Darwin-Katherine, Alice Springs and Tennant Creek systems for:

- short to medium term – 2012-13 to 2014-15; and
- medium to long term – 2015-16 to 2021-22.

4.49 The Commission has used two techniques to assess the generation supply-demand balance:

- N-X analysis of generation adequacy, which tests whether generation capacity is adequate to meet peak system demand under the P10 growth scenario at N-X. This is the approach adopted by the Commission for the three systems in previous Reviews; and
- probabilistic analysis, which establishes a loss of load probability (LOLP) to identify the likelihood of generation constraints occurring over the assessment period, for the Darwin-Katherine system only, consistent with the Commission's approach in the 2009-10 and 2010-11 Reviews. This is the approach most commonly adopted for generation planning purposes in Australia.

4.50 In carrying out these analyses, the Commission has adopted the P10 on Forecast Trend load forecast, which is consistent with the approach adopted in the ESOO.

N-X analysis of generation adequacy

4.51 An N-X analysis of generation adequacy involves progressively subtracting the capacity of largest unit from total installed capacity. For example:

- N is the system capacity regarded as available for service;
- N-1 is the system capacity minus the capacity of the largest unit of generation in the system;
- N-2 is the system capacity minus the capacity of the two largest units in the system.

Snapshot at December 2012

4.52 Table 4.4 provides the capacity available in each system at N-1 and N-2 as at 31 December 2012.

Table 4.4: N-X capacity

N-X capacity (MW) as at 31 December 2012	N	N-1	N-2
Darwin-Katherine	458[18]	410.4	362.8
Alice Springs	85[19]	73.3	62.6
Tennant Creek	17[20]	13.1	11.6

Source: Utilities Commission. Note: the N-X capacities change over time as generation units are added and replaced.

Loss of load probability

4.53 The LOLP is an indicator of generation reliability commonly used in Australia for assessing system adequacy and generation planning purposes. The LOLP indicates the probability that generation capacity will be insufficient to meet demand at some point over some specific period. It is considered a more useful measure for planning purposes than the N-X methodology.

4.54 Evans & Peck developed a simple probabilistic model for the Darwin-Katherine system to complement the N-X analysis of generation adequacy. The Commission stresses that this LOLP assessment has limitations, with additional information required to reflect good industry practice, and provide a robust planning tool. However, the Commission seeks to encourage participants in the Territory's electricity sector to use probabilistic analysis as the primary tool for assessing system adequacy and generation planning purposes.

4.55 A probabilistic analysis of the adequacy of generation capacity was applied by the Commission in the 2010-11 Review for the Darwin-Katherine system. Neither PWC Generation nor the System Controller currently undertake any probabilistic analysis of system adequacy.

Generation supply-demand balance – Darwin-Katherine system

4.56 The Darwin-Katherine system is expected to have sufficient generation capacity to meet forecast peak demand under any credible demand growth scenario in the medium and long term.

4.57 For the period 2012-13 to 2021-22, there is sufficient generation capacity available to provide an estimated average reserve margin of 45 per cent. The minimum reserve plant margin in the period is 29 per cent in late 2019 early 2020 when forecast peak demand reaches 376 MW against capacity of 487 MW (representing reserve capacity of 111 MW). This exceeds the N-2 criterion of the loss of 95.2 MW.

4.58 An N-X analysis of the supply-demand balance for the Darwin-Katherine system is presented in Chart 4.8. The analysis assumes that peak demand increases according to the P10 on Forecast Trend, and that all capacity is available (ie without accounting

[18] Includes Set 4 at the Katherine Power Station as it was commissioned in July 2012, and the N-X analysis starts from 1 January 2013.

[19] Excludes Uterne and Unit 1 & 2 at Ron Goodin Power Station.

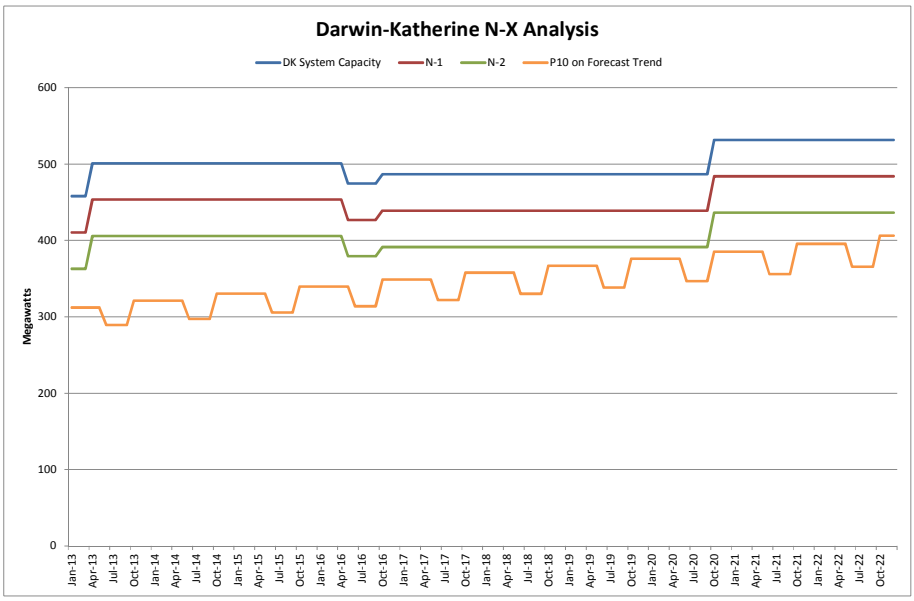
[20] This accounts for Unit 17 being out of service at present.

for planned maintenance). The key point is that the plant proposed to be commissioned during the period provides sufficient capacity to meet in excess of an N-2 event throughout the Review period.

4.59 N-1 is a capacity reduction of 47.6 MW, which represents the loss of 50 per cent of the capacity of the combined cycle block at Channel Island Power Station (ie the loss of one dual fuel turbine and 50 per cent of the steam turbine).

4.60 N-2 is a capacity reduction of 95.2 MW, which represents the loss of the total combined cycle block at Channel Island Power Station.

Chart 4.8: Darwin-Katherine system supply-demand balance for 2012-13 to 2021-22



Source: Evans & Peck and Utilities Commission.

4.61 Subject to industry standard operation and maintenance practices being followed, generation capacity should be sufficient to provide spare capacity above the N-2 criterion from January 2013 to 2021-22 under credible demand forecast scenarios.

4.62 An alternative indicator of system adequacy is the reserve plant margin, which is calculated as the total system capacity available less the actual maximum demand for electricity in a particular year, expressed as a percentage of maximum demand.

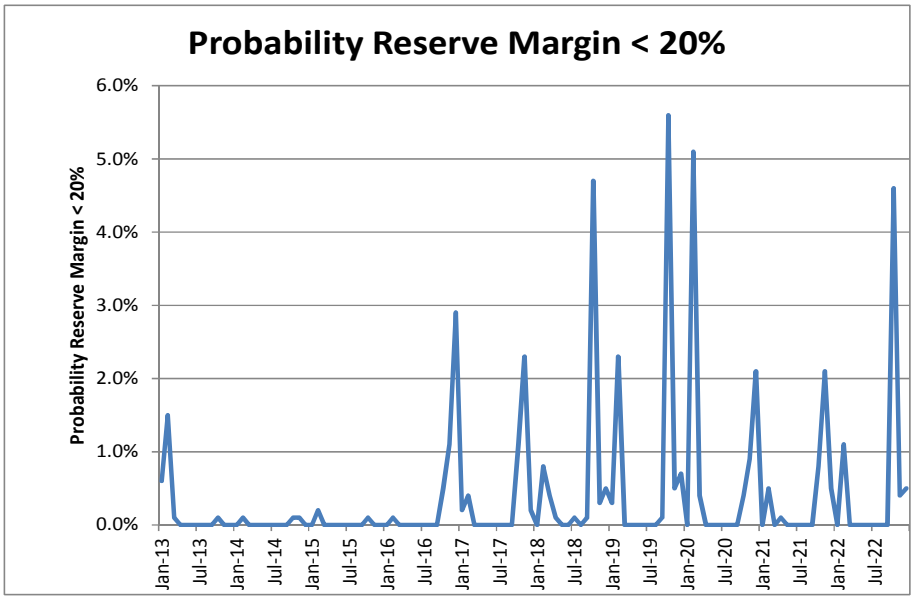
4.63 The Commission does not yet have a view on an appropriate benchmark reserve plant margin for each Territory power system. Evans & Peck advised that a starting point benchmark for a small power system is upwards of 20 per cent, subject to factors including the size of individual units relative to total system load. Also, industry benchmarks assume that industry standard performance is achieved across the power system. Where that is not achieved, for example generation availability being less than industry standard, increased reserve plant margins are required to achieve reliability targets. This leads to increased capital expenditure and higher tariffs. The alternative is a reliance on load shedding to maintain system stability.

4.64 The Darwin-Katherine system (accounting for planned outages) has an estimated average reserve plant margin of 37 per cent for the period of this Review. While the probabilistic model predicts the reserve plant margin reaches a minimum of 18 per cent in late 2019, it is above 30 per cent until October 2017. The low levels of reserve plant

margin are far enough in the future not to be of concern at this time, but this will be closely monitored in future Reviews.

4.65 Chart 4.9 presents the estimated probability of the Darwin-Katherine reserve plant margin falling below 20 per cent in the period 2011-12 to 2020-21. This demonstrates a low likelihood of the reserve margin falling below 20 per cent for the Review Period, and especially so prior to the summer of 2016-17.

Chart 4.9: Probability of a Darwin-Katherine system reserve plant margin of below 20 per cent 2012-13 to 2021-22

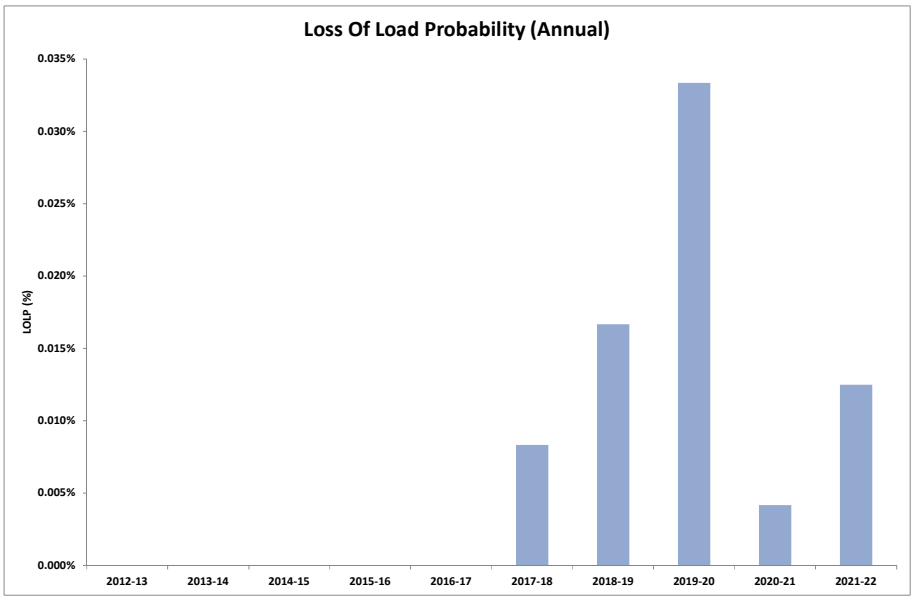


Source: Evans & Peck.

4.66 To supplement the N-X analysis of adequacy in the Darwin-Katherine system, the Commission has assessed the LOLP, using an LOLP of a one day loss in ten years (or 0.027 per cent) as the benchmark of a reliable system. An LOLP greater than 0.027 per cent is indicative of an unreliable system. The Commission intends to review the appropriateness of the LOLP of one day loss in 10 years benchmark to the Territory systems for the 2012-13 Review.

4.67 Chart 4.10 shows that the LOLP for the Darwin-Katherine system for the period 2012-13 to 2021-22 is generally at an acceptable level, with an average LOLP over the Review period of 0.008 per cent.

Chart 4.10: Darwin-Katherine system loss of load probability (LOLP) 2012-13 to 2021-22



Source: Evans & Peck.

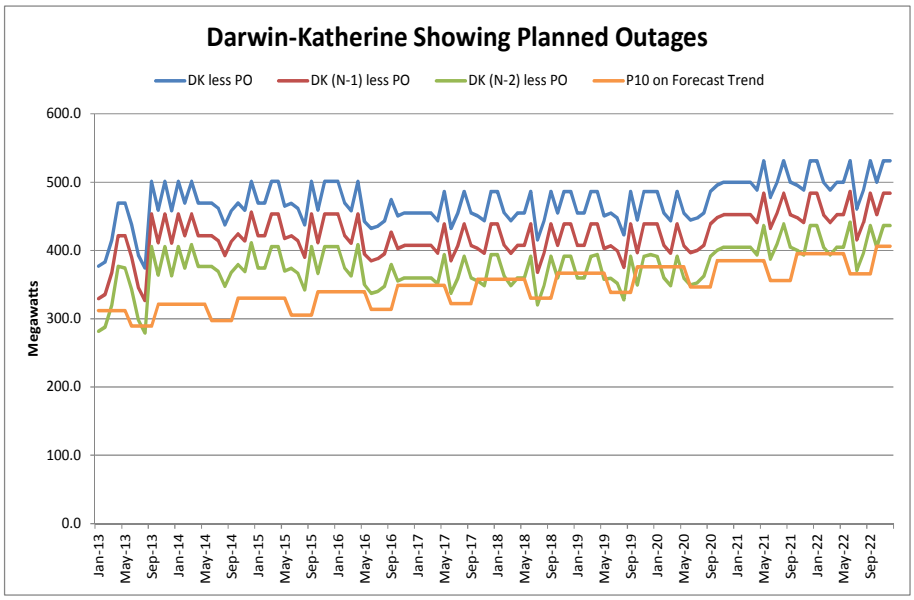
4.68 The annual average LOLPs start to rise in 2017-18, but remain below the benchmark of 0.027 per cent until 2019-20 which reaches 0.033 per cent. Charts 4.9 and 4.10 highlight that the most critical period for potential poor generation reliability in the Darwin-Katherine system is the summer of 2019-20. However this is far enough in the future not to require any action at this time, apart from continued monitoring in future Reviews.

Implications of generation plant condition and the maintenance program – Darwin-Katherine system

4.69 Planned and unplanned outages could have a significant influence on the incidence of generation constraints. The model has been set up to account for planned outages and a forced outage rate of two per cent as advised by PWC. Evans & Peck advises that a four per cent planned outage rate would be more appropriate for planning purposes, particularly as PWC has a spare engine for the LM6000 units and access to lease engines for the Trent generating sets.

4.70 Chart 4.11 presents the generation supply-demand balance for the Darwin-Katherine system, with capacity adjusted to exclude generation plant not available due to scheduled maintenance. This chart shows that even considering planned outages (which are normally considered as part of the N-X analysis) the system meets N-2 until 2020, confirming that system has a comfortable level of generation capacity in the medium term.

Chart 4.11: Darwin-Katherine supply-demand balance for 2012-13 to 2021-22 (with planned maintenance)

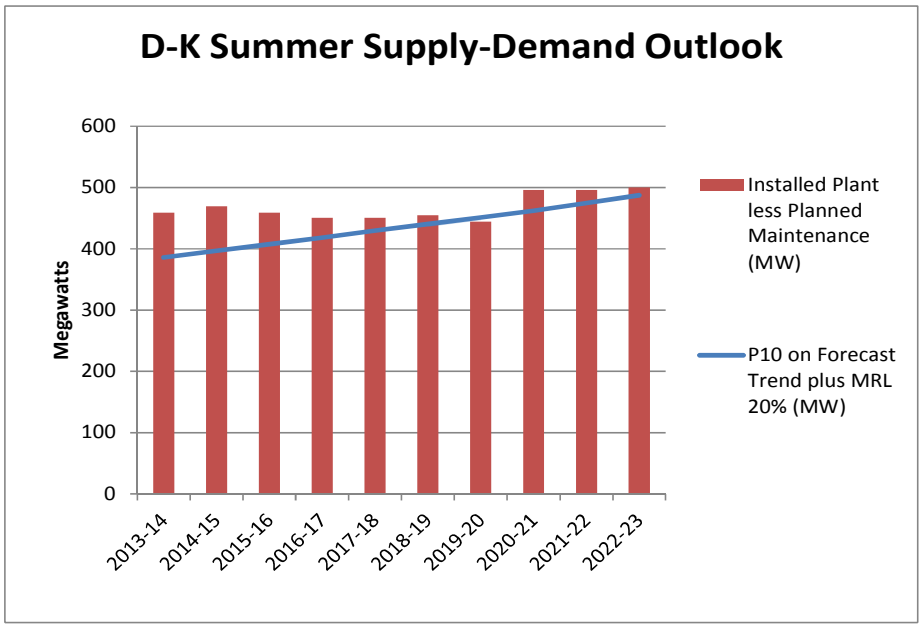


Source: Evans & Peck and Utilities Commission.

4.71 The maintenance schedule used by Evans & Peck to determine available capacity in each month was provided by PWC Generation as part of the data request. The Commission cannot comment on the detail of the maintenance program, but notes that variation to the timing and duration of planned maintenance could have implications for generation constraints and reliability performance.

4.72 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 Minimum Reserve Level (MRL) of 20 per cent has been added to the load forecast. This presentation demonstrates that a 20 per cent Minimum Reserve Level is exceeded in every year considered except for 2019-20, where the MRL is only just not achieved.

Chart 4.12: Darwin-Katherine Summer Supply-Demand Outlook



Source: Evans & Peck.

Concluding comments – Darwin-Katherine system adequacy

4.73 The Commission notes that a large proportion of the required refurbishment of the older units at Channel Island has been completed. As such the current maintenance program supplied by PWC no longer contains significant overlap of major outages, with all major outages on these units completed during 2014. With the better reliability performance that can be expected from these units, and from the new capacity that is in the process of being added to the system, the Commission expects the benefits of better reliability of generation plant to become evident on the Darwin-Katherine system through 2012-13. While the benefits of reduced outages due to generation trips have started to appear, with generation events at the average level for the last five years, and better than 2010-11, these have been delayed because of the late commissioning of Channel Island Units 8 and 9, and Weddell Unit 3. The Commission will continue to monitor the performance of the Darwin-Katherine system in future Reviews.

Generation supply demand balance – Alice Springs system

4.74 The Alice Springs system is expected to have sufficient generation capacity in the medium and long term to meet forecast peak demand under any reasonable demand growth scenario with the planned capacity additions.

4.75 It was noted in the 2010-11 Review that there was a credible risk of generation capacity constraints and poor generation reliability during 2011. The key risk identified was that the new Owen Springs units may experience teething problems. Although the generating units have been able to operate, their ability to do so has been affected by network constraints, resulting in very low operating hours being logged up to 30 June 2012 (Unit 1 - 1007 hours; Unit 2 - 444 hours; Unit 3 - 656 hours), even though these units were commissioned in October- November 2011. The results are also shown in the deteriorating reliability in the Alice Springs system in 2011-12. The Commission expects to see full utilisation of this plant going forward and a resultant significant increase in generating plant reliability at Alice Springs in the near future.

4.76 For the period 2012-13 to 2021-22 there appears to be sufficient generation capacity available given the planned retirements and additions of plant, providing an estimated average reserve plant margin of 53 per cent, with a minimum reserve plant margin of 41 per cent in the summer of 2016-17 when forecast peak demand reaches 61 MW against capacity of 86.3 MW (representing reserve capacity of 25.3 MW). This exceeds the N-2 criterion of 22.4 MW.

4.77 The timing of new plant in the Alice Springs system is influenced far more by the timing of decommissioning of capacity at Ron Goodin Power Station than by load growth. The timing of the installation of new plant and the decommissioning of plant at Ron Goodin Power Station should be kept under review to optimise the amount of new plant that is installed on the system.

4.78 An N-X analysis of the supply-demand balance for the Alice Springs system is presented in Chart 4.13. The analysis assumes that peak demand increases according to the P10 on Forecast Trend and that all capacity is available (ie without accounting for planned maintenance).

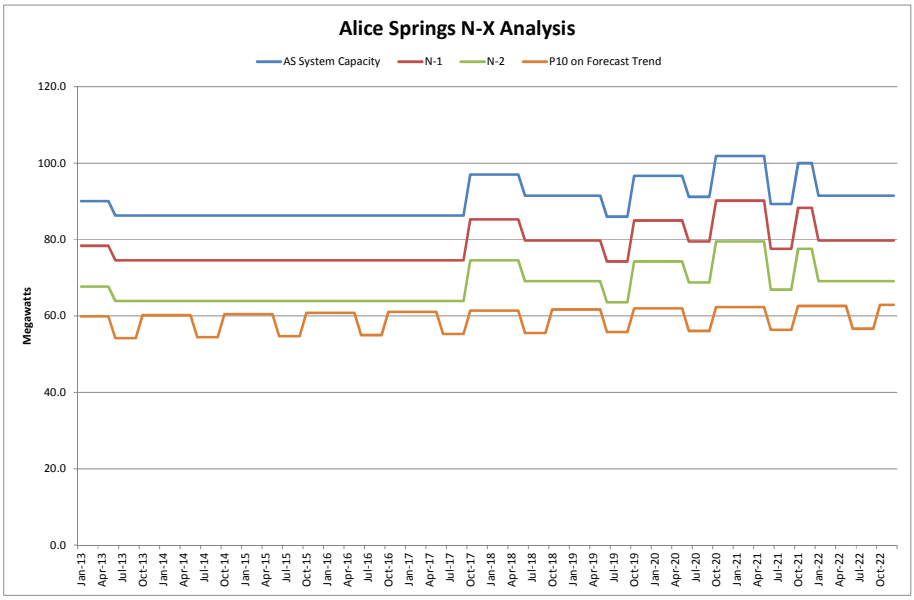
4.79 In the Alice Springs system:

- N-1 is a capacity reduction of 11.7 MW, which represents the loss of Unit 9 at Ron Goodin Power Station; and
- N-2 is a capacity reduction of 22.4 MW, which represents the loss of Unit 9 at Ron Goodin Power Station and one of Units 1, 2 or 3 (10.7 MW) at Owen Springs Power Station.

4.80 The key points from the analysis are:

- there is sufficient capacity to meet an N-2 event throughout the review period; and
- there is an opportunity to defer the installation of Units 4, 5 and 6 at Owen Springs Power Station from their currently planned commissioning dates should it be possible to defer the decommissioning of plant at Ron Goodin Power Station.

Chart 4.13: Alice Springs system supply-demand balance for 2012-13 to 2021-22



Source: Evans & Peck and Utilities Commission.

Concluding comments – Alice Springs system adequacy

4.81 There is significant potential for improvement in generation reliability throughout the Review period if the new plant at Owen Springs is able to be fully utilised. The Commission will be monitoring this aspect in future Reviews

4.82 The supply-demand balance for the period 2012-13 to 2021-22 is subject to the scheduled commissioning/decommissioning program for plant at Owen Springs and Ron Goodin, and the generation plant maintenance program. The Commission has identified that there is an opportunity to defer the installation of new units at Owen Springs should it be possible to defer the retirement of the units at Ron Goodin.

Generation supply demand balance – Tennant Creek

4.83 The generation supply-demand balance in the Tennant Creek system is adequate for the period to 2021-22.

4.84 An N-X analysis of the supply-demand balance for the Tennant Creek system is presented in Chart 4.14. The analysis assumes that peak demand increases according to the P10 on Forecast Trend and that all capacity is available (ie without accounting for planned maintenance).

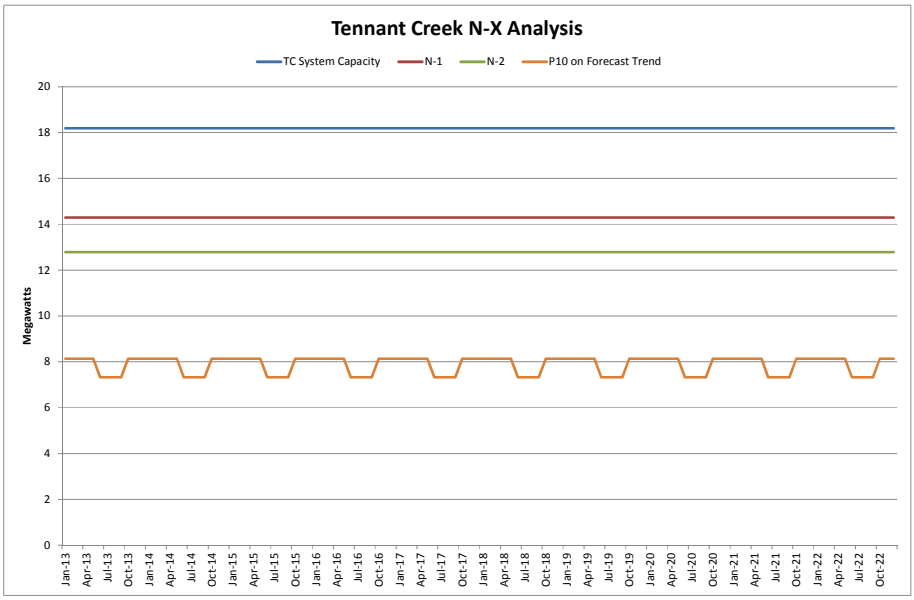
4.85 In the Tennant Creek system:

- N-1 is a capacity reduction of 3.9 MW, which represents the loss of Unit 15 at Tennant Creek Power Station; and
- N-2 is a capacity reduction of 5.4 MW, which represents the loss of Unit 15 and Unit 16 (1.5 MW) at Tennant Creek Power Station.

4.86 The key points are:

- the newest unit at Tennant Creek, Unit 17, commissioned in December 2010 is out of service, after running a total of 157 hours. The Commission understands that this is due to an unreliable switchboard;
- there is sufficient capacity to meet an N-2 situation for the period 2011-12 to 2021-22
- PWC advises that the retirement of the old sets will change the supply balance; and
- PWC advises that it plans to install a new switchboard in line with a Tennant Creek augmentation project.

Chart 4.14: Tennant Creek system supply-demand balance for 2012-13 to 2021-22



Source: Evans & Peck and Utilities Commission.

4.87 The estimated average reserve plant margin for the period January 2013 to December 2022 is 142 per cent, with a minimum of 119 per cent in late 2021.

Concluding comments – Tennant Creek system adequacy

4.88 Subject to industry standard operation and maintenance practices being followed, generation capacity is sufficient to meet forecast demand, with a significant reserve margin for the Review period.

4.89 The reliability delivered by the Tennant Creek system at present does not meet industry standards. The Commission considers that this system would benefit from an independent review similar to that carried out by SKM for the System Controller at Alice Springs. It is likely that many of the same issues exist at Tennant Creek as have now been documented at Alice Springs, such as the level of spinning reserves, machine settings, network parameters and the need to identify the root causes of feeder trips. PWC has advised that is plans to achieve system reliability and efficiency improvements through an augmentation project for Tennant Creek. The Commission will monitor this project in future reviews.

4.90 The Commission considers that further analysis is required to assess actual system availability (ie actual availability of generation sets) for all systems to assess the security and reliability (dynamic performance) of the system, with particular focus on forced outage rates and spinning reserves. The Commission notes that PWC (through System Control) has commenced a review of the spinning reserve requirement for all regulated systems. The Commission intends to place greater focus on actual system availability for the 2012-13 Review.

Chapter 5

Electricity networks

5.1 This chapter examines the capacity and adequacy of the Darwin-Katherine, Alice Springs and Tennant Creek transmission and distribution networks using the following data:

- network capacity (firm delivery capacity and demand) at 30 June 2012;
- network demand forecasts for 2012-13 to 2016-17, and forecast capacity and firm delivery capacity at the sub-transmission and zone substation level;
- supply-demand balance and supply-demand outlook at the sub-transmission and zone substation level to 2016-17, and actual and potential constraints related to sub-transmission assets and zone substations; and
- feeders that have exceeded their normal operating conditions in 2011-12, or are expected to exceed in 2012-13. The Commission notes that PWC has been able to provide data in this regard for the first time.

5.2 The PWC Networks business unit operates the Darwin-Katherine, Alice Springs and Tennant Creek transmission and distribution networks, which comprise the poles, wires, substations, transformers, switching, monitoring and signalling equipment involved in transporting electricity from the generator to the customer.

5.3 The transmission and distribution network control function is undertaken by the System Controller, and the PWC System Control business unit. The System Controller has statutory responsibilities for monitoring and controlling the operation of the system and network to ensure a reliable, safe and secure electricity supply.[21]

5.4 Table 5.1 provides some key details of the Territory's transmission and distribution network infrastructure, and operating characteristics.

Table 5.1: Transmission and distribution network characteristics

Parameter (as at 30 June 2012)	Darwin-Katherine	Tennant Creek	Alice Springs
Energy Delivered 2011-12	1 512 GWh	31 GWh	226 GWh
Peak Demand 2011-12	282 MW	7 MW	53 MW
Customers	63 012	1 527	11 724
Major Substations	25		
Distribution Transformers	4 369		
Power Poles	41 715		

[21] Electricity Reform Act, s38. The functions and duties of the System Controller are detailed in the System Control Technical Code and Network Connection Technical Code.

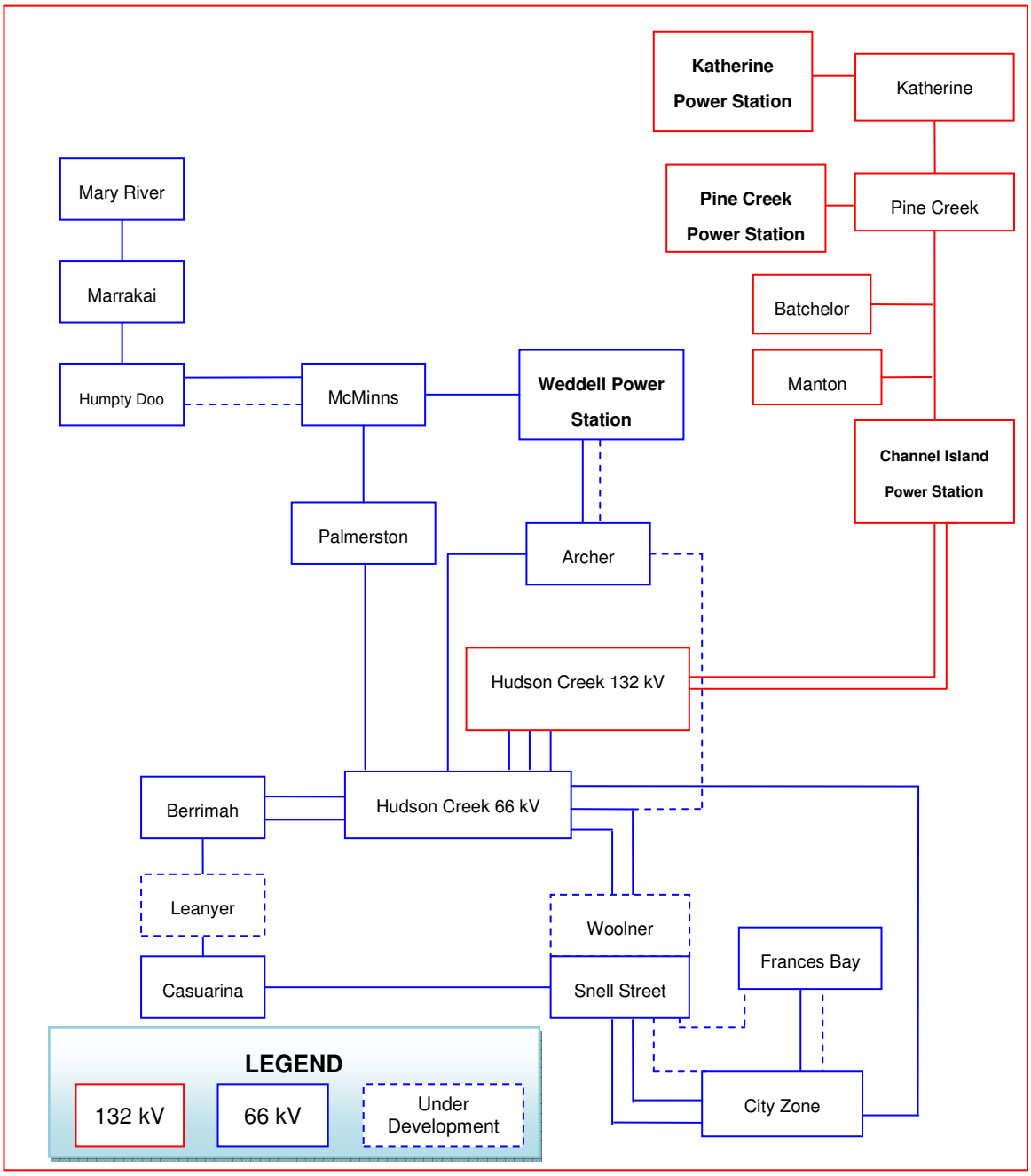
Parameter (as at 30 June 2012)	Darwin-Katherine	Tennant Creek	Alice Springs
Transmission Overhead (132 & 66 kV)	731 km		
Transmission Underground (66 kV)	35 km		
Distribution Overhead	4 939 km		
Distribution Underground	2 791 km		

Source: Power and Water Corporation

5.5 A transmission/sub-transmission network overlay exists in the Darwin region to transport electricity produced at Channel Island and Weddell power stations to primary load centres via two 132 kV transmission lines and a number of 66 kV lines. This transmission network is also connected with power stations and loads at Pine Creek and Katherine via a 132 kV line from the Channel Island Power Station.

5.6 A schematic of the Darwin-Katherine transmission and distribution network is presented in Chart 5.1.

Chart 5.1: Darwin-Katherine transmission and distribution network (major components)

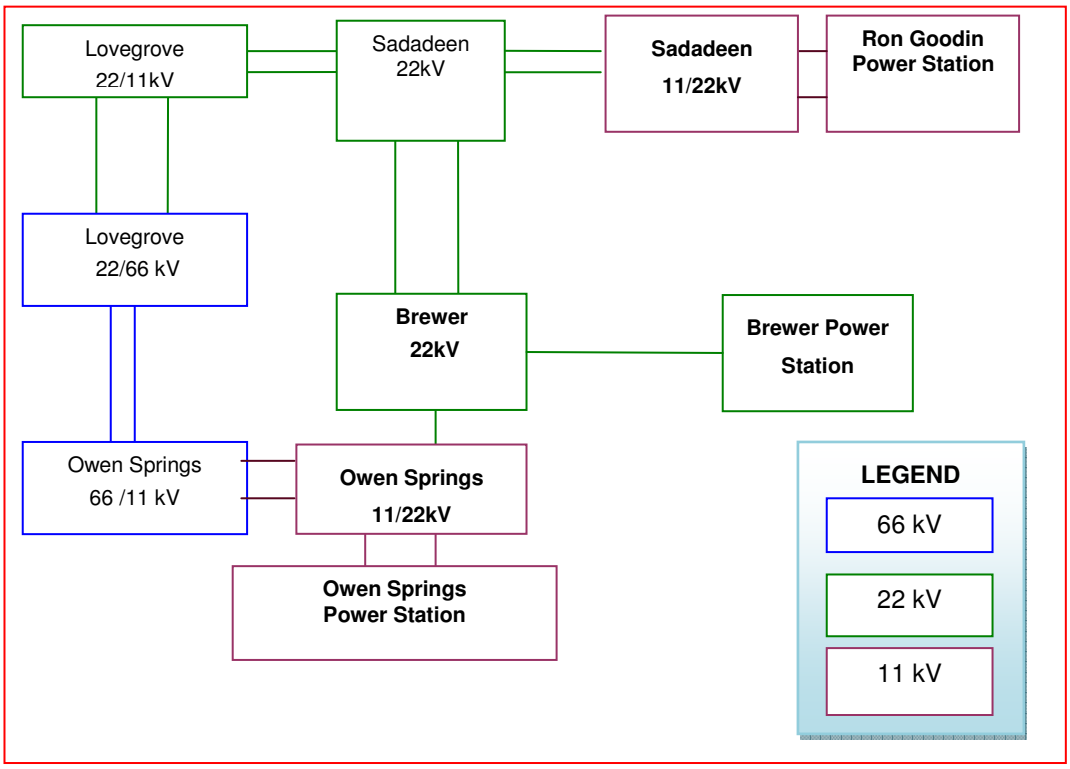


Source: Utilities Commission and Power and Water Corporation.[22]

5.7 Following the development of the Owen Springs Power Station, a transmission network has been constructed in Alice Springs, with electricity produced at Owen Springs supplied into the distribution network via a 66 kV transmission line and two 66 kV zone substations (Owen Springs and Lovegrove). Prior to the establishment of Owen Springs, all electricity was transmitted at 11 kV or 22 kV. A schematic of the Alice Springs transmission and distribution network is presented in Chart 5.2.

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

Chart 5.2: Alice Springs transmission and distribution network



Source: Utilities Commission and Power and Water Corporation.

Network peak demand forecasts

5.8 As outlined in Section 4.3, PWC Networks has implemented a "bottom up" – "top down" forecasting methodology. Asset specific forecasts are produced for:

- high voltage feeders;
- zone substations; and
- transmission substations.

5.9 Whilst regional demand forecasts should be consistent with the aggregate spatial forecasts of maximum demand on individual substations and feeders, some differences are to be expected due to the following reasons:

- the maximum load on individual assets may not occur at the same time of day or year. As a result, the regional load will generally be less than the sum of the individual demands to the extent that the loads diversify. This diversification factor can change from year to year as a result of changes in load shape;
- network demand is forecast in MVA, whereas regional demand is quoted in MW. Changes in power factor can alter the relationship between these two units; and
- as a result of load transfers from one asset to another, the load can appear on one asset for part of the year, and another asset for the other part of the year.

5.10 A comparison between PWC Networks' regional demand forecast and the aggregate of zone substation forecasts over the period 2012-13 to 2016-17 is presented in Table 5.2.

Table 5.2: Annual network peak demand for the Darwin-Katherine system

Region	Regional MW load growth 2012-13 to 2016-17 % per annum (average)	Undiversified zone substation MVA load growth 2012-13 to 2016-17 % per annum (average)
Darwin-Katherine	2.7	3.7
Alice Springs	0.5	1.2
Tennant Creek	0	0

Source: Power and Water Corporation

5.11 In both the Darwin-Katherine and Alice Springs systems, the "top down" reconciliation process has resulted in a downward adjustment of the aggregate spatial forecasts developed using a "bottom up" approach to derive the regional forecasts. As outlined above, there are valid reasons why such differences do occur between diversified regional MW demand, and undiversified substation/feeder maximum MVA load. Notwithstanding these differences, the Commission has adopted PWC's spatial forecasts for the purpose of considering forecast loading on major feeders and substations. Appendix C presents information from PWC Networks on actual and forecast zone substation demand and capacity for 2008-09 to 2016-17.

Network capacity and constraints

5.12 The Commission considers that the transmission/sub-transmission network comprises:

- all feeders rated at 66 kV and above;
- bulk and zone substations with a voltage of 66 kV or above; and
- some distribution substations (eg with a voltage of 11/22 kV) that perform a sub-transmission role.

5.13 The Commission considers that these assets play a critical role in network reliability and security due to the design of the network and limited number of alternative flow paths. Consistent with the approach taken in previous Reviews, the Commission sought advice from PWC Networks on forecast network peak demand and the capacity of transmission/sub-transmission feeders, zone substations and high voltage distribution feeders. The Commission's intent is to identify potential network capacity constraints in the period 2012-13 to 2016-17.

Transmission/sub-transmission feeder constraints

5.14 In its previous two Reviews, the Commission identified shortcomings in PWC's planning systems relating to the identification of potential transmission/sub-transmission feeder constraints. Evans & Peck performed a simplified analysis to identify potential issues. The Commission is pleased to observe that PWC Networks has developed a model that enables this analysis for the Darwin-Katherine system, and has provided the data for the 2011-12 Review.

5.15 Transmission/sub-transmission feeder utilisation is considered from two perspectives:

- firstly, the utilisation is determined at time of peak loading with all lines in service – the so called "N" utilisation. This can be measured directly by comparing the peak load on a feeder with its rating.
- secondly, the utilisation is modelled at time of peak loading to simulate the situation if another line is out of service (where multiple lines serve the same load) – "N-1" utilisation.[23]

5.16 The forecast utilisation of the 132 kV and 66 kV lines in the Darwin–Katherine system at time of maximum demand with all lines in service (N loading) has been analysed for 2012-13 and 2016-17. The highest utilisation forecast is 72 per cent in 2012-13 and 79 per cent in 2016-17.

5.17 A more stringent test of the capability of the transmission/sub-transmission system looks at the utilisation of lines when another line is out of service. PWC assigns two ratings to each line. The "normal" rating applies most of the time and is used when scheduling planned outages. Should planning show that the normal rating will be exceeded during planned works, work may have to be changed to periods when loads are lighter. A higher "emergency" rating is also calculated. This rating is generally only used during contingency conditions. It normally only applies for short periods until repairs can be completed, or switching completed to transfer load to other parts of the system. Based on forecast loading for the period 2012-13 to 2016-17, PWC Networks' modelling of the Darwin-Katherine system has identified eight situations where either the normal or emergency rating may be exceeded following an outage of a related line. These situations are shown in Table 5.3. The most critical issues relate to lines involving Weddell Power Station when the station is operating at high output[24]. This can be managed by reducing output from Weddell, but will be largely alleviated by the construction of a second 66 kV Weddell to Archer line due for completion in May 2013, and the continuation of this line from Archer to Woolner for completion in September 2013. Notwithstanding, an outage on the Weddell to McMinns 66 kV line can still result in a small (two per cent) potential overloading of the Hudson Creek to Palmerston 66 kV line in 2016-17.

Table 5.3: Projected transmission line constraints in 2012-13 and 2016-17 (N-1 conditions)

Line impacted	Line outage	2012-13 impact	2016-17 impact
Hudson Ck to Berrimah 66 kV Line 1	Hudson Ck to Berrimah 66 kV Line 2	Exceeds normal rating but within emergency rating[25]	
Hudson Ck to Berrimah 66 kV Line 2	Hudson Ck to Berrimah 66 kV Line 1	Exceeds normal rating but within emergency rating	

[23] This has to be modelled because it is unlikely that lines will in fact be out of service at time of peak loading.

[24] At present, System Control generally reduces the output of Weddell Power Station to 0 MW if any of the lines in the Weddell – Palmerston – Hudson Creek – Archer – Weddell loop are out of service to prevent island operation in the event of a second line outage. This is because of limitations on Weddell Power Station's ability to control voltage and frequency in an islanded mode. This will be resolved with completion of the second Weddell – Archer – Woolner line and potentially control improvements at Weddell Power Station.

[25] The emergency rating is a short term rating that allows slightly greater line sag for short periods that are considered to represent an acceptable level of risk which would not be acceptable for long periods of operation.

Line impacted	Line outage	2012-13 impact	2016-17 impact
Hudson Ck to Palmerston 66 kV	Weddell to McMinns 66 kV	Exceeds normal rating but within emergency rating	
Casuarina to Snell Street 66 kV	Leanyer to Berrimah 66 kV	Within normal rating	Exceeds normal rating but within emergency rating
Weddell to McMinns 66 kV	Hudson Ck to Palmerston 66 kV	Exceeds normal rating but within emergency rating	Exceeds both normal rating and emergency rating.
McMinns to Palmerston 66 kV	Weddell to Archer 66 kV	May exceeds normal and emergency ratings if output of Weddell Power Station > approx. 70 MVA.	Within normal rating. Resolved in 2013 through construction of second Weddell – Archer-Woolner 66 kV line
Leanyer to Berrimah 66 kV	Casuarina to Snell Street 66 kV	Exceeds normal rating but within emergency rating	
Leanyer to Casuarina 66 kV	Casuarina to Snell Street 66 kV	Exceeds normal rating in 2013-14 and 2014-15 but within emergency rating	
Other Lines		Within normal rating	

Source: Power and Water Corporation

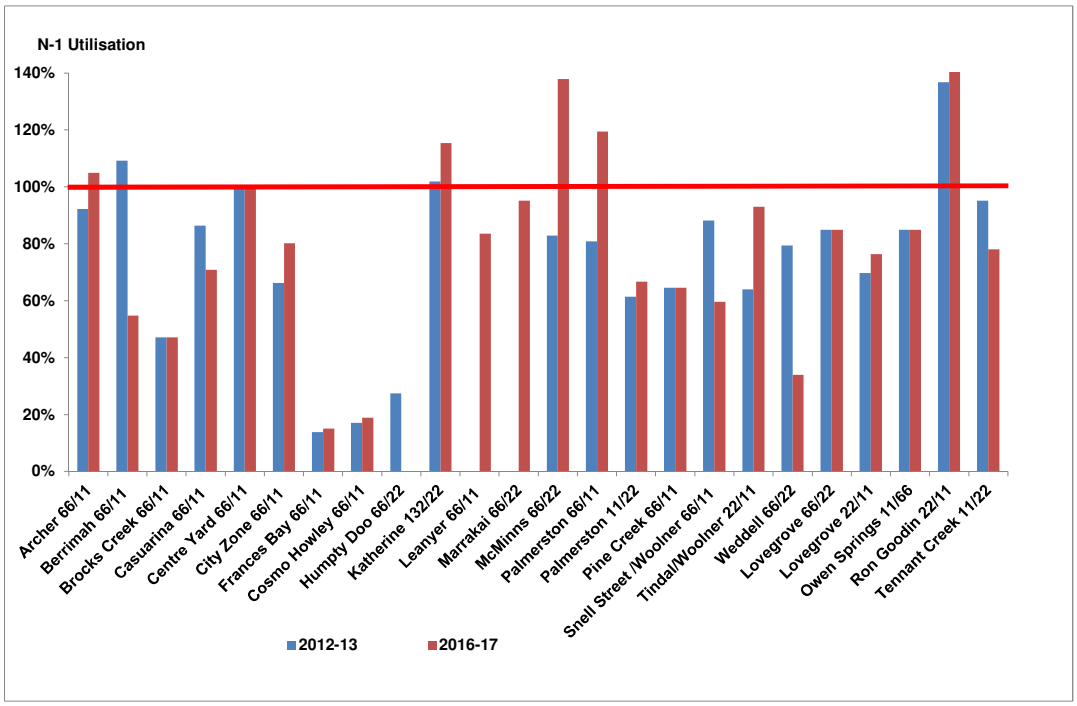
Transmission/sub-transmission substation constraints

5.18 There are 30 actual and planned transmission/sub-transmission substations across the Darwin-Katherine, Alice Springs and Tennant Creek systems. An assessment of substation utilisation has been completed for these. Substation capacity and potential constraints have been measured by examining the substation utilisation with:

- all network elements (ie transformers) in service (an N rating); and
- one network element out of service (an N-1 rating).

5.19 With all transformers in service, these substations should have sufficient capacity to meet forecast load for 2012-13 and 2016-17, subject to completion of planned upgrades. Chart 5.3 presents utilisation on 23 substations under N-1 conditions (one transformer out of service) in 2012-13 and 2016-17, based on forecast loads and system configuration in 2012-13 and 2016-17. For the purposes of this analysis, five substations with only one transformer have been excluded, and Snell Street/Woolner have been combined.

Chart 5.3: Projected substation utilisation in 2011-12 and 2014-15 (N-1 conditions)



Source: Evans & Peck

5.20 For the purposes of this graph, Snell Street and Woolner have been combined. Woolner replaces Snell Street during 2012-13. Humpty Doo substation, which has a load of 2.3 MVA, currently has three 2.5 MVA transformers that will be replaced by one 10 MVA transformer. While it will lose N-1 status in its own right with only one transformer, the load can be transferred to McMinns in an emergency situation. Under N-1 conditions, six substations face capacity constraints:

- Archer 66/11 kV – by 2016-17, N-1 utilisation is forecast to reach 105 per cent. Up to 10 MVA of load can be transferred to Palmerston on a temporary basis to relieve this situation;
- Berrimah 66/11 kV – N-1 utilisation in 2012-13 is forecast to reach 109 per cent. An emergency transfer of 7 MVA to Casuarina is available to relieve this situation. Berrimah generators are no longer available;
- Katherine 132/22 kV – forecast N-1 utilisation in 2012-13 is 102 per cent, rising to 115 per cent by 2016-17. During N-1 conditions, loading can be managed by changing the level of generation at Katherine Power Station;
- McMinns 66/22 kV – forecast N-1 utilisation in 2016-17 is 138 per cent with one transformer out of service. This arises as a result of the connection of a relatively large non-permanent load (the construction load for the Inpex project). A 10 MVA mobile substation has been placed on site and will be used to supply load in emergency conditions;
- Palmerston 66/11 kV – by 2016-17 forecast N-1 utilisation will reach 119 per cent. 6 MVA of temporary load transfers to Berrimah substation are available to relieve this situation; and

- Ron Goodin 22/11 kV – N-1 utilisation exceeds 100 per cent if all load connected at Ron Goodin is back fed through the 22 kV network. Normally, most of the connected load is fed directly from the operating power station. This potential constraint is managed with generation, but will become an increasing issue with the planned phase out of Ron Goodin Power Station.

5.21 The results in Chart 5.3 assume the following work is completed:

- additional 38 MVA transformer is installed at Berrimah in 2015-16;
- City Zone substation will be rebuilt in 2013-14;
- 10 MVA transformer is installed at East Arm in 2013-14;
- second 38 MVA transformer is installed at Frances Bay by 2012-13;
- Leanyer is completed by 2013-14;
- Mary River is decommissioned in 2012-13 and the load transferred to Marrakai;
- McMinns is rebuilt by 2015-16 with 2 x 27 MVA transformers;
- additional 19 MVA transformer is installed at Palmerston in 2012-13;
- additional 15 MVA transformer is installed at Weddell in 2012-13; and
- Woolner Zone substation replaces Snell Street by 2013-14.

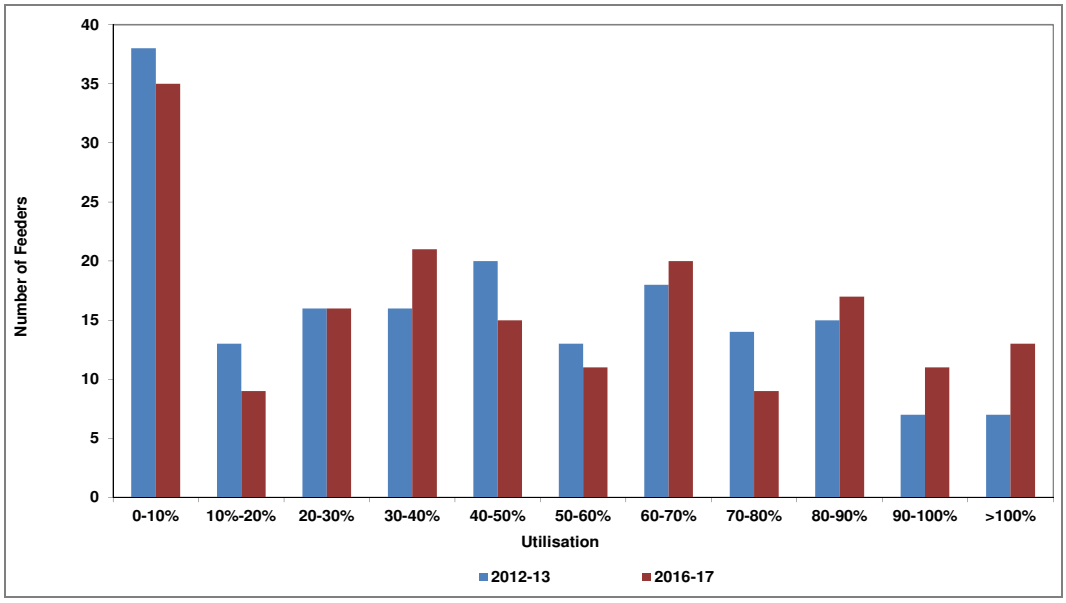
5.22 There has been a notable change in the expected N-1 utilisation of Frances Bay substation between the 2010-11 Review and the current forecast. In the previous Review, N-1 utilisation was projected to be slightly over 80 per cent, but is now projected to be approximately 15 per cent. The security of supply criterion for the Darwin CBD is N-2 (ie supply can be maintained even with two transformer failures). This is achieved by transferring load from Frances Bay to City Zone and vice versa in the event of emergencies. The current plan envisages more of the load being normally connected to the re-built City Zone than envisaged in the previous Review.

5.23 In previous Reviews, the Commission has raised concerns at the poor condition of critical infrastructure such as Snell Street, and City Zone. While still a concern, the Commission notes that Woolner will replace Snell Street in the near future, and works are programmed to rebuild City Zone in 2013-14. Whilst significant risks still exist, these should progressively reduce over the next two years.

Distribution network capacity and constraints

5.24 The Commission is pleased to note that, unlike in previous years, PWC Networks has been able to provide the results of studies on the utilisation of the high voltage (11/22 kV) distribution network. The results are presented in Chart 5.4.

Chart 5.4: Utilisation of high voltage (11/22 kV) feeders 2012-13 and 2016-17



Source: Power and Water Corporation

5.25 As a general principle in interconnected networks, industry practice is to endeavour to limit feeder utilisation to approximately 80 per cent so as to permit some transfer of load between feeders during emergencies. This is not always practical or economic. However, it is not considered acceptable to operate feeders in excess of 100 per cent of their capacity on a sustained basis, though such situations do arise across the industry. PWC has identified seven feeders that are forecast to exceed their rating in 2012-13, rising to 13 in 2016-17. A key objective of the Review process is to ensure that planning processes are in place that identify such circumstances, and to monitor progress in eliminating them. The Commission expects PWC to implement projects that will reduce feeder loading to within normal ratings as a matter of urgency.

5.26 In acknowledging the significant improvements that have occurred in PWC's ability to report on the utilisation of transmission/sub–transmission feeders, zone substations and high voltage feeders, the Commission notes that PWC Networks was not presently able to provide loading or capacity information for distribution substations. Consequently, the Commission is unable to identify if there are any actual or potential constraints in the distribution network.

5.27 Monitoring of distribution substation loading and capacity is currently based on the incidence of voltage complaints or overloads which activate protection schemes. This has been a common approach across the industry, but emerging industry best practice is to integrate:

- information technology into distribution substations to record and report loading, quality of supply, status and fault indication data in real time; and
- geographic information systems with network topology and customer billing information to determine the energy use through individual assets, which can then be combined with standard load profiles to determine substation utilisation.

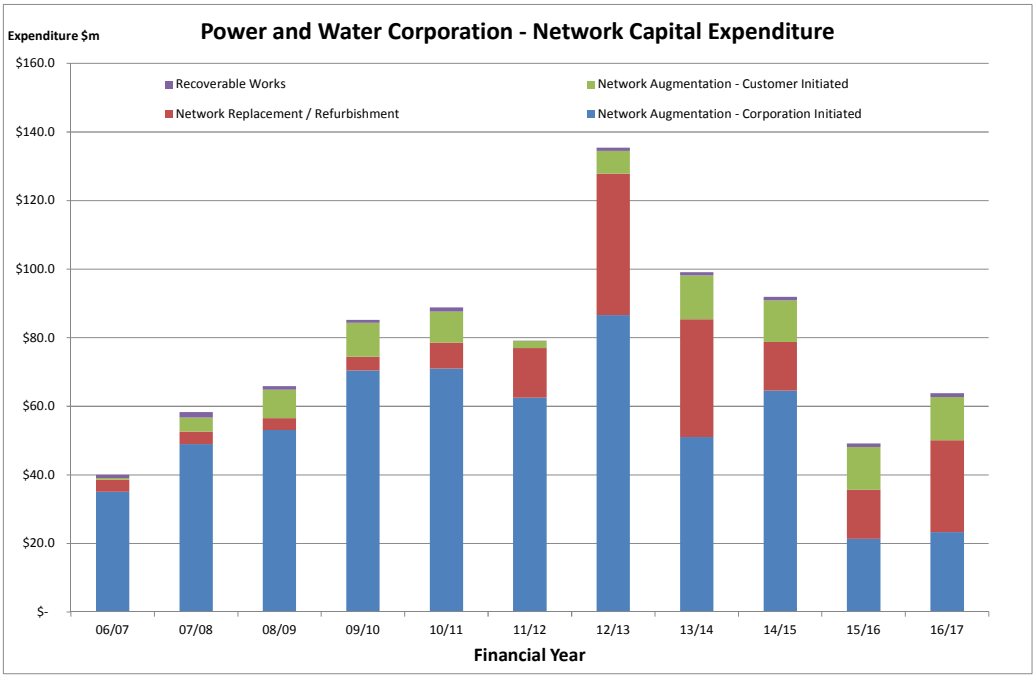
5.28 Consistent with the continuous improvement that has been occurring in reporting over the last the years, the Commission expects PWC Networks to more adequately address these issues in coming reviews.

Network investments

5.29 Chart 5.5 demonstrates PWC's actual network capital expenditure over the past five years, and the current five year projection. Corporation Initiated Augmentation capital is budgeted to peak at $86.6 million in 2012-13 and ramp down to approximately $23.3 million by 2016-17. Major projects include:

- Snell Street replacement (Woolner), expected to be complete by June 2012;
- City Zone substation replacement;
- Leanyer Zone substation (construction commenced);
- Berrimah Zone substation replacement;
- Frances Bay 2nd Transformer;
- replace McMinns Zone substation;
- replace Casuarina Zone substation 66kV switchgear;
- construct Mitchell St switching station;
- 11 kV switchboard replacement at Sadadeen; and
- 132/66 kV Terminal Station and Transmission Lines.

Chart 5.5: Power and Water Corporation – Capital Expenditure – Network

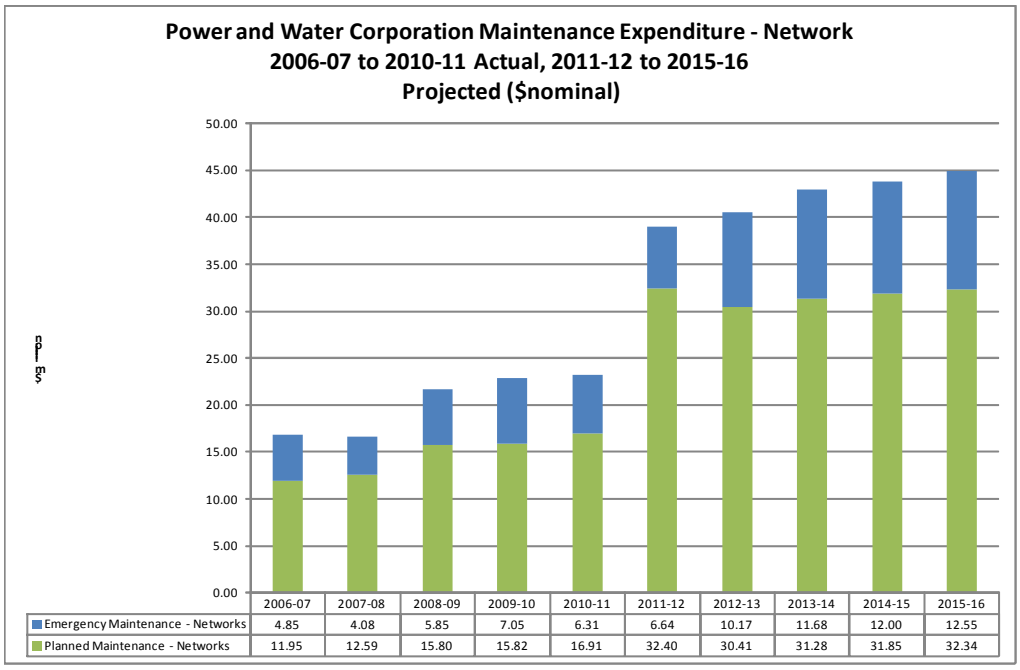


Source: Power and Water Corporation

5.30 In addition to providing additional capacity, expenditure at this level primarily focuses on reducing the risks of major outages due to equipment failure. While there have been a number of reliability related incidents attributable to these assets, major assets such as these should not, if well managed, be the major contributor to poor

reliability. Most reliability issues stem from poor resilience of the high voltage network, either due to poor design (eg overhead networks in areas subject to high wind and tree exposure) or poor maintenance (eg inadequate tree trimming, regular equipment failure). Implicit in Chart 5.5 is a transition from augmentation related expenditure to an increase in Replacement/Refurbishment, which increases from $14.5 million in 2011-12, peaking at $41.2 million in 2012-13. This is coupled with a notional increase in network maintenance, as shown in Chart 5.6 below.

Chart 5.6: Power and Water Corporation – Maintenance Expenditure – Networks



Source: Power and Water Corporation

5.31 In the expectation that at least some of the increase in maintenance expenditure is real, and the increased capital expenditure in Replacement/Refurbishment is appropriately targeted on those parts of the network significantly contributing to SAIDI and SAIFI, progressive improvement in the reliability of the PWC networks is expected. This should build on expected achievements stemming from the generation investment program. The Commission considers that further analysis is required to assess actual system availability (ie actual availability of networks) to assess the security and reliability (dynamic performance) of the system, with particular focus on voltage stability. The Commission intends to place greater focus on actual system availability for the 2012-13 Review.

Chapter 6

Customer service and reliability performance

6.1 Customer service performance and reliability of supply information is reported by PWC Generation, PWC Networks and PWC Retail as a requirement of the 2006 Territory's Electricity Standards of Service Code. The PWC 2011-12 Standards of Service: Key Service Performance Indicators Report covers:

- network and generation reliability performance;
- network feeder performance; and
- customer service performance, such as network reconnections/new connections, the time taken to answer telephone calls, and customer complaints about quality of supply and service (eg billing).

6.2 A new Electricity Standards of Service Code took effect on 1 December 2012, replacing the 2006 Electricity Standards of Service Code.

Overall reliability performance

6.3 Reliability performance is measured by calculating:

- the system average interruption duration index (SAIDI), which indicates the average duration of network and generation related outages experienced by a customer; and
- the system average interruption frequency index (SAIFI), which indicates the average number of network and generation related outages experienced by a customer.

6.4 The Commission has examined reliability performance for:

- generation and network performance in the Darwin region and Katherine region (of the Darwin-Katherine system), Alice Springs and Tennant Creek systems for 2007-08 to 2011-12, using a weighted total average of reliability outcomes for each system; and
- Central Business District (CBD), urban, short rural and long rural feeders for 2011-12 only, using a weighted total average of feeder reliability for each system.

6.5 Major Event Day "exclusions" are events that have been identified using the 2.5 beta method, which is a methodology developed by the Institute of Electrical and Electronic Engineers (IEEE) to statistically identify reliability events that may not represent business as usual and distort the underlying reliability trend.

6.6 Notwithstanding that the terminology used is "exclusions" or excluded events, this does not mean that the cause or consequences of the event should be ignored. Each

excluded event should be the subject of a review so as to provide a detailed understanding of the event.

6.7 Although the 2.5 beta method removes some statistical variability, reliability performance is still probabilistic and influenced by weather, equipment failure, actions by third parties and animals. However, a review of trends gives some insight as to whether reliability performance is stable, improving or deteriorating.

6.8 It can be noted that the new 2012 Electricity Standards of Service Code applies the 2.5 beta method with moderate variations based on local circumstances. It also excludes specific events which are considered to be outside the reasonable control of the network provider (eg load shedding due to generation shortfall, traffic accidents, vandalism, and network interruptions caused by a customer's electrical installation).[26] The Commission will consider aligning the review of PWC Networks' reliability performance and the application of the exclusion approach with the new Electricity Standards of Service Code when developing the 2012-13 Review.

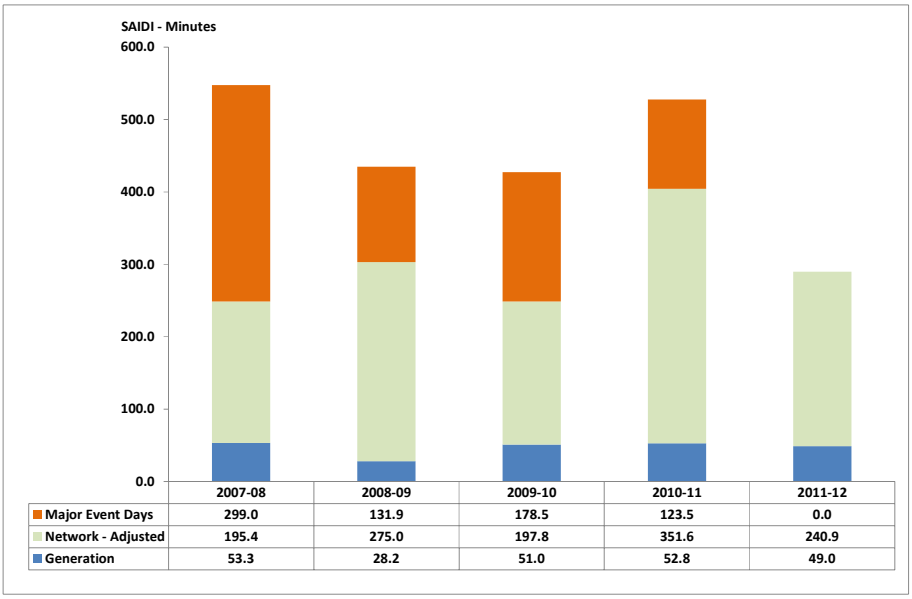
6.9 Chart 6.1 below shows the average total minutes off supply for a customer in the Darwin, Katherine, Alice Springs and Tennant Creek (combined) systems for 2007-08 to 2011-12. The key points highlighted by Chart 6.1 are:

- overall, reliability was significantly better than in the preceding four years;
- there were no Major Event Days (such as cyclones) resulting in exclusions in 2011-12;
- generation related outages, though significantly less than in 2010-11, were consistent with average performance over the five years. Given the significant expenditure on new generation in recent years; and
- network outages were significantly lower than in 2010-11, but again consistent with average performance over the last five years.

6.10 The Commission expects improvement in generation related outages. It is noted that Units 8 and 9 at Channel Island were only available for commercial service from January 2012, much later than planned, so these units have not contributed to improved reliability over the whole of 2011-12.

[26] Further details on the rationale underpinning the exclusion methodology adopted in the 2012 Electricity Standards of Service Code can be found in the Commission's Statement of Reasons released with the Code in November 2012

Chart 6.1: PWC weighted total average minutes off supply (SAIDI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	299.0	131.9	178.5	123.5	0.0
Network - Adjusted	195.4	275.0	197.8	351.6	240.9
Generation	53.3	28.2	51.0	52.8	49.0

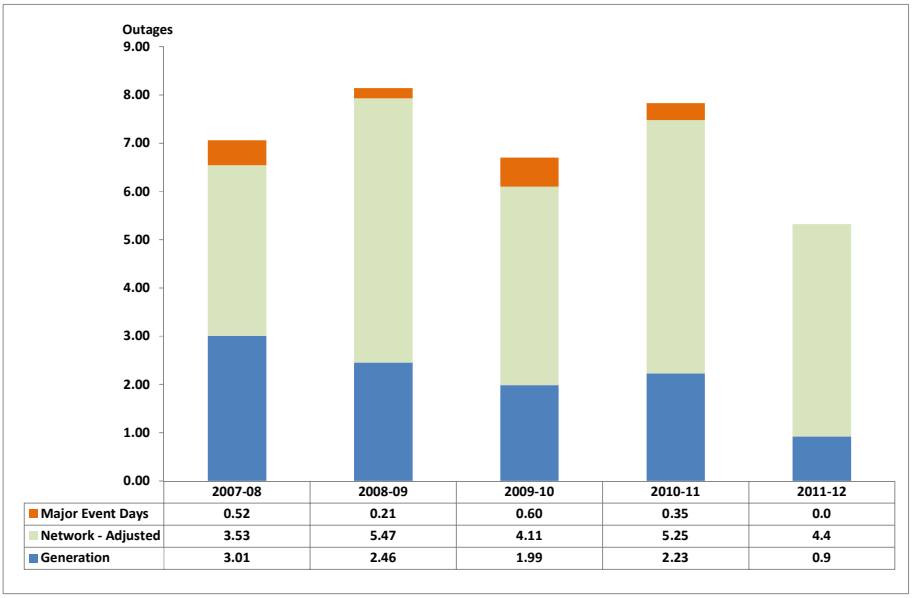
Source: Utilities Commission and Power and Water Corporation.

6.11 Chart 6.2 below shows the average total frequency of outages for a customer (SAIFI) in the Darwin-Katherine, Alice Springs and Tennant Creek (combined) systems for 2007-08 to 2011-12.

6.12 The key points highlighted by Chart 6.2 are:

- consistent with the SAIDI outcome, there were no exclusions in 2011-12;
- the number of outages caused by generation was the lowest in five years; and
- the frequency of network related outages in 2011-12 was lower than 2010-11 but mid-range in terms of the five years performance.

Chart 6.2: PWC weighted total average frequency of outages (SAIFI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	0.52	0.21	0.60	0.35	0.0
Network - Adjusted	3.53	5.47	4.11	5.25	4.4
Generation	3.01	2.46	1.99	2.23	0.9

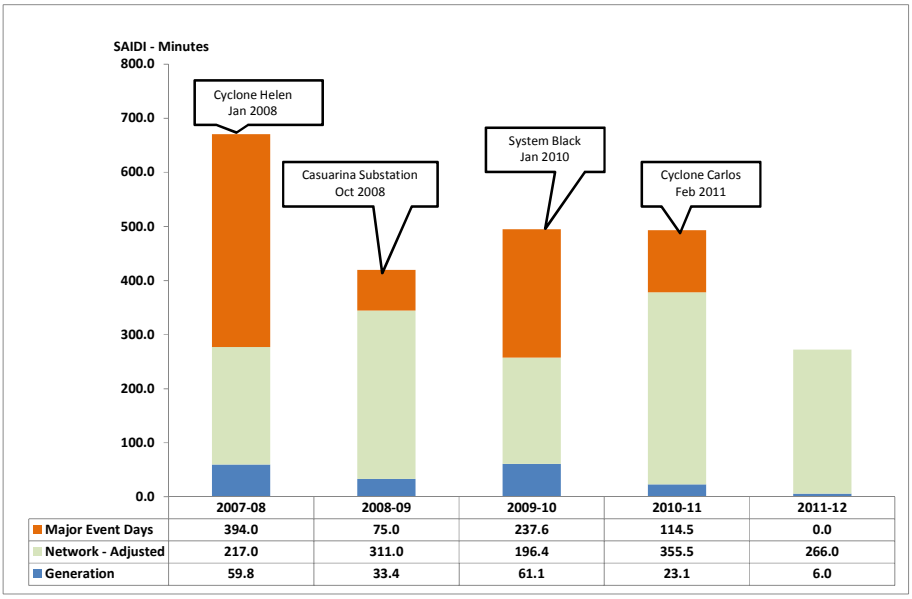
Source: Utilities Commission and Power and Water Corporation.

Darwin reliability performance

6.13 Charts 6.3 and 6.4 present the SAIDI and SAIFI performance for the five year period 2007-08 to 2011-12 for the Darwin sub-system. Chart 6.3 also identifies the events leading to the major event days resulting in exclusions from normal reliability reporting considerations. Notably, in 2011-12:

- overall, both outage time and the number of outages were significantly better than the previous four years;
- there were no Major Event Days resulting in exclusion events;
- generation performance was significantly better than in any of preceding four years;
- network performance was mid-range when compared to the five year performance; and
- as well as the six UFLS events, there were 21 Major Power System Incidents on the Darwin system which led to interruption of customer services (four of which were caused by human error). This highlights the need for ongoing training and skill upgrading in the field staff. Further details are provided at Appendix D.

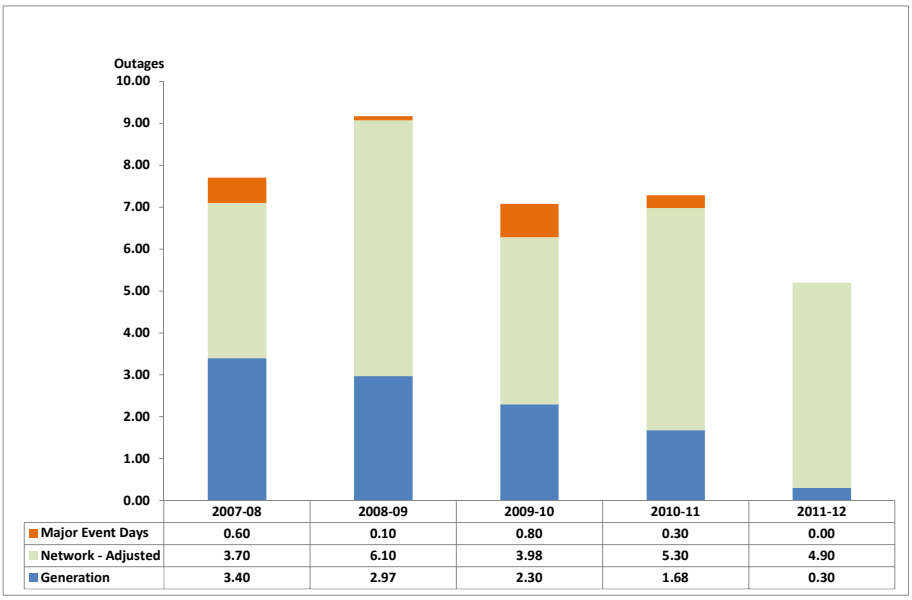
Chart 6.3: Darwin sub-system total minutes off supply (SAIDI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	394.0	75.0	237.6	114.5	0.0
Network - Adjusted	217.0	311.0	196.4	355.5	266.0
Generation	59.8	33.4	61.1	23.1	6.0

Source: Utilities Commission and Power and Water Corporation.

Chart 6.4: Darwin sub-system -frequency of outages (SAIFI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	0.60	0.10	0.80	0.30	0.00
Network - Adjusted	3.70	6.10	3.98	5.30	4.90
Generation	3.40	2.97	2.30	1.68	0.30

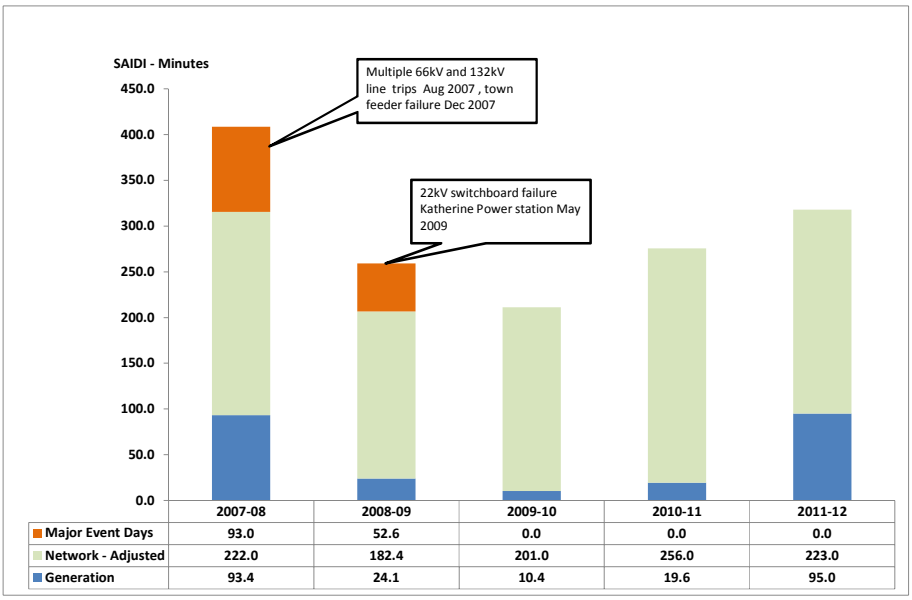
Source: Utilities Commission and Power and Water Corporation.

Katherine reliability performance

6.14 Charts 6.5 and 6.6 present the SAIDI and SAIFI performance for the five year period 2007-08 to 2011-12 for the Katherine sub-system. Chart 6.5 also identifies the events leading to the major event days resulting in exclusions from normal reliability reporting considerations. Notably, in 2011-12:

- overall, SAIDI and SAIFI were the second worst in the five year period;
- there were no Major Event Days resulting in exclusion events;
- generation performance was particularly poor showing a deterioration on the preceding three years; and
- network performance was mid-range when compared to the five year performance. The Katherine sub-system had five Major Power System Incidents that caused interruptions to customer service through the Review Period. Two of these were caused by human error. This highlights the need for ongoing training and skill upgrading in the field staff. Further details are provided at Appendix D.

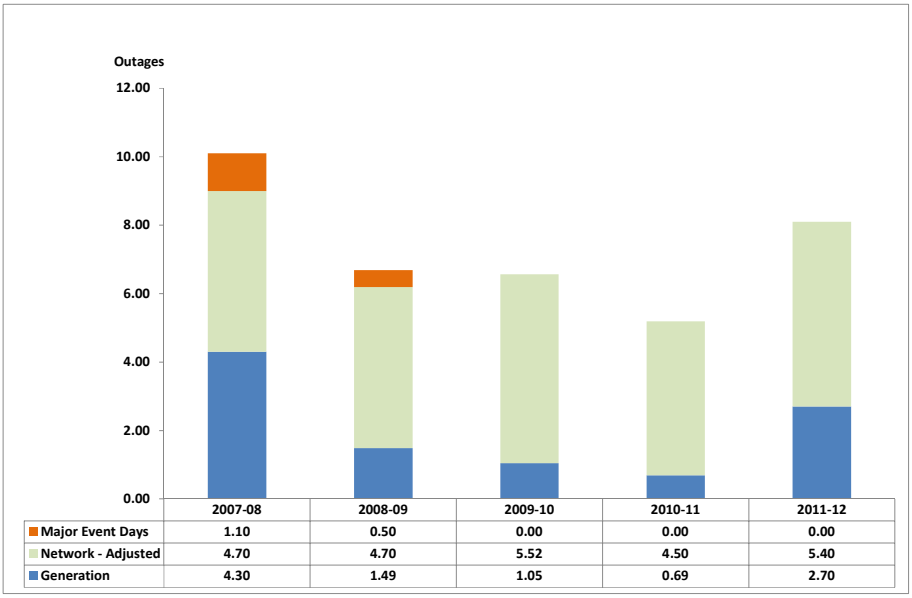
Chart 6.5: Katherine sub-system - total minutes off supply (SAIDI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	93.0	52.6	0.0	0.0	0.0
Network - Adjusted	222.0	182.4	201.0	256.0	223.0
Generation	93.4	24.1	10.4	19.6	95.0

Source: Utilities Commission and Power and Water Corporation.

Chart 6.6: Katherine sub-system - frequency of outages (SAIFI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	1.10	0.50	0.00	0.00	0.00
Network - Adjusted	4.70	4.70	5.52	4.50	5.40
Generation	4.30	1.49	1.05	0.69	2.70

Source: Utilities Commission and Power and Water Corporation.

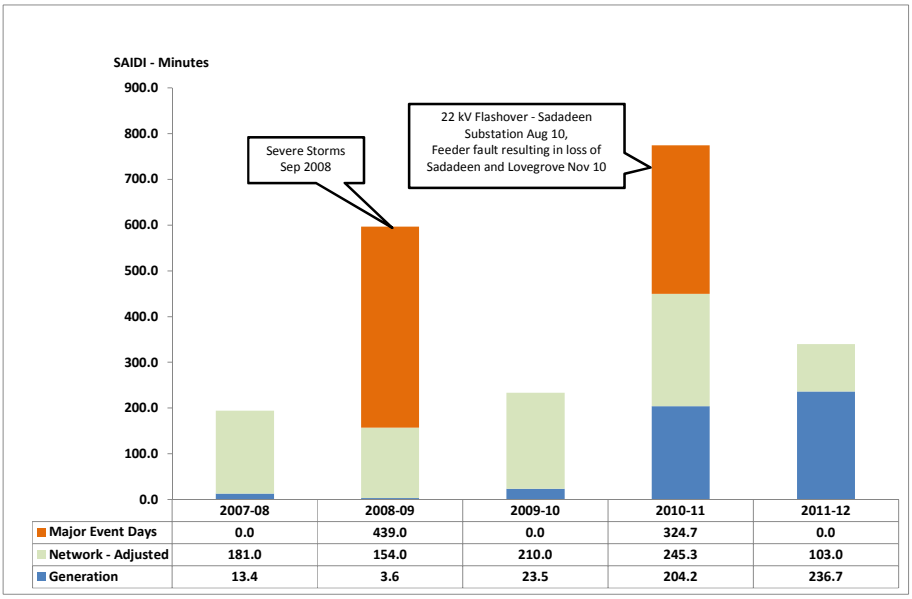
Alice Springs reliability performance

6.15 Charts 6.7 and 6.8 present the SAIDI and SAIFI performance for the five year period 2007-08 to 2011-12 for the Alice Springs system. Chart 6.7 also identifies the events leading to the major event days resulting in exclusions from normal reliability reporting considerations. Notably, in 2011-12:

- while better than the 2010-11 result, SAIDI was the second worst in the five year period (generation outages were the major contributor);
- generation SAIDI was the worst in five years, and generation SAIFI was the second worst in five years;
- conversely, network SAIDI and SAIFI were the best in five years;

- there were no Major Event Days resulting in exclusion events; and
- Alice Springs had four UFLS events throughout the Review Period. It also had nine Major Power System Incidents resulting in interruption to customer service.

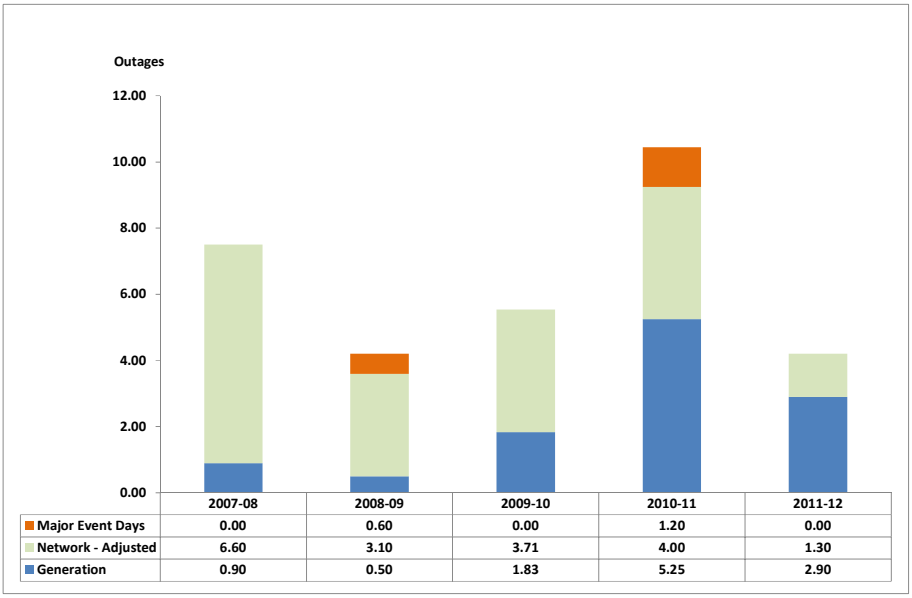
Chart 6.7: Alice Springs system - total minutes off supply (SAIDI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	0.0	439.0	0.0	324.7	0.0
Network - Adjusted	181.0	154.0	210.0	245.3	103.0
Generation	13.4	3.6	23.5	204.2	236.7

Source: Utilities Commission and Power and Water Corporation.

Chart 6.8: Alice Springs system - frequency of outages (SAIFI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	0.00	0.60	0.00	1.20	0.00
Network - Adjusted	6.60	3.10	3.71	4.00	1.30
Generation	0.90	0.50	1.83	5.25	2.90

Source: Utilities Commission and Power and Water Corporation.

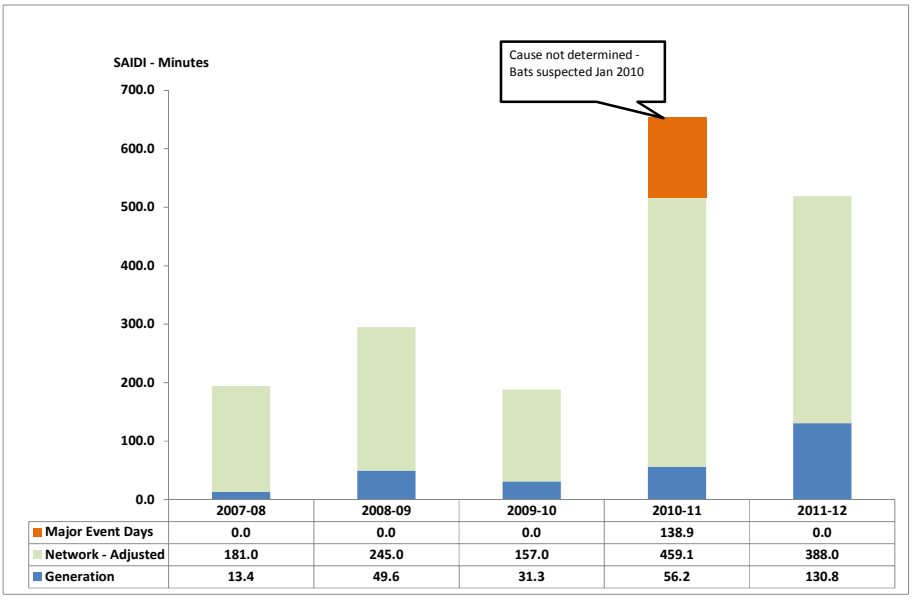
Tennant Creek reliability performance

6.16 Charts 6.9 and 6.10 present the SAIDI and SAIFI performance for the five year period 2007-08 to 2011-12 for the Tennant Creek system. Chart 6.9 also identifies the events leading to the major event days resulting in exclusions from normal reliability reporting considerations. Notably, in 2011-12:

- the overall SAIDI outcome was the worst (by a small margin) in five years;

- SAIFI was the second worst in the five year period;
- generation performance was the worst in five years;
- network SAIDI was the second worst in five years; and
- there were no Major Event Days resulting in exclusion events.

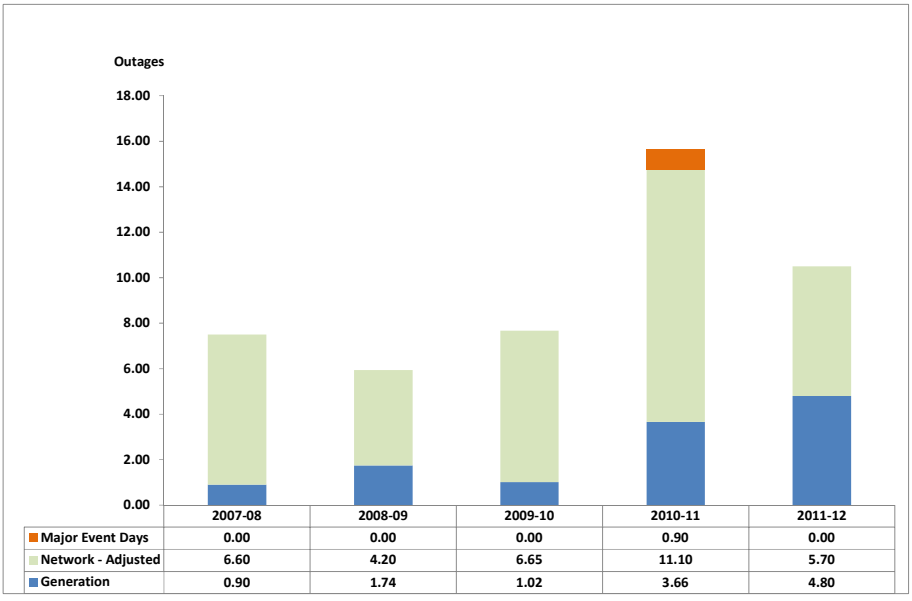
Chart 6.9: Tennant Creek system - total minutes off supply (SAIDI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	0.0	0.0	0.0	138.9	0.0
Network - Adjusted	181.0	245.0	157.0	459.1	388.0
Generation	13.4	49.6	31.3	56.2	130.8

Source: Utilities Commission and Power and Water Corporation.

Chart 6.10: Tennant Creek system - frequency of outages (SAIFI) for 2007-08 to 2011-12



	2007-08	2008-09	2009-10	2010-11	2011-12
Major Event Days	0.00	0.00	0.00	0.90	0.00
Network - Adjusted	6.60	4.20	6.65	11.10	5.70
Generation	0.90	1.74	1.02	3.66	4.80

Source: Utilities Commission and Power and Water Corporation.

Assessments of major power system incidents

6.17 Territory customers experienced an average of 2.1 generation related outages a year (SAIFI) between 2007-08 and 2011-12. Overall, the 0.3 generation related outages in 2011-12 was less than half the five year average.

6.18 Unfortunately, overall performance was not spread evenly across the systems. While Darwin improved significantly, the number and duration of generation related outages at Katherine was the second highest in the five year period. Tennant Creek recorded the worst performance in both the number and duration of generation related outages in the five year period and Alice Springs had the second highest number and highest duration of generation outages for the same five year period.

6.19 While the Commission is pleased to observe the continuing overall improvement in the number of generation related outages, it is important that PWC focus on delivering these improvements to all customers.

6.20 To develop an improved understanding of generation reliability performance, Evans & Peck examined UFLS events for the period 2007-08 to 2011-12 in each of the systems.

6.21 In the Darwin-Katherine system:

- there was an average of 16 UFLS events per annum over the five year period, but this reduced to six in 2011-12;
- the average time for full restoration of supply to all customers averaged 192 minutes over the five year period, but this was only 50 minutes in 2011-12; and
- the average number of customers impacted by each shedding event in 2011-12 was 8 954, above the five year average of 7 897.

6.22 In the Alice Springs system there were less events, but they were significantly longer and affected more customers:

- the number of UFLS events was four in 2011-12, below the five year average of 6.2;
- the average time for full restoration was 128 minutes, over twice the five year average of 61 minutes; and
- the average number of customers impacted in 2011-12 was 8 371, well up on the five year average of 4 520.

6.23 The Commission notes that PWC had an independent report prepared by SKM on three separate but related incidents on the Alice Springs system in February and March 2012. This report highlighted the main issues as:

- the dual functions (both sub-transmission and distribution) performed by the two 22 kV Brewer – Sadadeen ties make it problematic that an effective protection scheme can be achieved. This was demonstrated by the slow clearance of faults in each of the three cases investigated;
- the absence of Under Frequency Islanding schemes which allows the generators to stay on line feeding their own auxiliaries. This makes restoration a much faster exercise, and has been identified previously by the Commission as a necessary enhancement to PWC's operating procedures;
- the difficulty of communications between System Control at Hudson Creek and the staff at Ron Goodin Power Station, as System Control has only limited ability to remotely operate plant in Alice Springs. The ability for System Control to have more remote control over equipment would assist, and would allow the Ron Goodin

staff to concentrate on the power station rather than being diverted with network issues. This will become an increasing issue as Ron Goodin Power Station is phased out, with a consequential reduction in staff; and

- the level of spinning reserves carried at Alice Springs prolongs restoration times.

6.24 In addition, Evans & Peck have drawn attention to the fact that Unit 9 at Ron Goodin Power Station is rarely able to ride out events on the network and usually trips when these incidents occur. The Commission understands that Unit 9's Automatic Voltage Regulator (AVR)[27] is to be replaced in the immediate future. At this time the characteristics of the generator and control systems need to be re-established so that the performance of the unit in the system can be modelled and the control systems optimised to ensure that the unit complies with the requirements of the Technical Code and is as robust as practical.

6.25 It is also known that the Alice Springs system is subject to voltage fluctuations, transient stability issues, frequency oscillations and unit trips. The SKM report recommends that the control system of Unit 8 at Ron Goodin be investigated and rectified. This approach should be extended to all the operating units in the Alice Springs system.

6.26 As noted previously, the Owen Springs units have had very little operation during the 2011-12 year, even though they were commissioned in October – November 2011. The improvement in reliability that should have been expected as a result of the operation of these units has not occurred in the review period.

6.27 In the Tennant Creek system there was a significant increase in the number events, but they were of relatively short duration:

- the number of UFLS events was 12 in 2011-12, almost twice the five year average of 6.4;
- the average time for full restoration was 28 minutes, half the five year average of 56 minutes; and
- the average number of customers impacted in 2011-12 was 563, in line with the five year average of 589.

6.28 The Commission will continue to monitor generation performance through regular performance reporting and an incident reporting framework, and will report on progress in future Reviews.

Feeder category performance

6.29 Consistent with the 2009-10 and 2010-11 Reviews, the Commission requested PWC Networks to report reliability performance based on feeder type. The feeder categories adopted across Australia are:

- CBD – a feeder predominantly supplying commercial, high-rise buildings, supplied by a predominantly underground distribution network containing significant

[27] An AVR takes in a range of voltage levels and automatically outputs a voltage with a much narrower range.

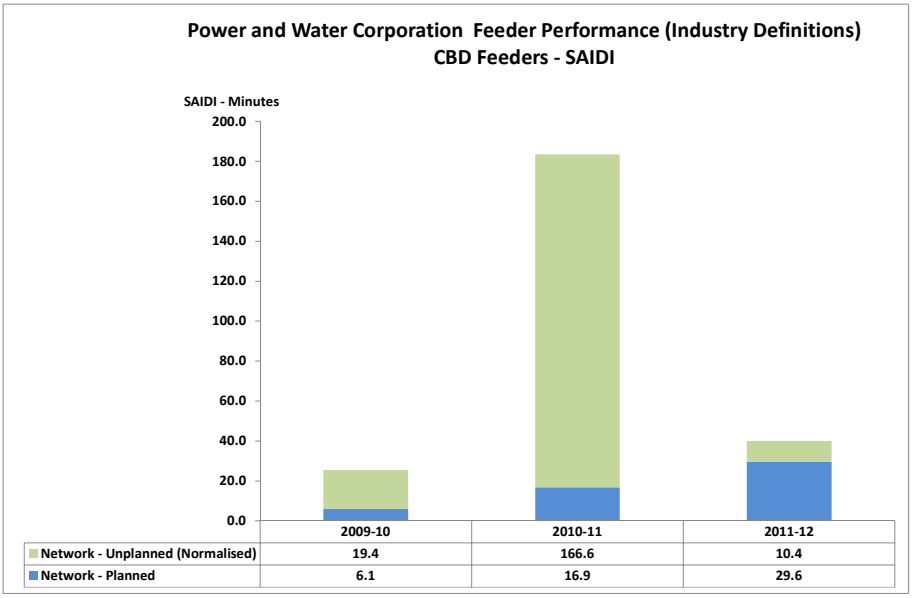
interconnection and redundancy when compared to urban areas. Restricted to the Darwin CBD;

- Urban – a feeder, which is not a CBD feeder, with actual maximum demand over the reporting period per total feeder route length greater than 0.3 MVA/km. When applied in the Territory, this definition gives rise to inconsistencies in the reporting of feeders in similar demographic locations. In December 2012, the Commission decided to change the definition of Urban Feeders to 0.12MVA/km. However, 0.3 MVA/km has been used in this Review;
- Short Rural – a feeder which is not a CBD or Urban feeder, with a total feeder route length less than 200 km. Short Rural feeders may include feeders in urban areas with low load densities; and
- Long Rural – a feeder which is not a CBD or Urban feeder with a total feeder route length greater than 200 km.

6.30 Examining feeder performance by feeder type to identify the network performance trend is the accepted approach in Australia. The first year this data was reported for the Territory was in 2009-10.

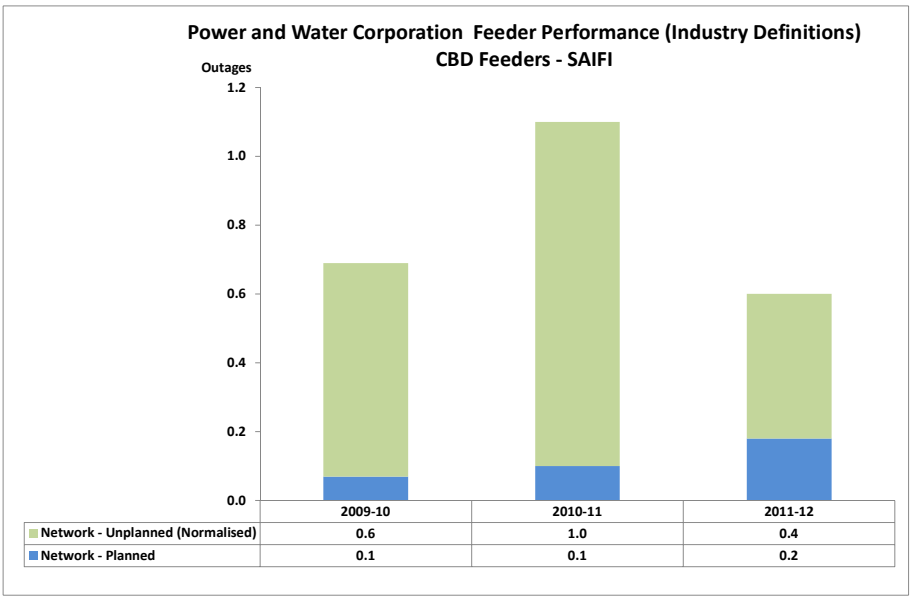
6.31 Charts 6.11 and 6.12 present the SAIDI and SAIFI performance of the CBD feeder category for Darwin for the period 2009-10 to 2011-12.

Chart 6.11: PWC Networks CBD Feeders - average outage duration (SAIDI) 2009-10 to 2011-12



Source: Power and Water Corporation

Chart 6.12: PWC Networks CBD Feeders - average number of outages (SAIFI) 2009-10 to 2011-12



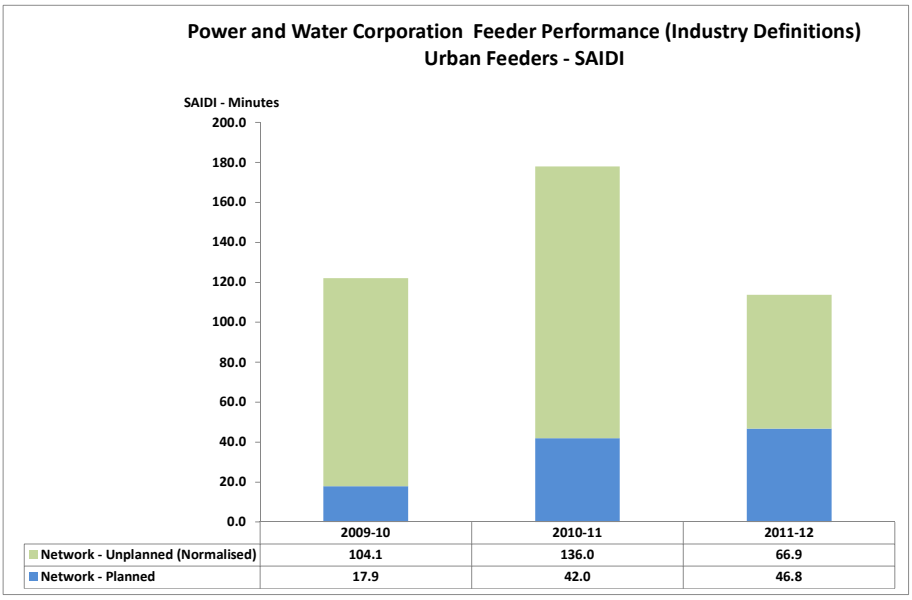
Source: Power and Water Corporation

6.32 CBD feeders have exhibited their best overall performance in the three year period. While there has been an increased level of planned outages (largely associated with maintenance programs at Woods St switching station), these outages are normally less disruptive to customers than unplanned outages. The level of unplanned outages in 2011-12 was well below the three year average.

Urban feeders

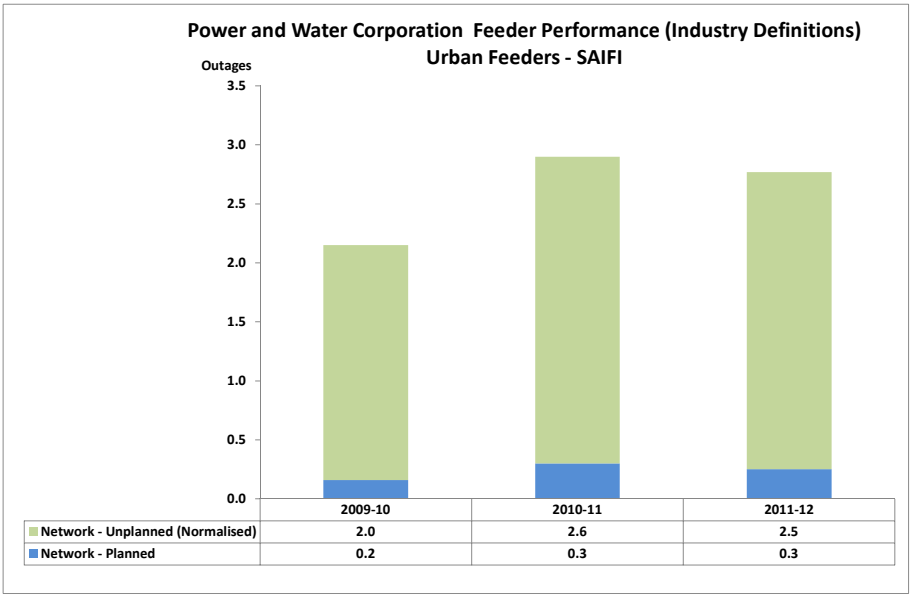
6.33 The SAIDI and SAIFI performance of Urban feeders across the Darwin-Katherine, Alice Springs and Tennant Creek Systems is presented in Chart 6.13 and Chart 6.14.

Chart 6.13: PWC Networks Urban Feeders - average duration of outages (SAIDI) 2009-10 to 2011-12



Source: Power and Water Corporation

Chart 6.14: PWC Networks Urban Feeders - average number of outages (SAIFI) 2009-10 to 2011-12



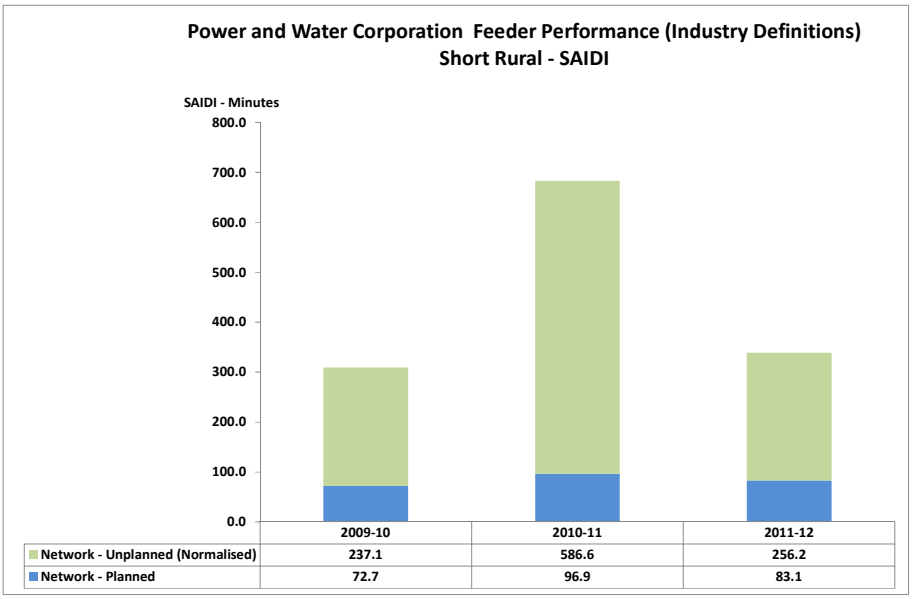
Source: Power and Water Corporation

6.34 Urban SAIDI performance was the best in the three years, despite a growth in planned outages. SAIFI was slightly below the 2010-11 value, but well above the 2009-10 performance.

Short Rural feeders

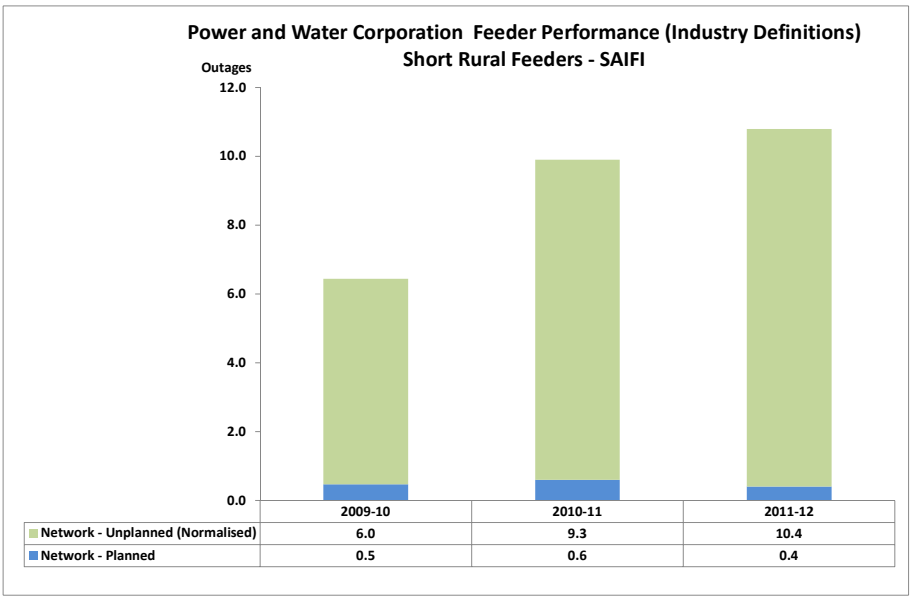
6.35 The SAIDI and SAIFI performance of Short Rural feeders across the Darwin-Katherine, Alice Springs and Tennant Creek systems is presented in Chart 6.15 and Chart 6.16.

Chart 6.15: PWC Networks Short Rural Feeders - average duration of outages (SAIDI) 2009-10 to 2011-12



Source: Power and Water Corporation

Chart 6.16: PWC Networks Short Rural Feeders - average number of outages (SAIFI) 2009-10 to 2011-12



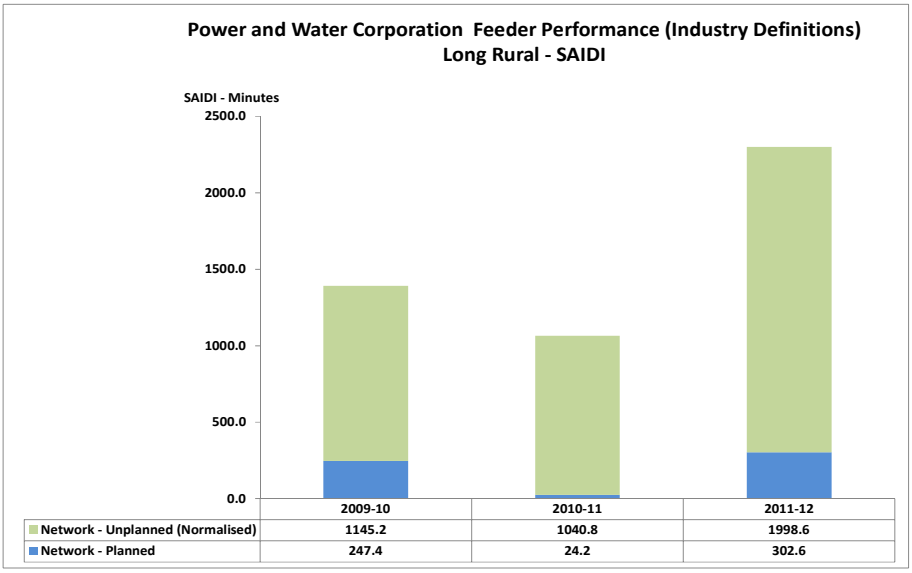
Source: Power and Water Corporation

6.36 While the duration of Short Rural feeder outages decreased significantly from 2010-11 levels, the average number of outages, particularly unplanned outages, increased to the highest level in the three year period. Equipment failure is the single largest contributor to the level of outages. The Commission expects PWC to implement measures to reverse this growing trend, and will monitor performance closely in future reviews.

Long Rural feeders

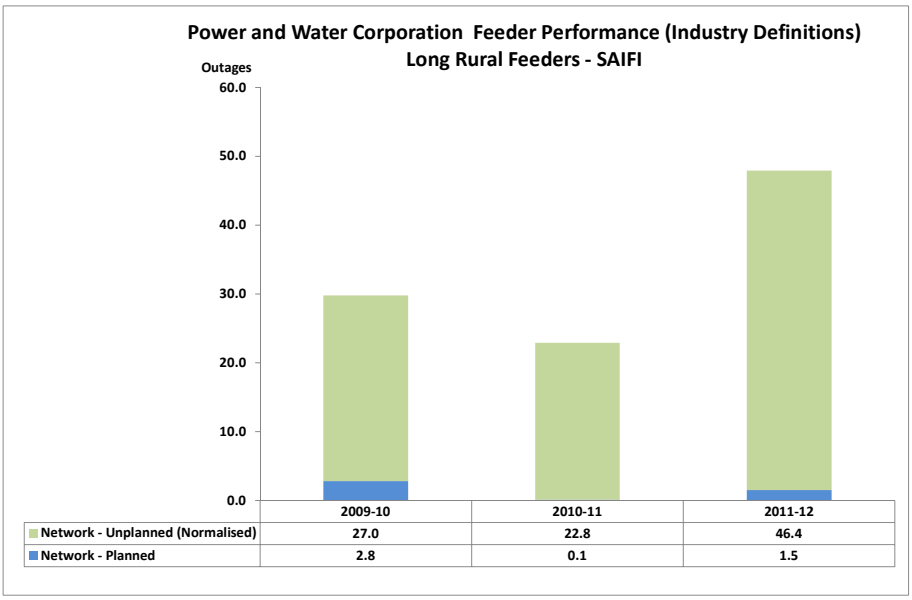
6.37 PWC has two Long Rural feeders – the Mataranka Feeder in the Katherine sub system, and Feeder 6 in the Tennant Creek system. As a result of the small number of feeders, annual results are expected to be relatively volatile. The SAIDI and SAIFI performance of Long Rural feeders is presented in Chart 6.17 and Chart 6.18.

Chart 6.17: PWC Networks Long Rural Feeders - average duration of outages (SAIDI) 2009-10 to 2011-12



Source: Power and Water Corporation

Chart 6.18: PWC Networks Long Rural Feeders - average number of outages (SAIFI) 2009-10 to 2011-12



Source: Power and Water Corporation

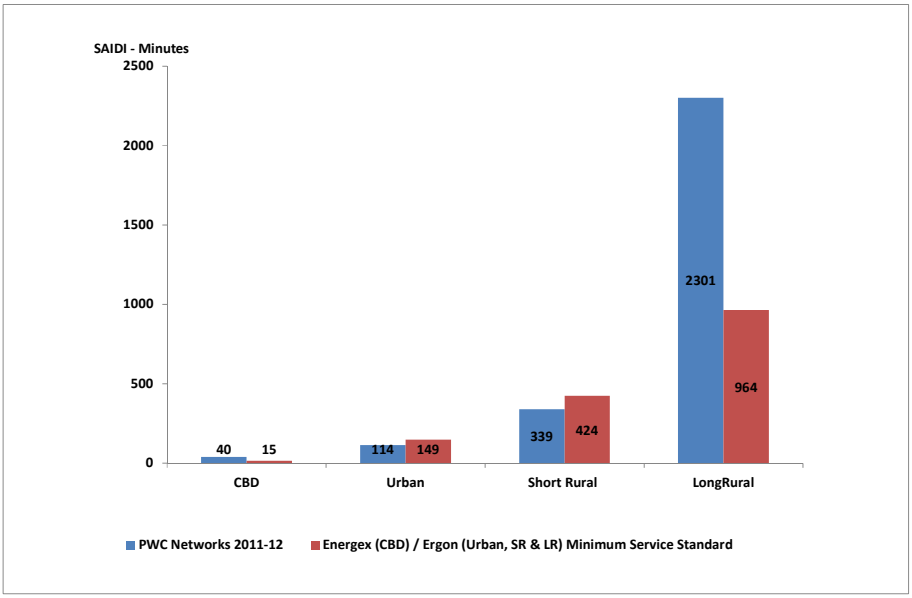
6.38 In 2011-12, both SAIDI and SAIFI were the highest in the three year period. Both Long Rural feeders are incorporated in PWC's "Worst Performing Feeder" list, and are the subject of increased focus aimed at improving reliability. In particular, an extensive review of the protection settings on Feeder 6 at Tennant Creek has been completed and corrective action initiated aimed at reducing the impact of outages on this feeder on the Tennant Creek system.

Feeder performance compared to peers

6.39 To assess relative performance of PWC Networks with regulatory expectations elsewhere in Australia, the Commission has compared PWC Networks' 2011-12 performance with the minimum service standards applicable in Queensland. The Commission considers the two Queensland electricity networks provide a reasonable point of comparison to PWC Networks (particularly Ergon). Chart 6.19 and Chart 6.20 present a comparison of feeder performance in the Territory with the Queensland minimum service standards. It should be noted that these comparisons are made on "normalized"[28] values. There were no exclusions in 2011-12.

[28] Normalisation refers to the exclusion of Major Event Days as determined under the IEEE 2.5 beta method.

Chart 6.19: Feeder performance (SAIDI) 2011-12 PWC Networks (actual) and Queensland (minimum service standards)

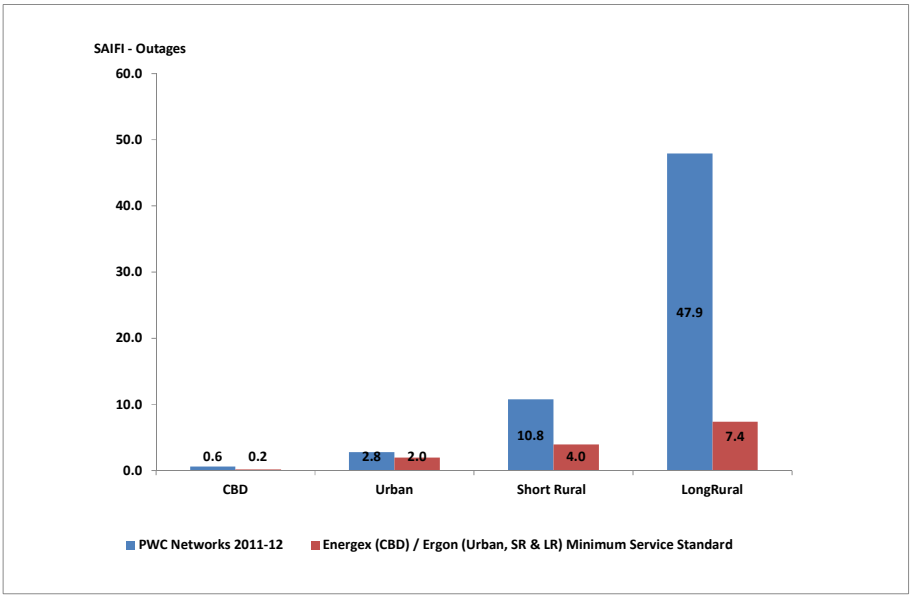


Source: Evans & Peck

6.40 The Commission has the following observations about the comparison of SAIDI performance:

- PWC Networks CBD feeder performance is worse than the Energex CBD minimum standard. CBD feeder performance is variable across Australia and volatile between years. A single event can have a significant influence on performance. As shown in Chart 6.11 unplanned outages in the PWC Networks CBD feeder category were 10.4 minutes in 2011-12. This is considered an acceptable level of performance;
- PWC Networks Urban and Short Rural performance both bettered the Ergon Energy minimum standards in 2011-12. The Commission considers this an acceptable level of performance; and
- PWC Networks Long Rural performance was particularly poor in 2011-12. As noted above, the small number of long rural feeders in the Territory could cause high statistical variation. Notwithstanding, the Commission is looking for improved performance in this category.

Chart 6.20: Feeder performance (SAIFI) 2011-12– PWC Networks (actual) and Queensland (minimum service standards)



Source: Evans & Peck

6.41 The Commission has the following observations about the comparison of SAIFI performance:

- In 2011-12 PWC Networks CBD SAIFI performance was worse than the Energex minimum service standard. However, the number of unplanned outages dropped below 0.5, or one every two years. The Commission considers this an encouraging performance;
- Urban SAIFI performance is worse than the Ergon Energy minimum standards, but is of a comparative order of magnitude; and
- PWC Networks Short Rural and Long Rural SAIFI are several multiples of the Ergon Energy standards. The Commission is particularly concerned at the high number of Long Rural outages which is approaching one per week. The Commission considers this level of performance unacceptable.

6.42 For future reviews, the Commission will continue to compare feeder performance in the Territory over time and with that of like network service providers elsewhere in Australia. However, as outlined above, the definition of Urban Feeders will be based on 0.12MVA/km.[29]

[29] The Commission's new Electricity Standards of Service Code which came into effect on 1 December 2012 changed the methodology for determining Urban Feeders from a threshold of 0.3MVA/km to 0.12MVA/km. The reason for the change was to ensure customers in like areas receive (or should expect to receive) similar standards with respect to the supply of electricity.

Chapter 7

Customer service performance

7.1 The customer service performance of PWC Networks and PWC Retail is measured using the following indicators:

- time taken to complete reconnections and new connections;
- number of complaints about quality of electricity supply;
- time taken to answer telephone calls (after the customer has chosen to speak to an operator); and
- number of complaints about PWC Networks and PWC Retail customer service.

Reconnections/connections

7.2 PWC Networks reports on the percentage of reconnections and connections of customers that occur after a defined time period:

- reconnections are to occur within 24 hours (connections to a property where there is an existing supply and no extension or augmentation of the network needed);
- connections to a property in a new subdivision in an urban area are to occur within five working days; and
- connections to a property in a new subdivision in an urban area where minor extension or augmentation of the network is required are to occur within ten weeks.

7.3 The percentage of reconnections and connections not occurring within the defined timeframe for 2007-08 to 2011-12 is presented in Table 7.1

Table 7.1: Percentage of reconnections/connections not made within the specified time limit

All customers (% not made)	2007-08	2008-09	2009-10	2010-11	2011-12	5 Year Average
Reconnections (existing)	1	0.8	0.5	0.3	0.08	0.5
Connections (new subdivision)	16	8.7	7.9	6.7	12.1	10.3
Connections (extension needed)	32	66.5	69.4	81.6	73.0	64.5

Source: Power and Water Corporation.

7.4 On time reconnections have reached a level of 99.92 per cent compliance with the standard. The number of “on time” connections to a property in a new subdivision has decreased to 87.9 per cent, below the five year average (89.7 per cent) and a significant deterioration on the performance over the preceding three years.

7.5 The number of “on time” connections where minor works are required has increased to 27 per cent, below the five year average of 35.5 per cent. In 2011-12, 73 per cent

still did not meet the required standard. While an improvement on the 2010-11 result, the Commission still considers this level of performance needs attention by PWC.

Quality of supply complaints

7.6 PWC Networks reports the number of complaints received in relation to quality of supply (eg voltage dips, swells and spikes). In the 2010-11 Review, Evans & Peck expressed concern that there was an increasing trend in the number of complaints that may have been related to the absence of a structured planning process for the low voltage network. Accordingly, the Commission initiated a close watch on these statistics to identify whether this is attributable to a statistical aberration, or is reflective of an emerging issue.

7.7 Following the release of the 2010-11 Review, PWC reviewed the basis of reporting of "quality of supply complaints". PWC has advised that in many instances, a customer call relating to a temporary variation in voltage was recorded as a quality of supply complaint. It is often the case that such situations arise due to the operation of protective devices following a fault on the system, and only last a short period until the system is restored to its normal operating condition. To this extent, the equipment is operating within its design parameters. It is common industry practice to record such issues as "fault"[30] rather than "quality of supply" issue necessitating network re-design or augmentation.

7.8 As a consequence of this investigation, PWC has separated "callouts" due to part power or fluctuating power from quality of supply complaints. Under this classification, the number of "quality of supply" complaints relating to voltage issues was only seven in 2011-12. In order to provide continuity in reporting, the number of reported call-outs over the period 2007-08 to 2011-12 is presented in Table 7.2.

Table 7.2: Quality of supply "call outs"

Number of Complaints	2007-08	2008-09	2009-10	2010-11	2011-12 "Call Outs"		
					Fluctuating Power	Part Power	Total
Northern (Darwin)	801	792	776	1112	159	871	1030
Katherine	195	109	317	149	28	169	197
Southern (Alice Springs)	96	139	114	145	29	111	140
Tennant Creek	26	21	77	19	2	21	23
Total	1117	1061	1284	1425	218	1172	1390

Source: Power and Water Corporation.

7.9 The resultant number of "call-outs" is down on 2010-11 for the Territory as a whole (with increases in Katherine and Tennant Creek), but still above the five year average.

[30] The Commission understands that distribution network providers in other jurisdictions include these events in their SAIDI and SAIFI figures from the moment the first customer calls.

7.10 The Commission notes that Ergon has a quality of supply rate of about 25 per 10,000 customers per annum for 2011-12.[31] Based on 80 000 customers, this would translate for PWC into 200-240 complaints per annum. The Commission considers PWC's 218 call outs regarding fluctuating power to be within the acceptable range.

7.11 The Commission is working with PWC to clarify the definition of a Quality of Supply complaint.

Telephone call response

7.12 PWC (Networks and Retail) report the number and percentage of telephone calls responded to within 20 seconds of the customer electing to speak to a human operator.

7.13 Table 7.3 presents the percentage and number of telephone calls answered within 20 seconds of the customer electing to speak to a human operator for 2007-08 to 2011-12.

Table 7.3: Percentage and number of telephone calls answered within timeframe

Telephone calls answered	2007-08	2008-09	2009-10	2010-11	2011-12
Percentages	58	62	63	62	60
Numbers	78 543	87 013	91 614	88 888	101 306

Source: Power and Water Corporation.

7.14 The 2011-12 result is slightly inferior to the previous three years, and is below the minimum service standard of 63 per cent. However, it is noted that there was a significant increase in overall call volume, increasing the challenge that PWC has in meeting this standard. The Commission will monitor both the trend in call volumes, and PWC's performance in relation to this standard.

Customer complaints (excluding Quality of Supply Complaints)

7.15 PWC (Networks and Retail) report the number of complaints received from customers.[32]

7.16 Table 7.4 gives the number of customer complaints received by PWC Networks and PWC Retail for the period 2007-08 to 2011-12.

[31] Ergon's Network Management Plan from 2012-13 to 2016-17, Part A, Graph 16, page 75.

[32] A complaint is (as defined in the Australian Standard ISO10002-2006) 'an expression of dissatisfaction made to an organisation, related to its products, or the complaint handling process itself, where a response or resolution is explicitly or implicitly expected'.

Table 7.4: Number of customer complaints

Number of Complaints	2007-08	2008-09	2009-10	2010-11	2011-12
Northern (Darwin)	1 778	1 781	1 830	1 553	1 516
Katherine	121	160	160	146	147
Southern (Alice Springs)	391	318	417	432	385
Tennant Creek	42	39	70	89	41
Total	2 332	2 235	2 477	2 220	2 089

Source: Power and Water Corporation.

7.17 PWC received 2 089 electricity service related complaints during 2011-12. This is the lowest in the five year period.

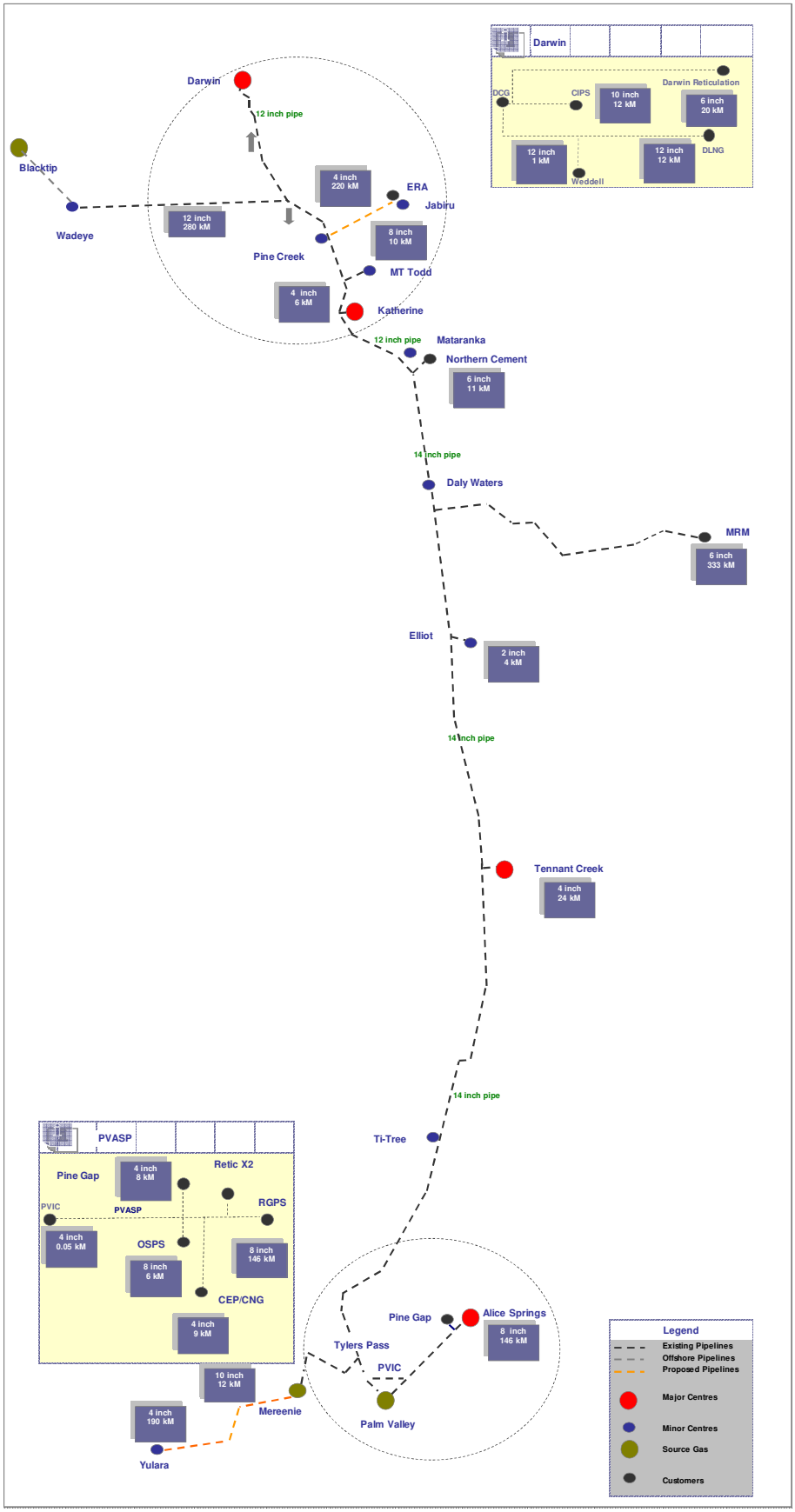
Chapter 8

Adequacy of fuel supply

Fuel supplies

8.1 Natural gas is the main fuel for electricity generation in the Darwin-Katherine, Alice Springs and Tennant Creek systems. The main source of supply is the Blacktip gas field, which is able to supply all PWC's needs through to the end of the current contract in 2034. In addition, PWC has access to gas from the Darwin Liquefied Natural Gas (DLNG) (limited to 2.5PJ/annum and draw down of 75 TJ/day) to cover periods when supply from Blacktip may not be available. Also, a number of PWC's generation units are dual fuel, and able to use liquid fuels (ie diesel) which historically has been the alternative fuel source to natural gas. A schematic of the Territory's high pressure gas pipeline system is shown in Chart 8.1.

Chart 8.1: Territory's high pressure gas pipeline system



Source: Power and Water Corporation

Natural gas supply

Blacktip gas field

8.2 The Blacktip gas field, which is owned and operated by Eni Australia B.V. (Eni), is located in the Bonaparte Gulf about 100 km west of Wadeye. The field has been developed to supply gas to PWC for electricity generation to replace the Amadeus Basin fields, from which the last gas was delivered in January 2012. PWC and Eni entered a 25 year gas supply arrangement in 2006 for the supply of 740 petajoules of gas from Blacktip field plus additional gas if required and available.

8.3 The recent issues relating to the supply of gas to the Gove Alumina Refinery have not been considered in this Review as they are outside the timeframe of the Review. Future reviews will need to consider these issues and their effect on fuel security for PWC.

8.4 The first gas from Blacktip was supplied in October 2009. The gas comes onshore to Eni's gas processing plant near Wadeye, and is transported by APA Group's 286 km Bonaparte gas pipeline (BGP) to join the Amadeus Gas Pipeline (AGP) at Ban Ban Springs.

8.5 For the period to 2021-22, the volumes of gas available under the PWC/Eni gas supply contracts are considered sufficient to meet forecast electricity demand.

Alternative fuel sources

8.6 PWC has two alternative fuel sources for backup and emergency use for electricity generation, natural gas from the DLNG facility at Wickham Point on Darwin harbour and liquid fuels (ie diesel) held in storage at some sites.

Contingency gas supply

8.7 PWC agreed a contingency gas supply arrangement with DLNG in 2009 involving the supply of a quantity of gas from the DLNG plant to the Darwin city gate gas hub in certain defined circumstances. This arrangement has operated successfully, such as during a scheduled outage of the Blacktip facilities.

8.8 The DLNG plant and Blacktip production and processing systems are geographically separate, thereby reducing the risk of both supply sources being impacted simultaneously by mechanical failure, cyclonic activity or other natural disaster.

8.9 PWC is also in the process of negotiating an additional source of contingency gas with the Inpex project to provide additional quantities to support the DLNG gas.

Contingency diesel supply

8.10 PWC Generation maintains a portfolio of generation plant able to use diesel as a last resort contingency if gas is not available, and has significant diesel storage facilities at Channel Island, Katherine, Tennant Creek, Ron Goodin and Owen Springs Power Stations.

8.11 Based on advice from PWC Generation, the diesel only capacity of each system is:

- 319.8 MW for the Darwin-Katherine system, against a peak demand of 282 MW (SWMD 295 MW) in 2011-12. This capacity does not include Berrimah Power Station (10 MW) or LMS Shoal Bay PPA (1.1 MW), although these units are not connected to the main gas supply;
- 80.6 MW for the Alice Springs system, against a peak demand of 52.6 MW (SWMD 54.8MW)in 2011-12; and
- 11.9 MW for the Tennant Creek system, against a peak demand of 6.9 MW (SWMD 7.8 MW) in 2011-12.

8.12 PWC has significant diesel fuel storage facilities at its facilities which are capable of dual-fuel firing, ie Channel Island, Katherine, Tennant Creek, Ron Goodin and Owen Springs power stations. PWC sets its diesel inventories to cater for normal use, which is minimal, plus a contingency for a failure in the gas supply system. The contingency quantity caters for several hours to several days, depending on the location of the station, with higher inventories maintained at Alice Springs and Tennant Creek power stations, on account of more alternative gas supply options for Channel Island and Weddell power stations.

Adequacy of fuel supplies

8.13 PWC has advised the Commission that its average daily requirement for power generation and sales for 2011-12 was some 56.7 TJ/d (which translates into approximately 20.7 PJ a year).[33] The annual quantity of gas to be supplied from the Blacktip field over the 25 year term of the contract ranges from 23 PJ to 37 PJ per year.[34]

8.14 The gas volumes available from the Blacktip field are projected to be sufficient to meet gas demand to well beyond the Review period to 2021-22.[35]

8.15 The commissioning of more efficient generation plant in both the Darwin-Katherine and Alice Springs systems should result in significant improvements in thermal efficiency and a decrease in the quantity of fuel consumed per unit of electrical output. No change is expected at Tennant Creek in the absence of new plant being installed there.

Adequacy of contingency arrangements

8.16 PWC has a range of contingency arrangements to maintain electricity supply in the event of the partial or complete loss of the primary gas supply from Blacktip:

- DLNG gas. The DLNG contingency gas supply arrangement does not represent a complete replacement supply from Blacktip. However, the DLNG gas would provide a second gas supply in the event of pipeline rupture or temporary production/processing problems that should reduce or eliminate the need to use diesel for electricity generation. These arrangements provide for up to 30 days supply into the interconnected Darwin-Alice Springs pipeline system at current

[33] 1000 terajoules equal 1 petajoule.
[34] Press article, Blacktip gas feed in pipeline soon, Northern Territory News, 18 August *2008*.
[35] This does not consider the impact of gas being supplied to the Gove refinery.

peak rates, significantly longer at the lower average consumption rates, and when supplemented by gas from pipeline line pack and by diesel fuel;

- Line pack gas, which is gas stored in the pipeline. Line pack gas may be sufficient to provide a short term (ie possibly a few days) source of supply if there is a disruption to the primary supply, particularly if there is forewarning so the pipeline can be brought to its maximum operating pressure;
- a further gas supply from Inpex is being considered; and
- diesel stocks held by PWC provide a last resort fuel source for dual fuel or diesel burning units.

8.17 These alternate fuel sources should provide access to a continued fuel supply to power stations, even in the circumstances of partial or complete loss of gas from Blacktip due to production or processing equipment failure or cyclonic activity or a pipeline rupture.

8.18 A multiple gas failure, eg from both Blacktip and DLNG would see full capacity available from diesel generation. The limiting factor in this case would be the adequacy of diesel stocks and the necessary transportation from bulk fuel depots to replenish PWC stocks. In a worst case of an extended total gas supply failure, there could be a gradual decline in diesel stocks as they may not be able to be replenished at the same rate as they are used.

8.19 However, the availability of Blacktip, DLNG gas and line pack gas are considered to provide sufficient diversity of supply to ensure adequate fuel supplies are available to avoid prolonged use of diesel which would effectively be the third contingency.

8.20 The most disruptive (and quite unlikely) event for Alice Springs and Tennant Creek would be a rupture of the supply pipeline near the power stations. It is expected that the four day diesel fuel stocks would in almost all circumstances be sufficient to cover the duration of repairs to the pipeline. Moreover, diesel fuel supply could be supplemented by road from local terminals.

Pipeline transportation

8.21 Firm gas transportation entitlements in both the AGP, the spur pipeline from DLNG and BGP are understood to match the PWC gas purchase entitlements, which exceed current and projected peak flow rates for the period of this Review.

APPENDIX A

Power stations included in the Darwin-Katherine, Alice Springs and Tennant Creek power systems.

POWER STATION/SYSTEM	Make/Model	Engine Type	Fuel Type	MW GMC RATING (Sustainable Installed Capacity)
CHANNEL ISLAND				
GT 1	GE Frame 6	Combustion Turbine	Gas or Diesel	31.600
GT 2	GE Frame 6	Combustion Turbine	Gas or Diesel	31.600
GT 3	GE Frame 6	Combustion Turbine	Gas or Diesel	31.600
GT 4	GE Frame 6	Combustion Turbine	Gas or Diesel	31.600
GT 5	GE Frame 6	Combustion Turbine	Gas or Diesel	31.600
ST 6	Mitsubishi	Steam Turbine	Waste Heat	32.000
GT 7	GE LM6000	Combustion Turbine	Gas	36.000
GT 8	Trent 60	Combustion Turbine	Gas or Diesel	42.000
GT 9	Trent 60	Combustion Turbine	Gas or Diesel	42.000
House Set 0.900 kW	*Kongsberg KG2*	*Combustion Turbine*	*Diesel*	
CIPS Total MW				**310.000**
WEDDELL				
Set 1	GE LM6000 PD	Combustion Turbine	Gas	43.000
Set 2	GE LM6000 PD	Combustion Turbine	Gas	43.000
Weddell Total MW				**86.000**

POWER STATION/SYSTEM	Make/Model	Engine Type	Fuel Type	MW GMC RATING (Sustainable Installed Capacity)
BERRIMAH				
GT 2[36]	Stal Laval PP4	Combustion Turbine	Kerosene	10.000
Berrimah Total MW				**10.000**
LMS SHOAL BAY PPA				
Set 1	Caterpillar 3516G	Reciprocating Spark Fired	Land Fill Gas	1.100
LMS Shoal Bay Total MW				**1.100**
PINE CREEK A PPA				
GT 1	Solar Mars	Combustion Turbine	Gas	9.640
GT 2	Solar Mars	Combustion Turbine	Gas	9.640
ST 3	Peter Brotherhood	Steam Turbine	Waste Heat	7.310
Pine Creek A Total MW				**26.590**
KATHERINE				
GT 1	Solar Mars	Combustion Turbine	Gas or Diesel	7.400
GT 2	Solar Mars	Combustion Turbine	Gas or Diesel	7.400
GT 3	Solar Mars	Combustion Turbine	Gas or Diesel	7.400
GT4	Solar Titan 130	Combustion Turbine	Gas or Diesel	12.100

[36] Used for emergency service only.

POWER STATION/SYSTEM	Make/Model	Engine Type	Fuel Type	MW GMC RATING (Sustainable Installed Capacity)
House Set 0.500 MW				
Katherine Total MW				**34.700**
DARWIN-KATHERINE SYSTEM TOTAL MW				468.390
TENNANT CREEK				
Set 1	Ruston 8ATC	Reciprocating Diesel	Diesel	1.300
Set 2	Ruston 8ATC	Reciprocating Diesel	Diesel	1.300
Set 3	Ruston 8ATC	Reciprocating Diesel	Diesel	1.300
Set 4	Ruston 8ATC	Reciprocating Diesel	Diesel	1.300
Set 5	Ruston 8ATC	Reciprocating Diesel	Diesel	1.300
Set 10	Caterpillar 3516G	Reciprocating Spark Fired	Gas	0.958
Set 11	Caterpillar 3516G	Reciprocating Spark Fired	Gas	0.958
Set 12	Caterpillar 3516G	Reciprocating Spark Fired	Gas	0.958
Set 13	Caterpillar 3516G	Reciprocating Spark Fired	Gas	0.958
Set 14	Caterpillar 3516G	Reciprocating Spark Fired	Gas	0.958
Set 15	Solar Taurus	Combustion Turbine	Gas or Diesel	3.900
Set 16	Cummins QSK60	Reciprocating Diesel	Diesel	1.500
Set 17	Cummins QSK60	Reciprocating Diesel	Diesel	0.000
TCPS Total MW				**16.690**
TENNANT CREEK SYSTEM TOTAL MW				**16.690**

POWER STATION/SYSTEM	Make/Model	Engine Type	Fuel Type	MW GMC RATING (Sustainable Installed Capacity)
RON GOODIN				
Set 1	Mirrlees KVSS12	Reciprocating Diesel	Diesel	1.900
Set 2	Mirrlees KVSS12	Reciprocating Diesel	Diesel	1.900
Set 3	Mirrlees KV16P Major	Reciprocating Dual Fuel	Diesel and Gas	4.200
Set 4	Mirrlees KV16P Major	Reciprocating Dual Fuel	Diesel and Gas	4.200
Set 5	Mirrlees KV16P Major	Reciprocating Dual Fuel	Diesel and Gas	4.200
Set 6	Pielstick PC2-3 V16 DF	Reciprocating Dual Fuel	Diesel and Gas	5.500
Set 7	Pielstick PC2-3 V16 DF	Reciprocating Dual Fuel	Diesel and Gas	5.500
Set 8	Pielstick PC2-3 V16 DF	Reciprocating Dual Fuel	Diesel and Gas	5.500
Set 9	ASEA GT35C	Combustion Turbine	Gas or Diesel	11.700
RGPS Total MW				**44.600**
OWEN SPRINGS				
OSPS A (Ex RGPS H set)	Solar Taurus 60	Combustion Turbine	Gas or Diesel	3.900
OSPS 1	MAN 12V 51/60 DF	Reciprocating Dual Fuel	Dual Fuel	10.700
OSPS 2	MAN 12V 51/60 DF	Reciprocating Dual Fuel	Dual Fuel	10.700
OSPS 3	MAN 12V 51/60 DF	Reciprocating Dual Fuel	Dual Fuel	10.700
OSPS Total MW				**36.000**
BREWER PPA				
G 1	Waukesha	Reciprocating Spark Fired	Gas	2.128
G 2	Waukesha	Reciprocating Spark Fired	Gas	2.128

POWER STATION/SYSTEM	Make/Model	Engine Type	Fuel Type	MW GMC RATING (Sustainable Installed Capacity)
G 3	Waukesha	Reciprocating Spark Fired	Gas	2.128
G 4	Waukesha	Reciprocating Spark Fired	Gas	2.128
Brewer PPA Total MW				**8.511**

Uterne PPA				
G 1	SunPower T20 Tracker	Photovoltaic	PV	0.964
Uterne PPA Total MW				**0.964**

ALICE SPRINGS SYSTEM TOTAL MW				**90.075**

APPENDIX B

System maximum demand forecast 2011-12 to 2021-22

Table A.1: Forecast Darwin-Katherine annual maximum demand for 2011-12 to 2021-22				
MW Demand	**PWC Base (P50 weather)**	**PWC Base (P10 Weather)**	**PWC High (P50 Weather)**	**PWC Low (P50 weather)**
2011-12 Actual	*282.1*	*282.1*	*282.1*	*282.1*
2012-13	303.3	312.1	304.8	302.1
2013-14	311.5	321.3	314.5	309.1
2014-15	319.9	330.4	324.6	316.2
2015-16	328.6	339.5	335.0	323.5
2016-17	337.4	348.6	345.7	330.9
2017-18	346.5	357.7	356.8	338.5
2018-19	355.9	366.8	368.2	346.3
2019-20	365.5	376.0	380.0	354.3
2020-21	375.4	385.1	392.1	362.4
2021-22	385.5	395.5	404.7	370.8

Table A.2: Forecast Alice Springs annual maximum demand for 2011-12 to 2021-22				
MW Demand	**PWC Base (P50 weather)**	**PWC Base (P10 Weather)**	**PWC High (P50 Weather)**	**PWC Low (P50 weather)**
2011-12 Actual	*52.6*	*52.6*	*52.6*	*52.6*
2012-13	57.7	59.9	58.0	57.6
2013-14	58.0	60.2	58.6	57.7
2014-15	58.3	60.5	59.2	57.9
2015-16	58.6	60.8	59.8	58.0
2016-17	58.9	61.1	60.4	58.2
2017-18	59.2	61.4	61.0	58.3
2018-19	59.5	61.7	61.6	58.5
2019-20	59.8	62.0	62.2	58.6
2020-21	60.1	62.3	62.8	58.8
2021-22	60.4	62.6	63.5	58.9

Table A.3: Forecast Tennant Creek annual maximum demand for 2011-12 to 2021-22				
MW Demand	**PWC Base (P50 weather)**	**PWC Base (P10 Weather)**	**PWC High (P50 Weather)**	**PWC Low (P50 weather)**
2011-12 Actual	*6.9*	*6.9*	*6.9*	*6.9*
2012-13	7.8	8.1	7.9	7.7
2013-14	7.8	8.1	8.0	7.6
2014-15	7.8	8.1	8.2	7.5
2015-16	7.8	8.1	8.3	7.3
2016-17	7.8	8.1	8.4	7.2
2017-18	7.8	8.1	8.5	7.1
2018-19	7.8	8.1	8.7	7.0
2019-20	7.8	8.1	8.8	6.9
2020-21	7.8	8.1	8.9	6.8
2021-22	7.8	8.1	9.1	6.7

APPENDIX C

Zone substation demand for 2009-10 to 2016-17

					Actual			Forecast				
Zone Substation	Voltage	Number of Transformers	Normal(N) Capacity MVA	Contingent (N-1) Capacity MVA	2009-10 Demand MVA	2010-11 Demand MVA	2011-12 Demand MVA	2012-13 Demand MVA	2013-14 Demand MVA	2014-15 Demand MVA	2015-16 Demand MVA	2016-17 Demand MVA
Archer	66/11	2	59.4	29.7	0	0	0	27.4	28.3	29.3	30.2	31.2
Batchelor	132/22	1	30.9	0	3.01	2.9	2.8	2.9	2.9	2.9	2.9	3.0
Berrimah	66/11	2	76.2	38.1	41.28	39.65	44.8	41.6	34.0	39.9	40.3	41.7
Brocks Creek	66/11	2	6.8	3	1.6	1.55	1.6	1.6	1.6	1.6	1.55	1.6
Casuarina	66/11	3	116.7	78	51.45	53.93	57.6	67.2	51.7	52.8	54	55.1
Centre Yard	66/11	2	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
City Zone	66/11	3	127.8	85	60.523	55.369	53	56.4	57.5	58.6	59.8	60.9
Cosmo Howley	66/11	2	14.6	7	1.04	1.19	1.22	1.25	1.28	1.31	1.35	1.38
East Arm	66/11	0	0	0	0	0	0	0	9	9	9	9
Frances Bay	66/11	1	89.2	45	0	6.02	6	6.14	6.28	6.42	6.57	6.72
Humpty Doo	66/22	3	12.6	8	2.47	3.17	2.3	2.3	2.3	2.3	2.3	2.3
Katherine	132/22	2	58.6	29	29.33	29.4	29.49	29.86	30.22	30.58	30.94	33.8
Leanyer	66/11	2	0	0	0	0	0	0	21.3	21.69	22.11	22.54
Manton	132/22	1	29.4	0	4.47	4.21	3.95	3.974	3.998	4.022	4.05	4.07
Mary-River	66/22	1	5	0	1.2	1.24	1.35	1.35	0	0	0	0
Marrakai	66/22	2	0	0	0	0	0	0	2.1	2.17	2.27	2.38
McMinns	66/22	3	57.1	41	22.56	25.58	24.8	34.3	43.6	49.3	50.18	51
Palmerston	66/11	2	76.2	38	45.07	44.08	49.7	30.8	33.7	35.4	43.7	45.5
Palmerston	11/22	1	26.5	8	2.6	3	4.1	4.6	5	5	5	5
Pine Creek	132/66	1	0	0	0	0	12.9	12.9	12.9	12.9	12.9	12.9
Pine Creek	66/11	2	40	20	-	-	12.9	12.9	12.9	12.9	12.9	12.9
Pine Creek	11/22	1	0	0	0	0	0	0	0	0	0	0
Snell Street	66/11	4	52.1	39	34.06	34.45	34.7	34.2	0	0	0	0
Tindal	22/11	3	12.9	9	5.21	5.26	5.5	5.5	5.5	5.5	5.5	8
Weddell	66/22	2	30	15	0	3.83	4.9	11.9	15	14.99	15	5.1
Woolner	66/11	3	0	0	0	0	0	0	33.7	33.2	32.7	32.2
Lovegrove	22/11	3	44.4	25	10.96	15.09	17.3	17.7	18.1	18.6	19	19.4
Lovegrove	66/22	2	90	45	0	0	38.2	38.2	38.2	38.2	38.2	38.2
Owen Springs	11/66	2	90	45	0	0	38.2	38.2	38.2	38.2	38.2	38.2
Ron Goodin (11 kV load)	22/11	2	48.4	0	38.6	35.8	32.9	33.1	33.3	33.5	33.7	34
Brewer + Sadadeen 22kV	0	0	0	0	0	0	0	2.6	2.6	2.6	2.6	2.6
Tennant Creek	11/22	2	16.4	8	0	7.57	7.8	7.8	7.8	7.8	7.8	7.8
Network Submission Totals		**62**	**1212.2**	**617.3**								

Source : Power and Water Corporation

APPENDIX D

Summary of incidents which occurred between 1 July 2011 and 30 June 2012

The Commission has reviewed a number of incident reports in the three regulated systems as part of the 2011-12 Review:

- Tennant Creek System: UFLS Events & Tennant Creek Black System Event - 20 March 2012 to 22 March 2012;
- Tennant Creek System: Tennant Creek Black System Event - 19 May 2012;
- Tennant Creek System: Stage 1 UFLS Events - 21 September 2012 to 30 September 2012;
- Darwin-Katherine System: Katherine Bus A Clearance Event - 31 May 2012;
- Darwin-Katherine System: CIPS Unit 6 Trip and UFLS Stage 1 - 1 June 2012;
- Darwin-Katherine System: UFLS Stage 4A - 30 June 2012;
- Darwin-Katherine System: City Zone Operator Error Event - 12 August 2012;
- Darwin-Katherine System: Operator Error Event - Farrar - 3 September 2012;
- Darwin-Katherine System: Frances Bay No Bus Protection Incident - 14 September 2012; and
- Darwin-Katherine System: Katherine Black & Rotational Load Shedding - 4 October 2012.

The Commission also reviewed the SKM report “Alice Springs Electricity Network System Black and UFLS Failure Independent Investigation Report” - 22 August 2012.

Incidents on the Tennant Creek System

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
Incident 1: UFLS events and TC black event	20/03/12	6:59	Over current earth fault and feeder 6 tripping	No cause found	64	17mn	1088mn	1.059mn		SC to recommend fault clearance times (status: Completed) ; SC to provide reference to the relevant parts of the Network Connection Code on the requirements of generator riding through faults (status: Completed); PWC Networks to repair, test and install CB2 at Tennant Creek (status: Completed); To review communication strategy for Power System Outages at TC and form a separate working group to address (status: reported separately); Generation to provide TC Restoration Procedures to SC for approval, and to revised documentation to provide a Generation Black Start Procedure; SC to produce a System Restart Procedure. PWC Networks to review TC Protection Settings for all TC circuits (status: Completed feeder 2, review of feeder 3,4,5 and 6 pending); Generation to test performance of generation plant under fault conditions (status: To be performed end of 2012); PWC Gen and Networks to report on GPS time synchronising/time stamping of Sequence of Events (Status: Tesla confirmed to be GPS time synchronised); PWC to install 36 channel Tesla recorder to capture data on network feeders, transformers and generator connection in switchyard. PWC networks to implement a Protection Grading Study new setting
		13:27	UFLS Stage 2, feeder 2,3 and 6 shedding	Fault on feeder 6 resulting in a surge on gen set 15 causing the machine to trip off on vibration	581	71mn	11959mn	12.74mn		
		17:25	Black station and UFLS events	Fault on feeder 6 causing the event causing coupling transformers to trip open from earth fault current.	1552	108mn	127891mn	54.74mn		
	21/03/12	6:56	SEF event	Suspected palm fronds causing event on feeder 3. Bird strike on feeder 2 (causing a HV bridge to be burnt).	463	155mn	12134mn	14.25mn		
	22/03/12	00:42	Multiple SEF events	Faulty contact within CB2 (blue phase) compounded by loss of SCADA.	92	10mn	46966mn	121.58mn		

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
										proposal. PWC Generation to change TC Unit 15 vibration time delay trip settings (status: Completed)
Incident 2: TC system black	19/05/12	7:00	Overcurrent Earth Fault initiated on Feeder 6 followed by a the tripped Set 15 lead to all stages of UFLS and system black	Fault on Feeder 6 followed by ULFS stages 1 to 3. Gen 15 tripped off due to the fault causing 'Generator End Exciter Vibrations'. Set 10 attempting to carry the load failed. Unit 10 tripped on under frequency.	1360	23mn	27976mn	7.67mn		Return to Unit (RUT) Sequence of Events (SOE), Tesla and Citec system required to be GPS synchronised to allow accurate recording and analysis of the events (status: PWC Gen is undertaking the GPS time synchronisation of the SOE and Citec Systems; Additional Tesla units (same recommendation as for Action 8 above); PWC Gen unit 15 to be investigated for pre-mature tripping on vibration (same Action 11 above).
Incident 3: TC system – Stage 1 UFLS Events	21/09/12	17:31	Feeder 6 tripped on INST (instantaneous over current); Feeder 2 tripped on UFLS (under frequency load shedding)	No cause found	110	15mn	1466mn	0.03mn		No recommendations extending from this report.
	24/09/12	15:25	Feeder 6 tripped on INST; Feeder 2 tripped on UFLS	No cause found	110	5mn	1190mn	0.01mn		
	27/09/12	18:51	Feeder 6 tripped on INST; Feeders 2, 3 and 4 tripped on UFLS	Fault on Feeder 6 causing transformers 3 and 4 to trip open from earth fault current. (see problem with Feeder 6 in Incident 1 and 2) All generators (except for #12) were tripped off on High Engine Speed	1182	152mn	12702mn	0.08mn		

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
	29/09/12	13:38	Feeder 6 tripped on OCEF (over current earth fault); Feeder 2 tripped on UFLS	No cause found (see problem with Feeder 6 in Incident 1 and 2)	110	14mn	1080mn	0.01mn		
	30/09/12	8:06	Feeder 6 tripped on OCEF (over current earth fault); Feeder 2 tripped on UFLS	No cause found (see problem with Feeder 6 in Incident 1 and 2)	110	125mn	8828mn	0.02mn		

Incidents on the Darwin-Katherine System

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
Incident 1: D-K System: Katherine Bus A Clearance Event	31/05/12	1:33	Event resulting in the clearance of KAZSS Bus A.	Fault on a feeder attached to Bus A, due to issues with the wiring of the bus protection scheme. The issue found to be earthing applied at both ends of the cable with CB end earth and CT causing flow of current between earths.	1308	61mn	55612mn	0.004mn		Wiring causing the fault to occur to be corrected (Status: Completed). Switch over process for cutting feeders from the old board to the new to be brought forward. (Status: Completed. All feeders are now fed via the new 22kV switchboard).
Incident 2: D-K System: CIPS Unit 6 Trip and UFLS Stage 1	1/06/12	22:24	Loss of C6 at CIPS resulting in Stage 1 UFLS	C6 tripping was caused by the failure of the Vibration Monitoring System due to a loss of power. The loss of power was caused by a blown fuse. The reason for the blown fuse is not known. As immediate action, C7 was brought online within 30 minutes, and C9 was brought offline and swapped with C1 coming	3894	8mn	24991mn	0.005mn	27.4MW	Replacement of the fuse at C6 (Status: Completed); Power supply to vibration rack to be changed to a spare, thus removing the single point of failure (Status: Completed).

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
				online within 2 hours.						
Incident 3: D-K System: Fault on the 66kV Pine Creek-Cosmo Howley line resulting in UFLS Stage 4A	30/06/12	01.37	Fault on the 66kV Pine Creek – Cosmo Line impacted the feeders associated with the following zone substations: Berrimah, Casuarina , City Zone, Francis Bay, Palmerston, Snell Street, Batchelor and McMinns	A three phase fault occurred on the 66kV Pine Creek-Cosmo line. Slow clearance on the 66PC305 (1.5 seconds), tripping on the overcurrent relay operating. This is thought to be caused by sticking relay contact or trip coil (which has since been rectified by repeated operation). No faulty components were identified. Volume of alarms generated and lack of a situational awareness tool hindered the initial fault finding.	31,712	91mn	708,089mn	5.39mn	28.43MW	Routinely test open/close on CB 66PC305 (and CBs of the same type) to avoid sticking relay contact or trip coil. Review of the overcurrent protection settings at Pine Creek with a view to reducing backup clearance time for feeder faults. Monitor the distance protection operation on CB 66PC305. Development of a Situation Awareness Tool at SC to aid System Controllers in the quick detection of the causes behind system events.
Incident 4: D-K System: City Zone Substation Operator Error Event	12/08/12	13:52	Event happened during the forward switching into gaining access to CZ 66kV Bus A VT for the planned testing and maintenance works.	Operator ‘s error in switching procedure	At least 1164	0.45mn				Automatic change over scheme at Austin Knuckey and Mott Street switching station to be performed is required to be tested to ensure correct operation. SC to review the workstation setup for Duty Grade 3 controller. SC to review Fault/Event Response Work Instruction and insure the event notification requirement is documented, and inform all Grade 3 controllers. SC to test voice recorder system to ensure correct operations.
Incident 5: D-K System: HV Operator Error Event - Lambrick Avenue, Farrar	03/09/12	15:02	Incident occurred when commissioning the new package substation (SS3150) in	Commissioning of the new SS150 required cutting into the existing HV cable and diverting the two cut ends into SS3150. In so doing, HV operator needs to complete 23	50	12mn	600mn			Senior System Controllers to review the Preparation & Restoration Instruction (PRI) to ensure that all permit earths are removed first before energising any apparatus as a precautionary measure against accidentally closing ton to earths that

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
			Lambrick Avenue. The incident resulted in interruption of power supply to the customers on the Roystonea feeder.	steps. The HV operator made 2 switching errors for steps 17 and 18 which resulted in short to earth causing a feeder trip. The error was compounded by the time taken by Grade 3 controller acknowledging the alarms due to high work load and other persistent alarms. (Similar issue to that raised in Incident 6.)						are still applied. Senior System Controllers to follow the "System Control Work Instruction SC O.4.1 Section 7 Block Switching" when undertaking block switching. HV operators to check the PRI's and raise any issues or any possible changes to the program with Senior System Controllers prior to switching. SC to investigate the persistent alarms issue in the control room so critical alarms are identified.
Incident 6: D-K System: Frances Bay No Bus Protection Incident	14/09/12	9.20	The MCB 10Q1 tripped, resulting in a loss of supply to the protection relays and trip circuits breakers (CBs) to the 11kV feeders.. A protection relay fail alarm was generated.	Investigation of the event shows that a Battery Charger Earth Fault at approximately the same time as the trip.	0	55hrs30mn				The performance of the 48V DC supply at Frances Bay to be monitored to ensure that the fault does not return. As per the previous incident at the Lambrick Avenue substation SC is to investigate and review the alarm/action procedures to ensure all Category 1 alarms are actioned/acted upon immediately.
Incident 7: D-K System: Katherine Black and Rotational Load Shedding	4/10/12	15:30	The event occurred after the trip of the 132/22 kV T2. Black start procedures proceeded.	The event was caused by the inadvertent removal of a current transformer secondary wire from its terminal by a contractor causing the 132/22 kV T2 breakers to operate on differential protection. SC's attempts to restore power on the 132KA02 and 132PK 03 caused spurious trips. This was the result of the design of the trip circuit attached to the 132/22kV transformer at Katherine. Additional delays were	3596	25mn	499919mn	0.087mn		KPS Black Start Procedures to be reviewed. Communication protocol between SC, KPS operators and other PWC Generation personnel to be reviewed. The KA 132kV TESLA DDR trigger configuration to be tested and the 22kV TESLA needs to be configured for the new 22kV switchboard The K4 Titan Unit to be included in the DDR . GPS time synchronisation of TELSA DDR's at Katherine and Pine Creek . The trip and close circuit philosophy at Pine Creek and Katherine to be

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed remedial actions
				caused by problems with the Station Black Start procedure used by KPS staff. The Tesla DDR's failed to trigger or record the initial event at the 132kV and 22kV substations because it had not been configured correctly to operate on the 22kV switchboard.						reviewed The feasibility of latched trips to prevent CB close operations, rather than having the CB operate and trip, to be investigated.

Incidents on the Alice Springs System – from SKM Report.

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed Remedial Actions
Stage 3B UFLS Event	13/2/12	03:29hrs	A system black event resulted from slow fault clearance and voltage regulation issues. The black system lasted 20mins, most customers restored after 150mins	Caused by the slow clearance of a fault on the Brewer ties. Resulted in voltage and frequency regulation issues leading to a Black System through lack of a UFLS Islanding Scheme. The initial fault is considered to be caused by trees coming in contact with the conductors.	10808	320mins			6.3	Review the current performance of the Brewer Tie Lines to significantly reduce the number of faults reported as "No Fault Found" to allow corrective actions. Create a dedicated Brewer-Sadadeen Tie and configure existing ties as radial distribution feeders. Review protection scheme in new configuration to meet critical fault clearance times. Improve vegetation management and tree cutting guidelines. Carry out line parameter tests on the Brewer lines for protection scheme design. Revise UFLS scheme to incorporate islanding ability. Investigate application of overvoltage protection.
Stage 2 UFLS Event	13/2/12	09:38hrs	UFLS event caused by loss of Unit 9 at Ron Goodin. Most customer restored after 40mins	Unit 9 tripped due to high lube oil temperatures	6231	65mins				
Stage 3 UFLS Event	5/3/12	07:25hrs	UFLS event caused by loss of Unit 9 at Ron Goodin. Most customer	Initial cause was a fault on the Brewer No 1 tie, again slow clearance time	8577	80mins				

Event	Date	Time	Event	Cause	Total cust. affected	Event duration (mn)	Cust. minutes	System minutes	Reserves level (MW)	Proposed Remedial Actions
			restored after 50mins							
										Undertake network modelling including steady state and dynamic analyses. Review UPS and standby power supplies for adequacy to ensure redundant and fail-safe operation. Review guidelines for recording network outages to minimise reporting of "No Cause Found" Investigate and rectify RGPS Unit 8 control system (Evans & Peck believes this should be extended to all units on the Alice Springs system, particularly RGPS Unit 9) Review System Control procedures regarding switching of 66kV cables. Adopt common guidelines and templates for reporting. Review SCADA data information management processes to allow rapid analysis. Synchronization of time stamping across SCADA, Protection and other systems.
										Review the System Secure Guidelines (Spinning Reserve Levels) Appoint a single Project Manager with responsibility to implement above recommendations.

Note that SKM have only investigated Event 1 above, ie event that occurred on 13 February 2012 in detail, due to lack of data from the other 2 events, and that in their opinion the causes are likely to be similar – Section 6 of the SKM report.

Also by the time of publication of this review, it is expected that a number of the SKM recommendations will have been completed by PWC.