NORTHERN TERRITORY GOVERNMENT

DEPARTMENT OF
TREASURY AND FINANCE

Consultation on the Form of Reliability Standards for the Northern Territory's Regulated Power Systems

Consultation Paper

Submissions due 1 March 2019

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1. Introduction

Since 2001, the Northern Territory electricity sector has been undergoing reform to enhance its efficiency and sustainability and improve outcomes for Territory electricity consumers.

In October 2018, the Government announced electricity market reforms designed to deliver lower cost and reliable power to meet its target of 50 percent renewables commitment by 2030. These reforms include the design and implementation of a wholesale electricity market in the Darwin-Katherine power network tailored to the Territory circumstances.

As part of a current program of work, the Department of Treasury and Finance (DTF), with its technical advisors Oakley Greenwood Pty Ltd, is developing a benchmark for reliability of supply in the Territory's three regulated power systems (Darwin-Katherine, Alice Springs and Tennant Creek).

Current Territory arrangements for reliability are a combination of informal generator-focused benchmarks and a contracting obligation under the System Control Technical Code, which requires generators to cover their customer demand without specifying the level of risk or how to measure demand, and thus ensure appropriate coverage.

In an environment with multiple generators and technologies (e.g. batteries), and more retailers supplying customers, it is necessary to be more prescriptive about how much generation capacity is available and who is accountable for it in order to avoid excessive capacity (which increases costs to customers) or insufficient capacity (which increases the risk of power outages). Establishing a formal benchmark, known as a reliability standard, is essential to achieving these outcomes.

The purpose of this consultation is to invite comment from stakeholders about the form of the reliability standard for generation to be established for each of the three regulated power systems. Subsequent sections of this paper will explain the concept of reliability, elements of a reliability standard and proposals relating to the form for the reliability standards.

Submissions are invited from market participants and interested parties on consultation questions posed in this paper on the focus of, and practical options for, the form of the reliability standard in each of the three power systems.

Submissions

DTF seeks submissions on the form of the reliability standards by **1 March 2019**

Submissions should be provided in Adobe Acrobat or Microsoft Word format by email to DTF's Utilities Reform unit, email DTF.UtilitiesReform@nt.gov.au. On receipt of a submission a confirmation of receipt will be provided, however, it is the submitter's responsibility to ensure successful delivery of their submission.

Any questions regarding the consultation should be directed to DTF's Utilities Reform unit by email DTF.UtilitiesReform@nt.gov.au.

Confidentiality

DTF will make submissions publicly available on its website, with the exclusion of confidential information. Submissions must clearly identify any confidential information and a version suitable for publication with the confidential information removed should be provided to DTF.

DTF may also exercise its discretion not to publish any submission based on content, such as submissions containing material that is offensive or defamatory.

Consultation Process

Following receipt of submissions, DTF will review the submissions and prepare a draft report that informs and summarises responses to the consultation and preliminary decisions on the form of the reliability standards for the three power systems. The draft report will be made available on the DTF website and respondents to the consultation (and other interested parties) invited to provide comment prior to finalisation.

Once the form of each reliability standard has been established, DTF will undertake work to determine the target level of reliability. This is a technical task which entails complex modelling to assess the cost benefit trade-off between value to customers and the cost of capacity.

2. The purpose of a reliability standard

The ability to meet the electricity needs of end users depends both on the amount of generation capacity that has been built as well as the operating performance of generators and the transmission and local distribution networks.

Reliability in this discussion paper is a measure of the ability of generation and transmission capacity to meet end-user needs. This consultation is a first step towards establishing a formal standard for reliability for each of the Territory's three regulated power systems. The consultation deals with how to express the reliability standard, that is, its **form**. The form of a reliability standard is important because it describes the most valued characteristic of generation sector performance. The level at which the standard is set and how and where it will be applied in each power system will be addressed in subsequent work.

Reliability associated with the Territory's electricity networks services and the responsibility of the Power and Water Corporation (PWC) is not part of this proposed standard and is determined separately.

When the reliability standard for each power system is fully developed it will replace the existing broad arrangements that have been carried over from the time when the PWC was a vertically integrated entity managing generation, networks and retailing to most customers in the Northern Territory. At that time, all generation capacity was owned and contracted by PWC.

Starting in 2014, the Territory Government has been undertaking a program of reform designed to allow more generation and retailing businesses into the Territory electricity industry, a path consistent with reforms at a national level to enhance competition and productivity[1]. The Territory's electricity market reform program commenced with the separation of PWC into three government owned corporations: Jacana Energy, an electricity retailer to manage electricity accounts and customer needs; Territory Generation, a power generator to supply Jacana and other electricity retailers; and the remainder of PWC to manage the electricity network, power system operation, gas, water and sewerage services. Territory Generation is presently the dominant generator in the Territory, but the number of businesses producing electricity is expected to increase in coming years, primarily as a result of increasing renewable generation, which is expected to be enhanced by the Government's 50 per cent renewable energy strategy.

To date, reliability in the Territory's regulated power systems has been assessed using a number of metrics in various Power System Reviews published by the Utilities Commission. Metrics include unserved energy, generator adequacy and loss of load expectation/hours. While these reliability metrics have been used for assessment purposes, they have not been formally employed as a reliability standard for determining the amount of generation capacity that is present.

[1] Intergovernmental Agreement on Competition and Productivity – Enhancing Reforms. Available at https://www.coag.gov.au/sites/default/files/agreements/IGA-productivity-reforms.pdf

A reliability standard is necessary to ensure there is an independent, objective way to determine whether the combination of generating units, owned by different parties in a power system, is sufficient. Equally, it will also ensure there is not excessive capacity as, although this may increase reliability, it also comes at a cost (of surplus capacity), which is passed on to customers through higher electricity prices (tariffs) and the Territory Government through the customer service obligation associated with regulated retail electricity tariffs[2].

Establishing a formal reliability standard for each of the three regulated power systems would fulfil two roles:

- to guide calculation of the total amount of generation capacity required to ensure an efficient level of reliability to end users (customers); and
- to be the basis for requirements that will drive the investment-related decisions of individual generators and retailers.

The purpose of this paper is to present the framework for a reliability standard and consider options for the form of the standard to be formally defined and administered. The structure of the paper is as follows:

- an introduction to the concept of reliability and the distinction between reliability and security within a disaggregated electricity sector[3];
- a discussion of the key components of a reliability standard; and
- practical options for the form of the reliability standard based on the characteristics of each power system.

3. Background

3.1. Continuity of supply

A continuous supply to all customers requires that the power system be both reliable and secure. Reliability is primarily determined by the level of investment in generation and network assets. Security of supply is determined by whether the available generation and networks assets can and are operated in a manner which ensures the power system remains stable and within safe technical limits.

In the Territory's power systems, reliability, security and network investment and performance are managed through different arrangements, similar to many other disaggregated power systems. Arrangements include operating and performance standards and independently regulated investment regimes. The following sections briefly introduce these arrangements.

[2] The Territory Government's regulated tariff policy requires electricity retailers to charge households and small business across the Territory a tariff that is lower than the cost of electricity supply. The regulated electricity tariff CSO reimburses retailers for the shortfall between revenue and the cost of supply. The estimated value of the CSO is $72 million in 2018-19.

[3] Where the electricity industry has been separated into separate sectors: generation, networks and retail.

3.1.1. Network performance

Network performance is regulated and assessed for compliance with a series of technical standards and commercial performance incentives that drive capital expenditure, operating costs and in some cases, the impact on efficient dispatch of generation. As part of the Territory Government's electricity market reform program, responsibility for network price regulation and oversight of network access has been transferred from the Utilities Commission of the Northern Territory to the Australian Energy Regulator, with effect from 1 July 2015. Network regulation will continue to transition with progressive application of the National Electricity Law and Rules, due to be completed by 1 July 2019. Further information on the regulation of electricity networks in the Territory can be found on the Utilities Commission (www.utilicom.nt.gov.au) and Australian Energy Regulator (https://www.aer.gov.au/) websites.

3.1.2. Power system security

Power system security is closely linked to reliability and concerns the manner in which a power system is operated and can withstand the impact of major disturbances. Standards for power system security are typically described in regulatory instruments and define limits on technical parameters such as power system frequency and voltage. Current regulatory instruments in the Territory include the System Control Technical Code, Secure System Guidelines and relevant parts of network codes. In the future, these may be incorporated in a Northern Territory version of the National Electricity Rules. Further information on these instruments and the operation of the Territory's power systems can be found on the Utilities Commission[4] and the Power and Water Corporation[5] websites.

3.1.3. Reliability

Reliability in the generation sector, which is the focus of this paper, is determined by whether the level of generating capacity that has been built and is available for service is sufficient to meet the demand of customers.

It is not feasible to aim for 100 per cent reliability of supply to customers in any power system, in part because to attempt this would be prohibitively expensive. Instead, a balance between cost and risk of interruption is set whereby there is an acceptance that on rare occasions interruptions to electricity supply may occur because of a lack of generating capability. A reliability standard is the formal statement of what that balance is in a power system.

A reliability standard is a key decision driver for the level and timing of investment, retirement and day-to-day availability of generating capacity. As a result, the reliability standard drives a substantial percentage of the cost of the electricity industry. In a competitive market, the costs associated with having the necessary level of capacity to meet demand are assigned to industry participants and eventually passed on to customers. Although customers in the Territory already pay for current generating capacity (through electricity tariffs), there is no formal mechanism to ensure there is not a surplus or deficit of capacity.

Finally, it is possible for a power system to be highly reliable yet still suffer blackouts due to loss of security. Conversely, a power system with inadequate generating capacity to meet all customer demand can be operated securely.

3.2. A reliability standard is essential

A reliability standard is an essential component of efficient management of electricity generation regardless of whether generation is operated by a single entity or through a competitive market.

[4] http://www.utilicom.nt.gov.au/Electricity/Technical/Pages/default.aspx
[5] http://www.powerwater.com.au/news_and_publications/publications/technical/system_control_technical_code

A well-designed and implemented reliability standard ensures that there is neither too much capacity, which would increase tariffs, nor too little capacity which, while lowering electricity tariffs, would increase the risk and thus potential impact to customers of interruptions of supply; for example, the cost of product spoilage and loss of business activity.

Typically, the form and level of the reliability standard are set as part of high level policy parameters and then reviewed occasionally. For example, the reliability standard for the National Electricity Market (NEM), which operates in southern and eastern Australia, is reviewed every four years.

Once the reliability standard is set, what matters is the implications for the physical capacity that must be present in the generation sector. Practical application of a reliability standard requires that regardless of the form of the standard, it is necessary to derive a physical level of generation plant that is expected to deliver the required level of reliability to customers. Thus, the focus of annual and daily market operation is on the physical capability needed to meet the standard from year to year, rather than on the reliability standard itself.

Previously it was common to present the required level of generation capacity as a simple total megawatt (MW) amount. Increasing penetration of variable renewable sources of generation (for example, solar and wind) raises new challenges for having an adequate supply of electricity to match demand at all times. For example, a solar plant may be capable of generating a peak level of MW output, but is not able to continuously operate at this level. This means that simple MW capacity is not enough and a more subtle definition, which deals with installed capacity and energy production over a period of time, is needed. It will also be necessary to account for emerging storage technology which can enhance the capability of intermittent resources such as solar to contribute to power system reliability.

Currently, the total nameplate capacity in the three power systems (at present largely gas or gas/diesel plant) appears to be greater than required for peak demand[6] however some of that plant is aged and will at some point be retired. Establishing an appropriate reliability standard will provide clarity on the required level of future capacity and improve planning for future investment and retirement. In parallel, the Territory Government has announced a target of 50 per cent renewable energy by 2030.[7]

4. Elements of a reliability standard

The key matters to be considered in establishing a reliability standard are the Form, Level and Application. This paper focuses on the **form** of a reliability standard, but for information purposes, this section provides a description of all three elements.

4.1. Form

The form of a reliability standard can be thought of as the characteristic of reliability that is (sometimes by default) regarded as the most important in a power system. For example, whether it is more important to aim to supply all customer demand based on the status of the generating units (generator focus) or on the basis of impact on customers (customer focus), and if the latter, how that impact is described.

Generator-focused standards, typically expressed as n-x standards, are based on the ability to meet all demand when components of the generating sector fail.[8]

In contrast, customer-focused standards deal directly with the key limitation of generator standards (that is, the lack of a link to customer impact). The NEM standard, for example, is expressed in terms of the

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[6] Territory Generation Statement of Corporate Intent 2017-18, pp. 15-17. Available at http://territorygeneration.com.au/wp-content/uploads/2016/11/Territory-Generation-Statement-of-Corporate-Intent-2017-18.pdf

[7] https://roadmaptorenewables.nt.gov.au/

[8] An n-2 standard, for example, would mean a system is deemed to have adequate generation if there is sufficient capacity to maintain supply despite the loss of the two largest units of generation plant and the ‘n’ in the equation refers to the total number of generating units in the power system.

maximum annual amount of energy that is required by customers, but which cannot be supplied (unserved energy).

4.2. Level

The level of a reliability standard is a value assigned to the chosen form of the standard.

Ideally, the level of a reliability standard would be set by assessing the value of reliability to customers (that is, how much they are willing to pay for reliability) and relating this to the efficient cost of capacity, which will vary between power systems. However, this is often a contentious undertaking and is typically benchmarked against a range of factors including other power systems, existing practice, the cost of supply and the value to customers. This paper is concerned with the form of standard, and subsequent work and analysis will determine the level of the agreed form.

4.3. Application

The application of a reliability standard deals with which parts of the supply chain the standard applies to, for example, whether the standard applies only to large generators that participate in the wholesale market or to large generators and main transmission lines. Although a final decision will be taken (likely to be at the same time as the level of standard is determined) it is likely the standard will apply to the generation sector through to major transmission connection points.

It should not be assumed that the form, level and application of a reliability standard will be the same in each of the Territory's three power systems. Rather, a reliability standard needs to align with important characteristics and features of a power system and these can differ between systems.

5. Focus of a reliability standard

The first consideration in determining the form of a reliability standard is whether it should be a supplier (generator)-focused standard or a buyer (customer)-focused standard.

5.1.1. Generator focus

Disaggregated competitive markets have rarely adopted a generator-focused standard, instead preferring a customer-focused form. If a generator-focused standard is used, there is no link between the cost of generation and the cost to customers. This means that if the cost of generation falls, there is no way to choose whether the level of reliability should be increased or tariffs lowered. The converse applies if the cost of generation rises, namely, whether reliability should fall (within limits) or tariffs increase (again within limits). Generator-focused standards ignore this cost-risk trade-off.

Additionally, as more intermittent generation enters the market, it becomes increasingly problematic to use a generator-focused reliability standard. This is because the capacity of intermittent resources (such as solar) varies with the weather (due to cloud cover) and there may be periods when no generation occurs (for example, at night for solar generation). Although battery storage can ameliorate intermittency for short intervals, it will generally not do so for extended periods of time such as consecutive days of monsoonal cloud cover during the wet season.

5.1.2. Customer focus

Competitive reforms in the electricity industry generally seek to deliver benefits to customers and reliability standards in these power systems therefore tend to be customer-focused.

Different approaches to customer-focused reliability standards are in use worldwide but are typically based on one or more of duration, frequency and depth of risk of interruption to supply due to inadequate levels of available generating capacity.

Frequency of interruption, as used in a number of power systems, sets a limit on how many times in one or more years there may be a risk of a period of interruption. Standards based on duration of interruption set a limit on the cumulative number of hours per year of (possible) interruption. A standard based on depth of interruption limits the size of each event. A standard based on energy at risk, such as the standard for the NEM, combines duration and depth without limiting either independently, and therefore makes no distinction between one short-lived but deep event, and a series of smaller events. Other markets express the standard in terms of how many days in a year (or multiple years) any level of interruption may occur (this is the common approach in North America) and others express the standard in terms of the number of hours a year there may be a risk of interruption due to limited generation capacity.

The objective of this paper is to consult on how reliability will be expressed in the Territory's power systems.

Duration, frequency and depth are related

In any given power system, the profile of customer demand and the nature of generator availability create a unique link between frequency, duration and depth of interruption. For this reason, it is not practicable to set independent limits for each parameter.

For example, the demand profile for the Darwin-Katherine power system is relatively flat across each day and is similar from day to day within each season (refer Section 7.1 for examples of the profile). In particular, the demand in the wet season is consistently high because there is little difference in temperature and humidity from day to day apart from short-term drops associated with a storm. As a result, any shortfall in generating capacity (that is, when there is insufficient capacity to generate enough electricity to meet the required level of demand) would likely lead to many hours of interruption (long duration) to a limited amount of demand (depth, e.g., the amount of MW consumption foregone by households and businesses without power).

This contrasts with the situation in Victoria, South Australia and the Western Australian electricity market around Perth where temperatures can vary markedly from week to week, resulting in significantly different demand profiles. For example, on extremely hot days, air-conditioning use and thus demand for electricity increases dramatically, while on other days when the temperature is lower, there is much less use of air-conditioning. As a result, the demand profile over a year in the southern states has more peaks where there may be a heightened risk of a shortfall in generating capacity, but those peaks are of short duration (therefore fewer hours over a year compared to peaks in the Darwin-Katherine power system) and greater amount of demand (depth) is at risk in each event. For this reason, the most appropriate form of reliability standard can vary between power systems.

A customer-focused standard is preferred

A customer-focused standard is preferable as it deals directly with the reliability experience of end-use consumers of electricity.

The presence of multiple generator businesses and diverse technologies means that a customer-focused standard is preferred for the Territory's power systems. Such a standard would also reflect the reliability experience of customers.

CONSULTATION QUESTION:

1. Are there reasons to use a generator-focused form of reliability standard rather than the preferred customer-focused form?

6. Options for the form of a customer-focused reliability standard

Interaction between standards for reliability and security

Before discussing options for the form of the reliability standard, it is important to note that there are currently requirements to maintain spinning reserve on the system to ensure power system security is maintained in the event of a sudden disturbance to the supply-demand balance. At present, these requirements mean that the reliability of supply may be assured by actions to maintain security of supply, although this may change over time with the introduction of different technologies including battery storage and demand side management. These changes may reduce the amount of generation needed to be on-line for security purposes. A clear statement through the form of the reliability standard will provide the means to plan, invest and operate to ensure both security and reliability are maintained.

Reliability standard coverage

While it is possible to have a different form (and/or level) of reliability in different parts of a power system, this implies that customers in different parts of the system place a different value on reliability and would be prepared to pay more (or less) than customers elsewhere in the system. Until there is a general capability for supply to be interrupted to those who value reliability from the shared system less than others, it is impractical to have different forms of reliability for different parts of each power system (this is particularly relevant to Darwin-Katherine where a single reliability standard will apply over a wide area). It would also be difficult to manage the consequences of different forms of reliability standard within a power system.

6.1. Practical options for the form of standard for the Territory's power systems

Assuming that reliability standards for the Territory's power systems will describe the customer impact directly, practical options for the choice of metric to use for the form have been limited to those with a customer focus. Each option has differing implications for the frequency, duration and depth of power system interruption, which are discussed in the sections to follow.

6.1.1. Unserved energy (USE)

An Unserved Energy (USE) form of standard (also known as Expected Unserved Energy (EUE)) refers to the amount of energy that is required by customers, but cannot be supplied. It is typically expressed as a percentage of total system energy consumption per annum, for example, the NEM standard for 0.002 per cent USE would mean that out of 10,000 MW-hours of demand, sufficient capacity to limit interruption to no more than 0.2 MW-hours would be installed.

Adopting a USE standard would align with the NEM, however this should not be regarded as a significant advantage, or disadvantage. Instead, other factors should drive the decision.

Key advantages of USE are that it reflects the economic impact on customers and is relatively easy to measure.[9] The USE form aligns with the energy-only market price (single price) arrangement of the NEM, putting a value on cumulative, long-term energy shortfall and rewarding extra energy generation (or demand side responses) to reduce that shortfall.[10]

Competitive wholesale market structures in the Territory are not proposed to take an energy-only form. It is also not anticipated that a competitive wholesale market will be introduced in Alice Springs and Tennant Creek as their small size means such arrangements are unlikely to be cost effective or efficient. A competitive wholesale market is being developed in Darwin-Katherine, however these arrangements

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[9] AEMC Reliability Panel. Comprehensive Reliability Review Final Report December 2007, accessed at http://www.aemc.gov.au on 19 May 2017.

[10] Ibid

are to comprise a capacity (investment) mechanism plus energy trading. Under these arrangements, the level of capacity supplying the Darwin-Katherine market will be separately administered to the trading of energy.

Rather than relying solely on price signals to stimulate investment in capacity (as in the NEM), there will be a specific function (a Reliability Manager function) responsible for determining the future capacity requirements (based on the reliability standards). Retailers will be assigned responsibility for a share of this capacity and will need to either directly contract with generators or pay the Reliability Manager to contract on their behalf.

A key disadvantage with USE is that while it will quantify the expected annual supply interruption, it does not indicate whether these are one-off or multiple events, or the depth of each event. For a relatively flat profile of customer demand, as occurs in the Darwin-Katherine power system, there would be greater uncertainty and high sensitivity of these secondary parameters, in particular of hours at risk. For example, with a flat profile of customer demand, insufficient generation could result in many hours of interruption to a small amount of customer demand before the level of USE per year, as specified by a reliability standard, was reached. In contrast, a demand profile with short but sharp peaks (such as in parts of the NEM and Western Australia) would mean many customers are affected, although for a much shorter period of time. If this sensitivity and uncertainty is understood and accepted then a standard based on USE is feasible.

6.1.2. Loss of load hours (LoLH)

Loss of load hours (LoLH) refers to the expected number of hours the available generation capacity is likely to fall short of total customer demand (that is, interruption is required). It takes the form of a number of hours over a specific period, for example, three hours per year.

LoLH may be a more appropriate form of standard where there is a flat demand profile because if there is a shortfall of capacity, it is likely that the interruptions will extend over a number of hours. That is, the relatively consistent (flat) level of demand means the shortfall will persist (as no generating capacity is available to meet the extra customer demand) compared to a peaky profile where the period when demand surges and exceeds capacity is likely to be short.

While LoLH takes no account of the energy demand or number of customers at risk of outage in aggregate or for any particular event, this may be of less concern when there is a flat profile because it means outages are likely to affect similar amounts of demand and customers.

6.1.3. Hybrid forms

Some jurisdictions use combination or hybrid forms of reliability standards. For example, the Western Australia (WA) reliability standard has two components: a minimum capacity reserve, which requires generating capacity to exceed forecast peak demand by a defined percentage, and a maximum USE set to the same value as the NEM. In the WA electricity market, the profile of demand is even sharper than in the NEM. As a result, the capacity reserve component dominates and the USE component.

6.1.4. Other measures

Internationally, other forms of reliability standards are also used (refer Table 1). Statistical measures such as Loss of Load Expectation (LoLE) or Loss of Load Probability (LoLP) reflect how frequently supply is interrupted, for example, the expected number of days per year in which generating capacity is insufficient to serve demand (LoLE) and the percentage (probability) of days per year in which generating capacity is insufficient to serve demand (LoLP). Other forms may reflect the cumulative duration of interruptions, for example, the total number of hours per year that outages to any (not necessarily the same) customer occurs. These measures are less effective in reflecting the economic impact of outages (lost consumption) and have not been employed in Australia.

6.2. International practices

Table 1 summarises the forms and levels of reliability standards used in a number of electricity markets around the world. It shows the diversity of measures, underlining the need for policy choice.

Table 1 Examples of reliability standards (form and level)

Form	Applied in	*Typical* level	Comment
Unserved Energy (USE)	Australia (NEM)	0.002 per cent (i.e. 99.998 per cent customer demand is met during the 12 month period)	Annual USE takes no account of hours or depth of interruption. Potentially most suitable for 'peaky' demand profiles where interruptions are likely to be limited to short periods of time (Darwin-Katherine has a relatively 'flat' demand profile, which means many hours at near peak demand). USE is also well aligned with the energy-only market pricing design of the NEM.
Hours of interruption (LoLH) Also labelled LoLE in some systems		3 hours per year (average)	Annual hours of interruption takes no account of energy or number of customers at risk in aggregate or in any given event. In a system with many hours at near peak demand each incident is likely to involve limited depth of interruption (relatively fewer customers interrupted at any given time compared to a peaky demand profile) but for an extended number of hours.
Loss of Load Probability (LoLP)/Loss of Load Expectation (LoLE) (1) These terms are used interchangeably in different locations	North America	1 day in 10 years	Requires sufficient capacity to limit risk of interruptions to no more than 1 day in 10 years. Established many years ago by utilities and is plausible for the very large North American systems; however, some have criticised the level of 1 in 10 as uneconomic. Definitions of 1 day in 10 years vary widely: • Some applications consider only the number of days on which there will be some level of interruption – taking no account of number of hours, amount of energy or depth of interruption although these can be assessed by analysis of the systems. • Others define this as 24 hours in 10 years or an average of 2.4 hours per year making it equivalent to LoLH/LoLE of 2.4 hours per year.
LoLP/LoLE (2)	Singapore, Malaysia, South Korea	2 days per year (i.e. undefined level of interruption on 2 days per year)	Requires sufficient capacity to limit risk of interruptions to no more than a specified number of days per year – the number of hours is not defined in the standard but can be forecast from detailed analysis of demand shape and generator performance. In some cases, government initiatives have overridden the minimum standard such that investment exceeds the minimum level needed and the actual reliability is always better than the standard. In Singapore, initiatives to diversify fuel sources have resulted in additional capacity and hence capacity exceeding the minimum.
LoLP/LoLE (3)	UK, Ireland, France	3 to 8 hours per year (average)	Requires sufficient capacity to limit risk of interruption to no more than a specified number of hours per year (probabilistic average). In the UK, 3 hours per year refers to the frequency of 'emergency intervention' action by the Grid Operator with far less (but undefined) risk of interruption to end users.
Capacity Reserve Margin	Germany, Italy, (current) WA WEM	15 to 40 per cent	Requires that generating capacity exceeds predicted demand by a defined percentage, which may be linked to the value of load at risk of not being supplied.

Form	Applied in	*Typical* level	Comment
Generator contingency margin	Utility practice: Hong Kong	n-x	Provides redundancy of ‘X’ generating units.

There is an element of choice in how reliability of supply from the generation sector can be described, that is, what form a reliability standard should take. The advantages and disadvantages of each form are summarised in Table 2.

Table 2 Summary of advantages and disadvantages

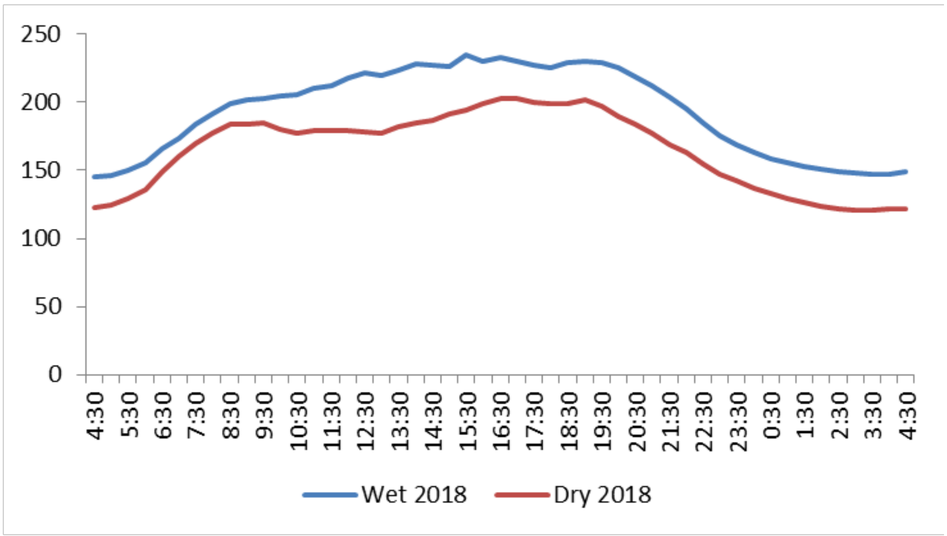
Form	Advantages	Disadvantages
Redundancy (n-x) (Generator focus)	Definitive Simple	Ignores cost-risk trade-off. No capital efficient signals. Problematic for introduction of high penetration renewable/intermittent generation.
Unserved Energy (USE) (Customer focus)	Aligns with NEM Easy to measure	Aligns to an energy-only market. Does not consider frequency of interruptions.
Hours of interruption (LoLH) (Customer focus)	Applies readily to flatter demand profiles (e.g. Darwin-Katherine) Easy to measure	Independent of number of customers. Does not consider energy lost – suitable for known profile of demand.
Loss of Load Probability (LoLP) (Customer focus)	Amenable to long term planning	Defined in esoteric statistical terms – difficult to communicate.

7. Recommended options for the form of reliability standards

7.1. Darwin-Katherine power system

While there is no ‘right’ answer on what form a reliability standard for the Darwin-Katherine power system should take, for reasons discussed previously relating to a flat profile of demand (refer Figure 1 for examples of the profile of demand in the Darwin-Katherine power system), a form that targets the maximum number of hours where there may be lack of supply – Loss of Load Hours (with the number yet to be decided) – is, on balance, preferred.

Figure 1 Average daily demand profiles (MW), Wet and Dry 2018, Darwin-Katherine power system



Note, also, a local network reliability standard is proposed to be set in relation to loss of the 132kV line to Katherine. This will mean Katherine will receive a similar standard of supply from the generation sector as other parts of the system but where there is a risk of interruption is due to network performance it will be the network business that must arrange.

Comment for questions below.

On balance, a standard based on hours at risk – LoLH – may be most appropriate for the Darwin-Katherine power system.

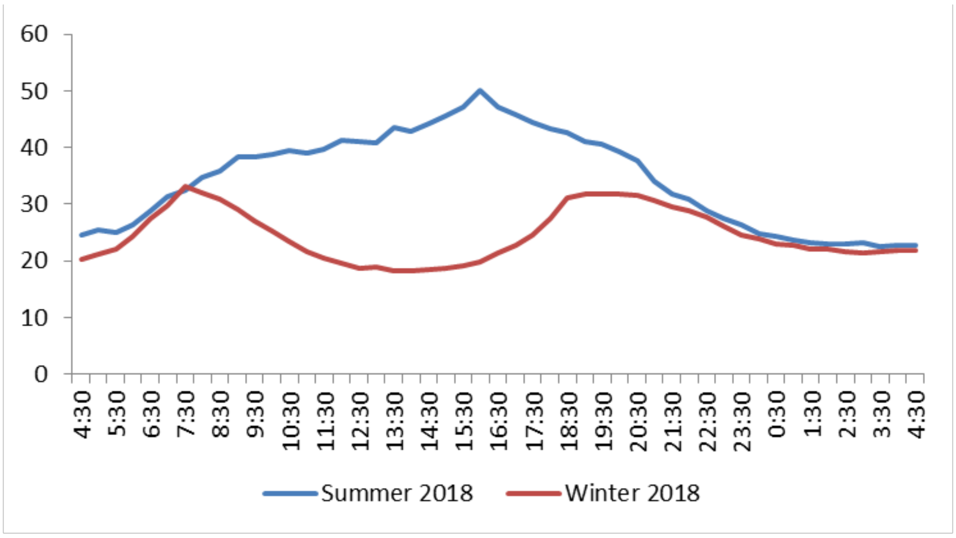
CONSULTATION QUESTIONS:

2. Assuming a customer focus is desirable, would Loss of Load Hours (LoLH) be preferred as the form for the Darwin-Katherine Reliability Standard? Please explain your response.
3. An Unserved Energy (USE) form of reliability standard could be used, but would require acceptance that the amount of energy at risk would be more likely to vary from year to year and there is no direct focus on the duration of outage. Can this variability be understood and accepted by generators and customers?
4. Should another form for the Darwin-Katherine Reliability Standard be considered? What are the advantages and disadvantages of that form compared to LoLH and USE?

7.2. Alice Springs power system

Electricity demand in Alice Springs is highly variable between seasons, with summer having a relatively flat profile while winter has two peak periods of demand, at about 7.30 am and 6.30 pm (refer Figure 2).

Figure 2 Average daily demand profile (MW), Summer and Winter 2018, Alice Springs power system



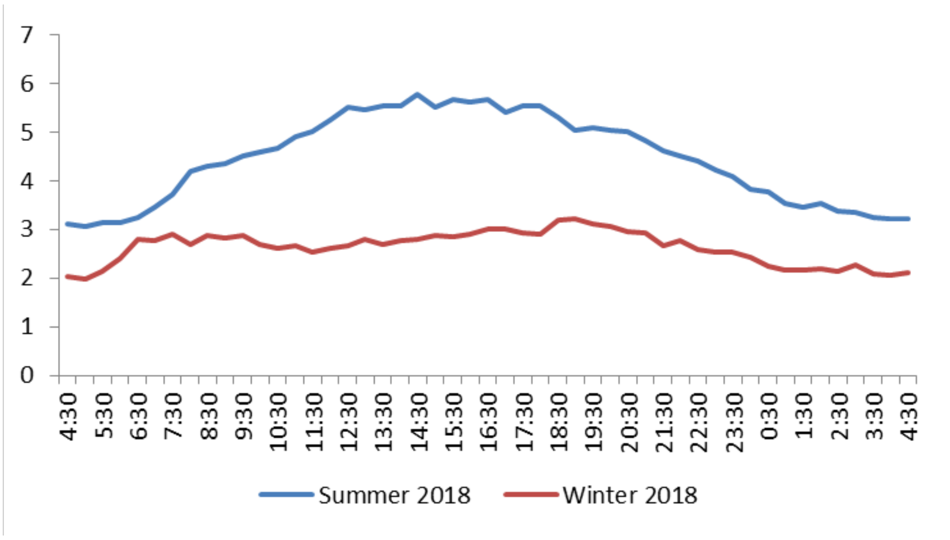
With increasing 'behind the meter' solar penetration, the profile of demand in Alice Springs for energy drawn from the grid is changing, with peak demand shifting to coincide with the start and end of the day (as solar generation ramps up or down). The level of demand drawn from the grid during the day is also declining (accentuating the curve seen in Figure 2) as demand is increasingly met from solar generation.

The intermittency of solar has implications for the security, resilience and reliability of power systems. This variability increases the security requirements to maintain frequency and voltage control and accommodate disturbances to the power system. This could result in requirements to have synchronous generation online for security purposes ensuring that the reliability standard is always met by default.

7.3. Tennant Creek power system

The demand profile for Tennant Creek has similar characteristics to Alice Springs (Figure 3) although peak demand in summer is much higher than in winter. The small size of the power system and the range in demand (between 2-7MW) means that, like Alice Springs, reliability of supply may be assured by actions to maintain security of supply.

Figure 3 Average daily demand profile (MW), Summer and Winter 2018, Tennant Creek power system



CONSULTATION QUESTIONS:

5. Assuming a customer focus is also desirable for the Alice Springs and Tennant Creek power systems, is Loss of Load Hours (LoLH) also preferred as the form for each system's Reliability Standard? Please explain your response.
6. Should another form for the Reliability Standard be considered for Alice Springs and/or Tennant Creek? What are the advantages and disadvantages of that form?

Note: A Reliability Standard is the basis for robust means to manage the level of investment. It is needed regardless of whether investment is managed through a market or is fully regulated.