SUPPLEMENTARY CONSULTATION PAPERS

"FRAMEWORK FOR THE FUTURE"

GENERATOR PERFORMANCE STANDARDS

NORTHERN TERRITORY REGULATED POWER SYSTEMS

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GENERATOR PERFORMANCE STANDARDS SUPPLEMENTARY INFORMATION

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GENERATOR PERFORMANCE STANDARDS SUPPLEMENTARY INFORMATION

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GENERATOR PERFORMANCE STANDARDS SUPPLEMENTARY INFORMATION

Introduction

This paper has been produced by Power and Water as part of the consultation process regarding the Code changes proposed on 18 December 2018 associated with the Network Technical Code (NTC) and System Control Technical Code (SCTC) driven by the new Generator Performance Standards (GPS). The content of this paper is based on the valuable feedback received so far from stakeholders via the information session held on 18 February 2019 and correspondence received to date.

The following paper seeks to provide an overview of the context of the development of the GPS with further specific details around the rationale and proposed additional GPS clause on Capacity Forecasting as well as further rationale around the default generator scheduled classification.

Power and Water look forward to hearing further from stakeholders on the proposed amendments in the context of the Territory's journey to a renewable energy future.

"Framework for the Future"

The regulated Territory electricity systems are in varying stages of transition to renewable energy sources. Based on policy settings, global trends and investor interest it is likely that the Territory power systems will be rapidly transformed where a significantly high percentage of the customer energy demand will be met by renewable energy sources. The dominant technology being deployed in the Territory is solar PV.

The connection of grid scale PV arrays (asynchronous generators) to the power system presents both challenges and opportunities in managing power system security. Asynchronous technologies have no inertia (resistance to change in frequency) that is inherent in synchronous technology and limitations in reactive power range capabilities. However asynchronous technologies are much faster in their ability to change active and reactive power output than synchronous technologies. The transition to a power system dominated by asynchronous technologies will require these generators to provide some of the services and capabilities previously offered by synchronous plant in order to maintain a secure and reliable power system. If there is not a framework to ensure these capabilities are provided by new asynchronous generation it will limit the uptake of renewable energy in the Territory.

The proposed changes to the Network Technical Code (NTC) that incorporate the new Generator Performance Standards (GPS) define the capability that generators must meet in order to connect with the power system. The GPS capabilities form the "Framework for the Future" regarding technical capabilities of the future power system.

The manner in which the GPS capabilities are called upon in dispatch are determined through a Security Constrained Economic Dispatch process.

The approach in developing the "Framework for the Future" GPS has incorporated a "no regrets" mindset. This means that the GPS were developed with the long term in mind so that there is a set of connection standards that facilitate <u>increased</u> levels of renewable energy in the power system and technology agnostic as far as possible to avoid disadvantaging one generator over another. The key reason for this approach is that the Territory power systems are different to the NEM due to the potential rate of renewable connection, whereas the NEM had the scale to allow the evolution of the GPS over time. Some of the key differences to the NEM include:

- Scale – the Territory systems are small so there is higher risk and less room to change if the frameworks aren't right.
- No current market for power system security services in the Darwin to Katherine Interconnected System (DKIS) and will not exist in Alice Springs or Tennant Creek systems.
- There is no interconnection to other geographically diverse markets.
- The current pipeline of renewable technology is PV so there is limited diversity in energy source.
- Current costs and physical practicalities including scale and terrain does not lend itself to long term energy storage technologies in the short to medium term.

The development of the proposed GPS has leveraged the learnings from the NEM whilst considering the realities of the abovementioned differences in the Territory in achieving its renewable energy goals while maintaining power system security.

In regard to the specific content of this paper in Papers A and B, the following excerpt from the Australian Energy Market Operator's (AEMO) "Power System Requirements – page 3" provides relevant context for the capacity forecasting requirements proposed and the importance of scheduled generation.

> *"To achieve a secure and reliable power system, capable of supplying consumers with the electricity they demand with a very high degree of confidence, AEMO and network service providers (NSPs) must have access to a number of critical operational levers to manage the power system within its technical limits. 'Operational pre-requisites' are summarised in Table 1……."*

Table 1 Operational pre-requisites for the power system

Attribute	Description
Dispatchability of the power system	Ability to manage dispatch and configure power system services to maintain system security and reliability. "Dispatch" refers to the process whereby AEMO issues instructions to generators (and certain loads) to operate at a certain output.
Predictability of the power system	Ability to: • Measure or derive accurate data on energy demand, power system flows, and generation output across numerous time frames (real time, hours/days/weeks/years ahead) as key inputs into planning and operational decision-making. • Forecast upcoming power system conditions and have confidence in how the system will perform.

Figure 1 - AEMO Power System Requirements Excerpt[1]

The interrelationship between the GPS driven Code changes, the above essential tenements associated with power system requirements and clauses specific to this paper are illustrated in the following Figure 2 below.

[1] AEMO "Power System Requirements" – March 2018 Reference Paper page 5

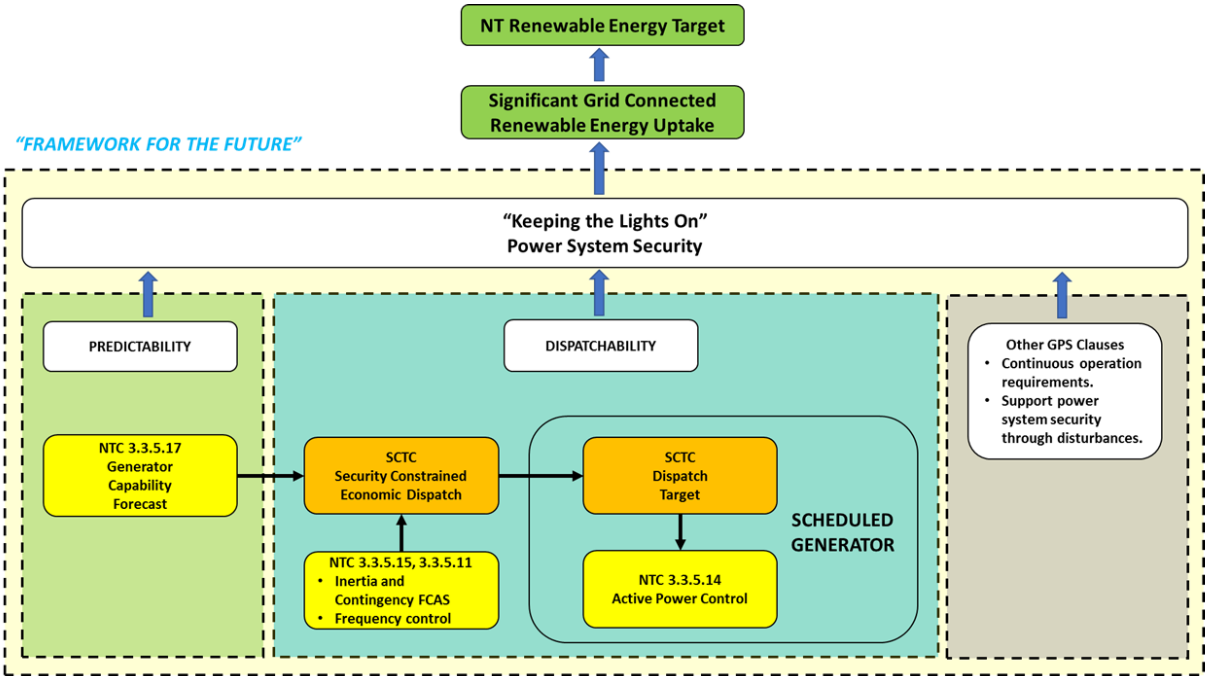

Figure 2 - Framework for the Future overview

The key take outs regarding the above Framework for the Future are:

- The Framework for the Future only represents the GPS that define the capabilities required of generators to connect.
- The proposed capabilities are aligned to the achievement of the NT Government's goal of high penetration of renewable energy whilst meeting power system security requirements.
- Predictability is being achieved through the requirement of a series of forecasts with associated confidence of generator output capacity (new proposed NTC clause 3.3.5.17 – refer Part A of this paper).
- Dispatch of generators based on their forecast capabilities including inertia and contingency Frequency Control Ancillary Service (C-FCAS) will be determined by the Security Constrained Economic Dispatch process informed by the associated regulated system pricing framework. (i.e. cost structure or NTEM[2])
- Generators will be required to be scheduled and follow their dispatch target (proposed NTC clause 3.3.5.14 – refer Part B of this paper).
- Other GPS clauses place requirements of the conditions for generators to remain online and contribution to supporting the power system during disturbances.

The following parts of this paper set out to provide further information in regard to Capacity Forecasting and Scheduled Generator classification.

[2] Subject to outcome of NTEM Consultation Process

PART A – CAPACITY FORECASTING

Introduction

This part of the paper seeks to outline the proposed new GPS capacity forecasting obligations whilst also providing the objectives, context, rationale and philosophy in setting the parameters for capacity forecasting requirements.

The proposed requirements for capacity forecasting are highly aligned with the principles in achieving dispatchability and predictability as discussed under “Framework for the Future”.

In summary the development of the proposed capacity forecasting requirements have been guided by the following principles:

- Day(s) ahead forecasts with sufficient confidence to manage planned outage requests by participants (i.e. generators, load customers and the Network Operator).
- Pre-dispatch forecasts with sufficient confidence to minimise changes in real time security constrained dispatch.
- Short term forecast capability changes that meet this standard should not be managed as a credible contingency event. (e.g. a cloud event for a solar generator should not impact on contingency frequency control ancillary service (C-FCAS) reserves)
- The aggregated system wide capacity forecasting error based on a probabilistic allocation to individual generators should not cause a real time power supply / demand mismatch that would result in the requirement to carry additional and call upon regulating frequency control ancillary service (R-FCAS) or C-FCAS reserves.
- The generator is obligated to provide the capacity forecast to Power and Water Corporation (Power and Water) as it places the accountability for forecasting accuracy onto the generator.
- The obligation to be placed on the generator to report on compliance to this standard.
- Feasibility given the capabilities of current forecast technologies and /or supporting engineering solutions.

The proposed clause to be added to the NTC to achieve the above principles is as follows.

3.3.5.17 – Capacity Forecasting

The term capacity in this clause shall be interpreted as the maximum capability of a generating system to deliver an active power output rather than the actual active power produced at a given point in time.

The capacity forecasting automatic access standard is :

(a) A generator must supply to the Power System Controller a forward forecast of the capacity of its generating system.

(b) This forecast must include the following:

(1) A month ahead forecast for capacity; and

(2) A week ahead forecast for capacity with an accuracy such that for a rolling week period the associated forecast average capacity does not exceed the actual average capacity for the same period of time by more than 30%; and

(3) A 24 hour ahead forecast for capacity updated at 30 minute intervals with an accuracy such that in any rolling 24 hour period at least 90% of the non-zero 30 minute forecast updates do not exceed the actual capacity; and

(4) 12 hours ahead forecast for capacity updated at 10 minute intervals with an accuracy such that in any rolling 12 hour period at least 90% of the non-zero 10 minute forecast updates do not exceed the actual capacity;

(5) 60 minutes ahead forecast for capacity updated at 1 minute intervals with an accuracy measured such that in any rolling 60 minute period :

(i) For at least 95% of the non-zero 1 minute forecast updates the forecast capacity does not exceed the actual capacity; and

(ii) For the 5% of forecast updates that do not meet (i) the forecast update shall not exceed the actual capacity by a margin that is the lesser of 5% generator nameplate rating or 1 MW.

(6) A real time measurement for capacity that is within +/- 0.5 % of actual capacity.

(c) These forecasts must be provided to the Power System Controller in a format determined by the Power System Controller.

(d) The generating system owner will be required to provide compliance reporting against the above requirements in a format and timeframe determined by the Power System Controller.

This standard will be subject to periodic review with operational as generation mix and associated technologies change the capability of the power system in regards to withstand discrepancies between forecast and actual active power capacity.

Explanation of the Standard

The following provides a more detailed explanation of the purpose of each capacity forecast subclause (b) (1) – (6).

A month ahead forecast for capacity

This is required to enable "best intention" capability to assist the Power System Controller in managing the planned outages requested by generators, load customers and the Network Operator. There is no accuracy obligation.

A week ahead forecast for capacity updated daily with an accuracy such that for a rolling week period the associated non-zero forecast average capacity does not exceed the non-zero actual average capacity for the same period of time by more than 30%

This forecast is used for outage planning due to the closer proximity of requested outages by participants who require a greater level of confidence of outages going ahead and reducing the risk of late cancellations. It is also easier to manage the power system with excess capacity than less. Therefore this forecast needs a suitable measure and it is proposed that the capacity is measured over a one week period given the varying durations of outage requests and ability to recall outages.

A 24 hour ahead forecast for capacity updated at 30 minute intervals with an accuracy such that in any rolling 24 hour period at least 90% of the non-zero 30 minute forecast updates do not exceed the actual capacity.

This is required as a balance between the expected energy availability and the certainty of capacity in order to have higher confidence of likely actual dispatch.

12 hours ahead forecast for capacity updated at 10 minute intervals with an accuracy such that in any rolling 12 hour period at least 90% of the non-zero 10 minute forecast updates do not exceed the actual capacity

This is required as a balance between the expected energy availability and the certainty of capacity in order to have higher confidence in the near real time forecast for pre-dispatch to ensure that there is suitable generator capacity available to meet the demand requirements and sufficient reserves for managing regulation and credible contingency events.

60 minutes ahead forecast for capacity updated at 1 minute intervals with an accuracy measured such that in any rolling 60 minute period :

- **For at least 95% of the non-zero 1 minute forecast updates the forecast capacity does not exceed the actual capacity; and**
- **For the 5% of forecast updates that do not meet (i) the forecast update shall not exceed the actual capacity by a margin that is the lesser of 5% generator nameplate rating or 1 MW.**

This is required to manage re-dispatch for real time capacity variations while maintaining all regulating and contingency reserves.

A real time measurement for capacity that is within +/- 0.5 % of actual capacity.

This is needed to understand the reserves available on the system in real time and as a metric to compare against the forecast to ensure accuracy of forecasts is achieved. This is expected to be an easily achieved standard for all generator types. For synchronous generators the capacity is known from test results and ambient temperature conditions and are generally highly repeatable. For solar generators it is assumed the capability is measured on the DC side of the inverter and the conversion losses are well known and calibrated.

How does this compare to the NEM?

The table below illustrates that similar levels of forecasting are required in the NEM:

NT GPS capacity forecast 3.3.5.17 (b)	Most relevant NEM forecast
(1) A month ahead forecast for capacity	Medium Term – Projected Assessment of System Adequacy (MT- PASA)
(2) A week ahead forecast for capacity	Short Term – Projected Assessment of System Adequacy (ST- PASA)
(3) A 24 hour ahead forecast for capacity	Pre-dispatch
(4) A 12 hour ahead forecast for capacity	Pre-dispatch
(5) A 60 minute ahead forecast for capacity	Pre-dispatch / Dispatch

Table 1: Comparison of forecasting requirements to the NEM

How Did Power and Water Formulate the Standard?

The following provides further insight behind the methodology and rationale in developing the standard with particular focus on the hour ahead forecasting requirements.

Managing Power System Frequency Objective

The overall objective for Power and Water in managing power system frequency in the context of capacity forecasting is that the aggregated system wide capacity forecasting error (delegated to individual generators) should not cause a real time power supply / demand mismatch that would result in the requirement to hold additional or call upon R-FCAS or C-FCAS reserves.

The following Figure 3 illustrates the effects where an under frequency event is caused by a loss of generation. Equally there could be an over frequency event caused by the disconnection of a significant amount of load but the under frequency event is the more challenging scenario to manage power system security and reliability in the Territory.

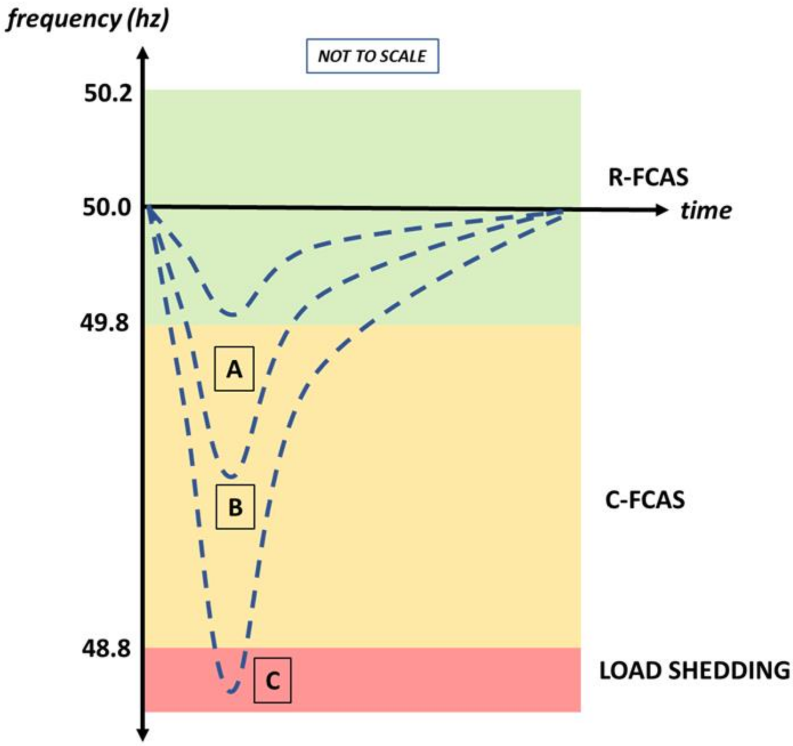

Figure 3 - Forecasting accuracy scenario power system impacts

Ideal scenario

This would require the forecast capacity to always be greater than or equal to actual capacity. This would result in dispatch of generators such that normal FCAS reserves for regulating for system wide load variations were always maintained under any change in generator capacity scenarios.

Scenario A – "Acceptable risk by exception" forecasting error scenario

In this scenario the inaccuracy of capacity forecasting results in a sudden supply / demand mismatch that is able to be managed by the other online generators that are regulating frequency (R-FCAS). If this were to be a regular occurrence rather than just in the exceptional circumstance there would be increased levels of R-FCAS and C-FCAS reserve being dispatched resulting in higher costs to manage the increased customer reliability risk.

Scenario B – "Unacceptable Increased Reliability Risk Scenario"

Under this scenario the level of forecasting accuracy is such that the residual change in generation causes the frequency to fall outside the normal band and requires C-FCAS generators to assist in restoring frequency. This scenario exposes customers to a higher level of risk of supply interruption if a subsequent credible contingency event occurs at the same time. If this were to be a regular occurrence there would be significantly higher levels of C-FCAS reserves dispatched to maintain capacity for defined contingency events resulting in higher costs. It is an unacceptable scenario for events that are not credible contingencies.

Scenario C – "Unacceptable impact on customers"

This capacity forecasting error scenario results in a supply / demand mismatch that is beyond the level of dispatched C-FCAS and relies on under frequency load shedding schemes to disconnect customers to restore supply / demand balance. This scheme is reserved for emergency situations typically where more than one generator unexpectedly trips or certain islanding events. It is an unacceptable scenario for events that are not protected or non-credible events.

Given the above, Power and Water propose that for at least 95% of the time the capacity forecasts result in the "Ideal" scenario and that up to 5% of the time the forecasting error is contained within the "Acceptable risk by exception" scenario.

Power System Tolerance to Capacity Forecast Errors

In order to understand the tolerance of the Territory power systems in regard to each of the above scenarios (i.e. in real time operations), the following Figure 4 illustrates an estimate of the amount of power supply / demand mismatch at various levels of system demand in the Darwin – Katherine power system to reach each of the above scenarios ignoring FCAS contributions from online regulating generators (i.e. no governor or AGC response) in line with the overall forecasting objective not to call upon C-FCAS or R-FCAS.

The blue line illustrates the quantum of total system wide effective loss of generation to operate within Scenario A described above and the amber line is the onset of load shedding which is unacceptable but shown to illustrate the size of power mismatch. The assumed frequency prior to the step-change forecasting error is 50.0 Hz.

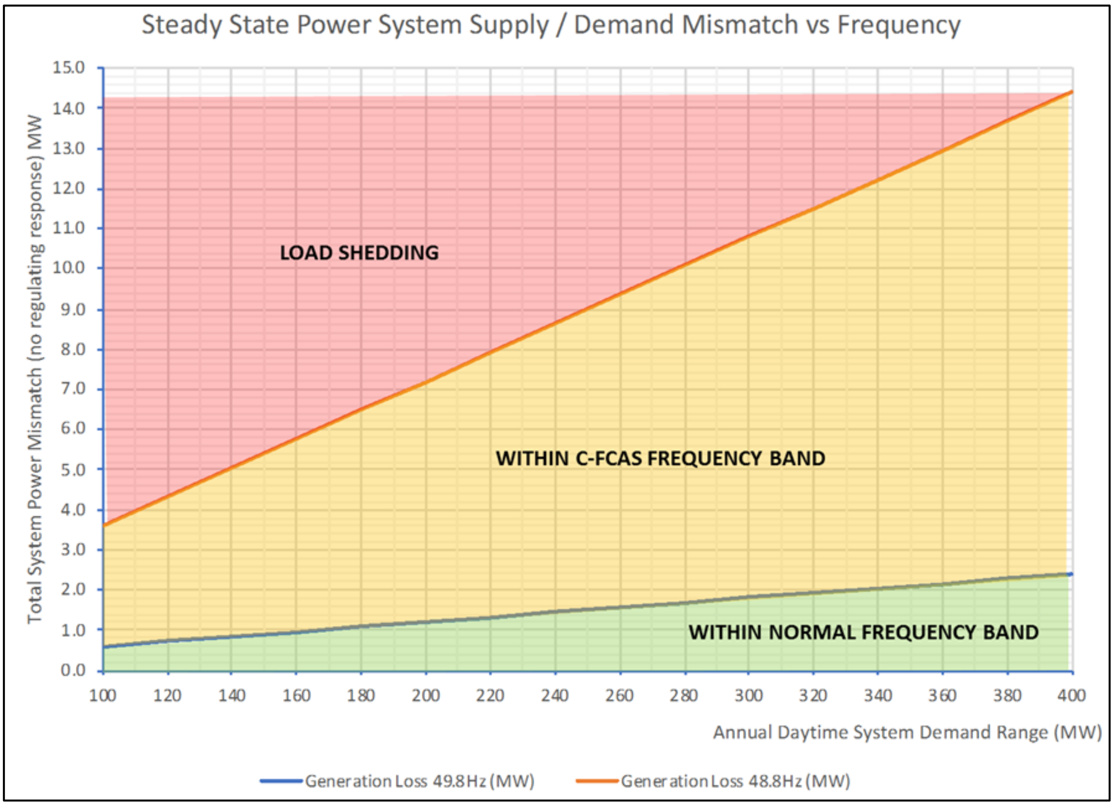

Figure 4 - Power Supply / Demand Mismatch vs System Demand and Unregulated Frequency Impacts

Figure 4 represents the possible range of the Darwin – Katherine system wide daytime demand. This system has been used to identify an appropriate scaling factor that could be applied to the other Territory regulated power systems.

Based on the above a forecasting error resulting in a step reduction in power supply would need to be contained within the range of 0.6 – 2.4 MW to achieve Scenario A. The outer limit where load shedding would commence is between 3.6 – 14.4 MW. Note – in reality governor action would not allow load shedding at these levels but that is not the purpose of this assessment as stated above.

These figures are used to determine the hour ahead capacity forecast requirements as follows.

In the interest of providing a reasonable single number and compromise between minimum and maximum demand, an assumed midpoint of 1.5 MW system wide step change has been used. Note - at minimum daytime demand levels there is a risk of relying on R-FCAS and C-FCAS.

Given the understanding of the current status of new solar generators poised to connect to the power system in terms of size and location, Power and Water's working assumption is to allow for 30MW worth of system wide dispatched generation to be affected by concurrent capacity forecasting error (i.e. "the remaining 5%). This results in 1.5MW/30MW (5%) on a prorated basis. To allow for the possibility of a larger generator (e.g. 30MW or more) concurrently providing a forecast error is capped at 1 MW error per generating system. Note due to the proposed connection locations it is likely that two or more sites may have concurrent forecasting errors.

Capability of Existing Generators to Manage Capacity Forecast Reductions

The most challenging scenario to manage in terms of power system supply / demand balance is counterbalancing a supply shortfall. Generally it is far easier for generators to reduce output than to increase output.

In the short term the ability to provide the counterbalancing power supply to match a forecast reduction in generator output will fall on the existing synchronous generator fleet. The ability for regulating generators to respond to short notice generation shortfall is a function of their loading rates and start times and size of generation shortfall being counter balanced.

The current operating practice is that all existing synchronous generators provide frequency regulating services. The power system is operated to have an optimal range of online capacity in reserve to respond to expected variations in system demand (i.e. there is no R-FCAS provision for shortfalls in generation). Forecast shortfalls in generation capacity may require additional generators to be brought online in advance.

Figure 5 illustrates the range of operating scenarios in regards to the relationship between online regulating generators and incremental forecast reduction on generation capacity required to be counter balanced.

Figure 5 - Frequency regulating generator capability

The blue line in the above Figure 5 illustrates a high system demand scenario with a high level of dispatched generation whilst the red line typifies a low system demand. These "bookends" provide an instructive view with the following observations.

- Higher dispatch associated with higher system demand provides more online generation headroom than low system demand.
- The blue line scenario can result in a relatively fast allowable dispatch ramp rate and can be deployed without delay.
- The red line scenario illustrates the start time and staged loading rate is due to the need to bring additional units online and fewer generators to counterbalance the shortfall.

Note that the Power System Controller will always provide a dispatch target ramp rate at the level that the real time operating scenario permits.

However, for the purpose of developing a near real time forecast parameter to manage power system security in the event of a forecast capacity reduction, Power and Water proposes a 60 minute ahead forecast in order to enable the range of capacity forecast reduction vs counterbalancing generation required. The red line above shows the historical delay in bringing plant online of 30 minutes and immediately uses all surplus regulating capability available to manage the ramp off of plant over the next 15 minutes. The 60 minute ahead requirement is built up from the following considerations in relation to the red line above.

- Start time of additional generation lag of 30 minutes
- 15 minutes to ramp additional generation
- 15 minute allowance for existing manual processes:
  - Manual handover of plant (local control to System Control).
  - Decision making by controllers such as:

- assessing forecast demand/reserve levels and collating multiple capacity forecast sources (ensuring a unit start required before requesting).
- Other security requirements (such as voltage control and system constraints)
- Coordination activities for multiple generator starts and ramps as required.

Capability of Solar Forecasting Technology

The main challenge for forecasting generator capability lays with solar PV generators in particular longer term capacity and cloud events. Power and Water understands the capability to achieve the accuracy requirements vs timeframes to be within the realm of current technology. This is based on discussions with solar forecasting providers and the following study contained in an ARENA Report "Australian Solar Energy Forecasting System Final report: project results and lessons learnt"[3].

Table 2 – Accuracy in terms of NMAE for the Black Mountain Test Systems

	5 minutes ahead	1 hour ahead (60 min)	4 hours ahead (240 min)	12 hours ahead (720 min)	24 hours ahead (1440 min)	40 hours ahead (2400 min)	6 days ahead (8640 min)
Mar-14	5.62%	6.45%	7.72%	8.34%	8.69%	9.19%	13.28%
Apr-14	5.13%	8.13%	10.00%	10.07%	10.42%	10.70%	13.56%
May-14	4.13%	6.36%	7.67%	7.68%	8.14%	8.28%	11.96%
Jun-14	4.65%	7.95%	9.80%	9.88%	10.14%	11.37%	13.66%
Jul-14	4.38%	7.10%	9.37%	9.19%	9.41%	9.44%	11.46%
Aug-14	5.74%	14.15%	15.84%	15.95%	15.70%	15.91%	16.26%
Sep-14	5.43%	9.49%	11.06%	11.37%	11.97%	12.04%	14.87%
Oct-14	3.91%	6.06%	7.65%	7.84%	8.15%	7.89%	9.92%
Nov-14	4.20%	4.76%	5.27%	5.37%	5.62%	5.66%	7.60%
Dec-14	5.59%	5.69%	6.42%	6.63%	6.73%	7.48%	8.38%
Jan-15	6.02%	5.45%	6.11%	5.92%	6.01%	6.14%	8.75%
Feb-15	6.40%	6.86%	7.99%	8.19%	8.20%	8.70%	9.97%
Mar-15	4.73%	5.25%	6.52%	6.77%	6.92%	6.89%	9.05%

Figure 6 - Normalised mean average error for ARENA PV test system[4]

It is important to note that this study was undertaken three years ago and relied solely on forecasting capabilities with no battery support provisions. Power and Water also

[3] - An undated report although the project ran from 2013 – 2016.

[4] Arena Report - Australian Solar Energy Forecasting System Final report: project results and lessons learnt page 15 - undated

understands that forecasting technology has progressed significantly in this time period. Regardless of the above, the results outlined in Figure 6 are broadly in line with the proposed requirements.

In terms of the ability to forecast cloud events, the following is extracted from page 24 of the same ARENA report.

> *"The three figures below show typical examples of this process, forecasting the timing of a shade event with approaching clouds. These examples were chosen to show the performance of the system in several typical cloud conditions which cause intermittent solar generation – high cirrus cloud, relatively stable / low advection cumulus, and high advection (dissolution) cumulus clouds. The system was able to detect the upcoming shade events more than 10 minutes in advances in all cases, and shade-event forecasts were all forecast on or prior to the actual event."*

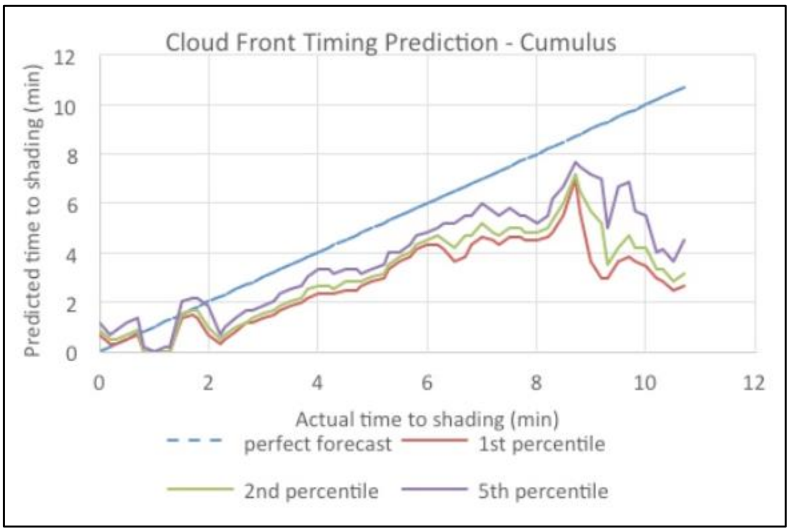

Figure 7 - ARENA test station cloud forecasting results

Although Figure 7 only shows 10 minutes ahead it may indicate that the timing for a cloud event might typically be ahead of actual time.

Discussions during the information session held on 18 February 2019 provided a mixed view among the attendees particularly in regard to the hour ahead forecasts.

Power and Water concludes that there appears to be sufficient basis that the proposed capacity forecast standard is possible to achieve.

Options to Manage Capacity Forecasting Accuracy and Operational Risks

Despite the proposed capacity forecasting standard there is a risk of the standard not being met on occasions or that a particular generator seeks to mitigate forecasting error risk or maximise energy sales in the case of a solar generator during cloud events. (ie optimising ramp rates)

Possible options to address these issues are summarised in Table 2 below. Note these are provided merely to provide stakeholders examples of the options available to both generators and Power and Water and are not intended to be an exhaustive list.

Options	Pro's	Con's
Generator side	• Allows more renewable energy to be dispatched. • Allows generator to better manage forecast risk. • Intermittent generators minimise harm to the system as additional reserves aren't held online at all times.	
Use of a battery or other technical solution to automatically compensate: • for some or all of the reduction in solar PV output between Power and Water dispatch target ramp and "uncontrolled" generator output. • To negate cloud forecasting conservatism required to deal with short duration (low energy component) cloud cover events.	• Possible optimisation / dual use with required C-FCAS • Spend less on cloud forecasting technology. • Less spilled energy.	• Additional capital cost
• Include a conservative bias in capacity forecast (eg for cloud events).	• Control over the quantum of spilled energy when compared to Power and Water options.	• Greater level of spilled energy.
• Invest in higher accuracy cloud forecasting technologies.	• Less spilled energy due to less conservative bias applied by the generator on their forecast.	• Additional capital cost.
Power and Water side These options are only expected to be used in the event of a generator not meeting the forecasting standard.		• A lower level of renewable energy will be dispatched than for generator side options. • Intermittent generators cause harm to the system by requiring additional reserves to online at all times.
• Constraining generator output on days of increased risk (eg	• Reduces need for additional contingency	• Greater level of spilled energy.

Options	Pro's	Con's
cloudy forecast days).	reserves. • Reduces load shedding risk.	
• Dispatching higher levels of frequency ancillary services.	• Reduces load shedding risk.	• Increased cost to customers. • Higher constraints on solar generators.

Table 2 - Options for managing generator capacity forecast accuracy and operational risk

In setting the right framework for a future where significant energy is supplied by renewable energy, it is essential to have accurate capacity forecasting to enable scheduling and dispatch. The GPS has placed the obligation of the provision of accurate capacity forecasting onto the generators as it is the asset owner that understands their plant best. The table above supports the approach of generators in managing forecasting error risk and minimising spilt energy as it doesn't impact on other users and better supports the goal of achieving the Territory's renewable energy target.

PART B – SCHEDULED GENERATOR CLASSIFICATION

Introduction

This part of the paper has been provided to supplement the information provided during the public information session held on 18 February 2019 in relation to the proposed change to the System Control Technical Code (SCTC) 3.2.3 (b) which removes the classification of semi scheduled generators. Further, The Network Technical Code (NTC) 3.3.5.14 "Active Power Control" only refers to scheduled generators. This paper also addresses stakeholder questions raised in regard to whether a renewable generator could be classified as a non-scheduled generator.

What is Security Constrained Economic Dispatch?

Security constraints are applied first to either limit the maximum output of generating plant or require a minimum level of generation online for system security purposes. The economic dispatch component follows the security constraints and allocates energy providers to supply a quantum of energy and reserves where the sum total of energy dispatched matches the demand and reserve requirements to cover unexpected changes in either the supply or demand.

The amount of reserve required to cover unexpected changes in supply are dependent on the level of uncertainty of the unexpected supply changes, traditionally this is only the failure of an on-line generating system. This is proposed to remain the case.

The amount of reserve required to cover unexpected changes in demand are dependent on the level of uncertainty of the unexpected demand changes, traditionally this is the failure of a network asset supplying load or the aggregated system wide variation in the power consumption of users (relatively minor).

Due to this it is critical that the supply can be relied upon to meet the energy demand and reserve requirements, these features are only provided by scheduled generation. Without confidence in capacity forecasts (predictability) and dispatchability, this cannot be achieved.

How do we propose to classify generation?

Classification of non-scheduled or semi-scheduled are only applied to generation that is not capable of being scheduled. The GPS sets out a framework that ensures connecting generators are capable of being scheduled, via the active power control arrangements and the capacity forecasting mechanism. The known technologies available including solar PV with supporting equipment such as batteries, sky cameras etc. are able to meet the requirements set out in the GPS. Thus, the appropriate classification for new connections is proposed to be scheduled.

Why Non-Scheduled Is Inappropriate

Non-scheduled generators are able to "self-dispatch" meaning they can operate at any output that they want to. Non-Scheduled generation does not have any obligation to operate within maximum or minimum system security constraints or to follow a dispatch instruction to match supply to demand.

- Non-scheduled generation cannot be relied upon to meet energy demand or reserve requirements.

- Non-scheduled generation increases the reserves required on the system to manage generation supply uncertainty.

The above two points place a limit on the extent of non-scheduled generation that can be accepted onto the system as it needs to be supported by scheduled generation which requires a portion of the energy to operate in a stable manner.

In the context of the objectives of the Framework for the Future outlined in the front of this paper and the increasing role of renewable energy in the energy mix, it would be counterproductive to allow discretion over which generator should / should not be a non-scheduled generator.

The overwhelming majority of generation currently installed is scheduled.

Why Semi Scheduled Classification Is Inappropriate

Semi-Scheduled generation is similar to the non-scheduled generation, with the exception that a security constraint to operate at or below a value can be applied. The two core issues for non-scheduled generation are still applicable to semi-scheduled:

- Semi-scheduled generation cannot be relied upon to meet energy demand or reserve requirements.
- Semi-scheduled generation increases the reserves required on the system to manage a new form of generation supply uncertainty.

For example, a solar PV site that is semi-scheduled is self-dispatched and may intend to operate at its capacity except when restricted by a security constraint. The solar PV site has no obligation to achieve this capacity; it could cease supplying energy at any point in time.

Why Scheduled Classification is appropriate

Scheduled generators are dispatched by the Power System Controller meaning their output is co-ordinated to ensure energy supply and demand are matched and the appropriate level of security reserves can be relied upon and optimised. Scheduled generation has an obligation to operate within maximum or minimum system security constraints and to follow a dispatch instruction to match supply to demand.

Building on the example above of a solar PV site, if the same site was scheduled it may operate at its capacity (subject to economic dispatch requirements) except when restricted by a security constraint. However it can be relied upon to achieve its capacity as it is obliged to achieve this capacity when it is dispatched to this level; thus it may also contribute to meeting security reserves.

Conclusion:

To facilitate the level of PV generator connection applications received and to progress towards the 50% renewable energy target, it will be required that renewable technologies supply a significant portion of energy. For solar PV, which is the currently the most feasible renewable technology in the Territory, this will require that a large majority of energy (trending towards 100%) is supplied by solar PV for some periods of the day. As such it is critical that this technology can be relied upon to meet the energy demand and reserve requirements. These features are only provided by scheduled generation. Hence the new renewable generation must be scheduled to achieve high renewable penetration.