Review of the Northern Territory Generator Performance Standards

Application to the Utilities Commission to approve amendments to the Network Technical Code and System Control Technical Code

September 2019

PowerWater

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Glossary of terms

Term or abbreviation	Meaning
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ASEFS	AEMO's Australian Solar Energy Forecasting System
Capability	Connection requirement (in the network technical code): Connecting parties are to demonstrate that plant can supply FCAS services if the generator is in the appropriate control mode to do this and with appropriate headroom/floorroom. It does not specify a generator will be obligated to operate in this mode or curtailed to ensure provision.
C-FCAS	Contingency Frequency Control Ancillary Services
Commission	Northern Territory Utilities Commission
Delivery	Operation is the result of provision when a service is used. For instance if a generator tripped, other generators providing C-FCAS raise would then deliver this service by increasing their output in response to the low system frequency.
DKIS	Darwin Katherine Interconnected System
dual fuel	gas/diesel
Electricity Reform Act	*Electricity Reform Act 2000* (NT)
Electricity Reform (Administration) Regulations	*Electricity Reform (Administration) Regulations 2000* (NT)
Enablement	Operational requirement (SCTC): If the System Controller requires a generator to be enabled for FCAS it will only supply it if it has the headroom (for raise) or floorroom (for lower) to do so. A generator operating at maximum output can be enabled for FCAS, but be unable to supply FCAS raise as it has no headroom. In regards to lower service, a generator can provide FCAS lower if it is enabled and it is dispatched above its minimum stable load.
GPS	generator performance standards
insolation	solar irradiance forecast
I-NTEM	Current commercial arrangements in the NT energy market for the Interim Northern Territory Energy Market
Licensee	system controller
MW	megawatts
NEM	National Electricity Market
NER	National Electricity Rules
NT	Northern Territory

NTC	Network Technical Code
NTEM	NT Electricity Market
NTPSPR	Northern Territory Power System Performance Review
NT NER	National Electricity Rules (Northern Territory)
Power and Water or PWC	Power and Water Corporation
Provision	Operational requirement (in the system control technical code): If the System Controller requires a generator to be enabled for FCAS services AND its dispatch level has the headroom or floorroom to supply the FCAS service it is providing FCAS. For example, a generator dispatched below maximum capability that is enabled for FCAS is able to provide an FCAS raise service. This service is the quantity referred to in any market payment arrangements.
RE	renewable energy
R-FCAS	Regulating Contingency Frequency Control Ancillary Services
SCTC	System Control Technical Code
SSG	Secure System Guidelines
TGen	Territory Generation
the Application Act	*National Electricity (Northern Territory) (National Uniform Legislation) Act 2015*
UFLS	under frequency load shedding
UIGF	unconstrained intermittent generation forecast
Utilities Commission Act	*Utilities Commission Act 2000* (NT)
VRE	variable renewable energy
WEM	West Australian Energy Market or Wholesale Electricity Market (WA)

Executive summary

Power and Water performs critical roles in system control and network operation in the Northern Territory (NT), and is responsible for developing various technical instruments that enable statutory objectives to be met, notably the Network Technical Code and System Control Technical Code. However, we require the Commission's approval to change these codes.

The generator performance standards (GPS) are an important pillar of the NT's power system regulatory and coordination framework. They support the interests of Territorian electricity consumers by:

- enabling third party private owners of generation assets to connect those assets to the power system and sell their energy; and
- ensuring the power system remains secure and reliable, and that those who drive risks and costs to the system face those costs, to minimise them commercially.

Doing nothing in relation to GPS for the NT is not an option. The renewable industry is maturing, and increasingly being called on to play a central role in meeting the energy demands of the NT power systems. The NT's extremely small power systems will rapidly move to the point where renewable generators represent the majority of the generation production at certain times. Unless appropriate GPS are implemented as soon as possible, the objectives of both the Utilities Commission Act and Electricity Reform Act will be undermined.

This application follows nine months of formal consultation with stakeholders on the introduction of GPS for the NT, which is described within this application. That consultation has resulted in a number of improvements to our proposed amendments. It has also highlighted some stakeholders' initial misconceptions regarding the NT context, and the suitability of equivalent National Electricity Market (NEM) arrangements.

The solutions proposed in this application and code changes are appropriately tailored to the specific conditions that are found in the NT. They are also solutions that Power and Water believes best meet the statutory objectives.

Structure of this application

This application is structured to document how Power and Water has met the content, procedural and consultation requirements to enable the Commission to approve the proposed code changes that are set out in mark-up in the Appendixes.

Part A | describes changes proposed for the Network Technical Code and System Control Technical Code, explains why, and seeks formal Utilities Commission approval for the proposed changes.

- Section 1 introduces the purpose and regulatory framework for this application
- Section 2 sets out the context for and triggers giving rise to the proposed code amendments
- Section 3 documents the consultation process undertaken by Power and Water that has informed and refined the proposed code amendments
- Section 4 provides an overview of the proposed code amendments

Part B | provides supporting information on key issues raised during consultation on the proposed changes

- Section 5 – application of GPS and grandfathering provisions
- Section 6 – forecasting requirements and consideration of other options
- Section 7 – generator classifications
- Section 8 – inertia and/or C-FCAS capability requirements.

For each of these key issues, Power and Water describes the proposed amendment, the problems the amendment seeks to address, why the proposed amendment is preferable to alternatives considered and raised by stakeholders, and how the proposed amendment meets the requirements that the Commission must consider under section 6(2) of the *Utilities Commission Act*.

Appendix A | Amended Network Technical Code

Appendix B | Amended System Control Technical Code

Appendix C | List of proposed code change provisions

Appendix D | Outcomes of the June-July 2019 round of consultation

Appendix E | Report by Entura confirming positions after consultation

Appendix F | Industry Initiated Code Change Proposals

Part A | Required GPS changes

1. Introduction

1.1 Purpose of this application

This application seeks approval from the Utilities Commission (the Commission) for amendments to the Network Technical Code (NTC) and System Control Technical Code (SCTC) as marked up in Appendix A and Appendix B.

These amendments give effect to the generator performance standards (GPS) that Power and Water Corporation (Power and Water) has been consulting stakeholder on since late 2018.

1.2 Framework for approving code changes

The framework for developing and approving changes to the instruments affected by the GPS is set out in the instruments listed in the table below.

Table 1.1: Powers and processes to amend GPS-related instruments

Instrument	Source of power to amend	By whom? In what capacity?	Process required
Network Technical Code NTC	Regulation 25 of the Electricity Reform (Administration) Regulations 2000 NTC content stipulated in Schedule 2 of those Regs	Power and Water in its capacity as **network provider** The Commission is consulted, and can require amendments to the proposed amendments[1]	Network provider must: publish draft proposed amendments; invite submissions and allow a reasonable time; and consider submissions[2] Network provider must change the proposed amendments if required by the Commission

[1] Regulation 25(5)(b) of the Electricity Reform (Administration) Regulations 2000

[2] Regulation 25(6) of the Electricity Reform (Administration) Regulations 2000.

Instrument	Source of power to amend	By whom? In what capacity?	Process required
System Control Technical Code SCTC	Section 38(1) of the *Electricity Reform Act 2000* - power to make SCTC The content the SCTC may include is set out in regulation 5A, Electricity Reform (Administration) Regulations 2000 Content and power to amend are also set out in Clause 15 of the Power and Water System Control Licence Clause 1.8.2 in the SCTC sets out the amendment process	Power and Water in its capacity as system controller (licensee) subject to approval of Commission as regulator Commission may require amendment to the SCTC	Licensee *may* amend at any time, with the prior written approval of the Commission[3] Licensee *must* amend if requested to do so by the Commission[4] Licensee must consult with all electricity entities holding a generation licence, network licence or retail licence (or current market licence) when establishing and amending the Code[5] Commission must not approve unless satisfied that the system controller has consulted with all electricity entities that are engaged in the operation of, contribute electricity to, or take electricity from, the power system[6] System controller must publish consultation submissions when Code is approved[7]
Secure System Guidelines SSG	Clause 3.5 of the SCTC	Power and Water in its capacity as Power System Controller	Can amend, vary or replace at any time, provided: - Must consult first with System Participants[8] - Must take into account government policy, system controller's statutory obligations, historic levels of reliability, and costs and benefits[9]

2. Drivers for code amendments

The generator performance standards (GPS) are an important pillar of the Norther Territory's (NT) power system regulatory and coordination framework that:

- enables third party private owners of generation assets to connect those assets to the power system and sell their energy; and

[3] Regulation 5A, Electricity Reform (Administration) Regulations 2000; clause 15.3 System Control Licence issued by the Commission to Power and Water; Clause 1.8.2(e) of the SCTC
[4] Clause 15.4, System Control Licence issued by Commission to Power and Water
[5] Clause 15.5, System Control Licence; clause 1.8(f) of the SCTC
[6] Regulation 5A(3) Electricity Reform (Administration) Regulations 2000
[7] Clause 1.8.2(g) of the SCTC
[8] SCTC clause 3.5.3
[9] SCTC clause 3.5.4 (a) to (d)

- ensures the power system remains secure and reliable, and those who drive risks and costs to the system face the costs of doing so that they can commercially minimise these.

Power and Water initiated the formal consultation on the GPS requirements with the publication of the proposed instrument changes in late 2018. Our lengthy consultation in part reflected the fact that our NT context was not well understood by some stakeholders who considered Power and Water should simply adopt the equivalent current National Electricity Market (NEM) arrangements.

This section explains the following matters and where relevant responds to stakeholder submissions on these during the second round of consultation:

- The multiple instruments and functions within Power and Water that are required to give effect to and implement the GPS;
- The NT policy context within which this GPS review is being performed;
- The NT system contexts for the three regulated power systems within which the GPS must perform their intended function;
- The principles and least cost assessment approach that have informed how Power and Water has approached this review, and how these relate to those matters that the Commission is required to consider when reviewing and approving amendments to the instruments that give effect to the GPS; and
- How the above points give rise to a framework for the future that has governed this GPS review.

2.1 Power and Water's system control role

The System Controller's role is to monitor and control operation of the NT's regulated power systems to achieve safety, security, reliability and efficiency of power system operations. In practice this means that all day every day, Power and Water must balance the supply of energy coming into the power system with customers' demand for energy. To do so, Power and Water must keep energy moving through the system and account for any constraints in the power grid (poles and wires) that delivers energy from generators to customers.

In this way the System Controller's job is to 'keep the lights on' by balancing supply and demand for energy in real time. This is often called maintaining power system security, and is equivalent to the role that the Australian Energy Market Operator (AEMO) performs independently in the interconnected NEM and in the West Australian Energy Market (WEM). This System Control role differs from the Network Operator (or grid) part of the Power and Water business who also work to 'keep the lights on' but who do so by building and maintaining the grid assets that deliver energy—see section 2.2.

2.1.1 Relevant system control instruments

Power and Water is licenced by the Commission to perform the functions of the System Controller.[10] As System Controller, Power and Water rely upon the conditions of generator connection[11] to be able

[10] The System Controller's functions are established under section 38 of the Electricity Reform Act.
[11] Which are found in the Network Technical Code.

to manage the power system securely, and are responsible for two key regulatory instruments that allow us to operate generators in accordance with the GPS:

- *System Control Technical Code (SCTC)* | The SCTC sets out operating protocols, arrangements for security and dispatch, arrangements for disconnection, and any other matters relating to monitoring, operation and control of regulated power systems, which the System Controller considers appropriate for the reliable, safe, secure and efficient operation of the power systems. The SCTC is formally approved by the Commission.

- *Secure System Guidelines (SSG)* | The SSG are an instrument of the SCTC that outlines in a public document how System Control seeks to meet the requirements outlined in the SCTC. The SSG set out the principles and details for determining whether the power system is in a secure state. The SSG also contains a section on overarching power system parameters, and participant-specific sections for potentially commercial-in-confidence or ring-fenced information. The participant-specific sections are developed on an as-needs basis. The SSG is developed by Power and Water through a public consultation process, and is issued by Power and Water. Power and Water reports on compliance on the key provisions of the SSG to the Commission.

2.2 Power and Water's network operator role

Power and Water is also licenced by the Commission to operate three regulated electricity networks and a number of non-regulated electricity networks. The licence allows us to perform the functions of the Network Operator in those networks. As Network Operator, Power and Water are responsible for delivering energy from power generators to homes and businesses in a safe and reliable way. Power and Water also connect new generators and energy users to the grid, provide and read meters to measure energy use for billing purposes, restore power after faults and emergencies happen due to severe weather events and other causes beyond our control, and communicate outage and restoration information.

2.2.1 Relevant network operator instruments

A key element of our role relevant to the GPS is to provide access services to parties who request to connect to the regulated NT networks. The key instrument that the network operator administers for this purpose is the *Network Technical Code (NTC)*.

The NTC has two elements: the network technical code and the network planning criteria. For the purpose of this consultation, we use the term NTC to refer to both elements.

The network technical code portion of the document is applicable to all equipment connected to our network but particularly generators and large loads. It covers:

- network performance criteria including frequency, quality of supply, stability, load shedding, reliability, steady state criteria and safety and environmental criteria;

- technical requirements of users' facilities including the connection of generators and loads and protection requirements;

- inspection, testing and commissioning;

- power system security;[12] and
- metering.

The network planning criteria portion of the document details the criteria used for assessing plant and equipment performance and response to power system events. These cover matters such as plant and network performance to support frequency events, voltage events, stability events, system reserve, reliability of supply and quality of supply. Power and Water apply these to ensure the regulated networks:

- meet high safety standards;
- provide a high quality, reliable and secure electricity supply;
- meet environmental standards; and
- optimise equipment utilisation.

2.3 What the GPS do and why we're updating them

The GPS are established under the NTC, the SCTC and the SSG are being updated to ensure alignment.

The GPS set conditions generators must meet for connection to the grid. These are important because they ensure that the system can be managed to balance supply and demand in real time to avoid customer outages. They do so by making sure the levers that System Control needs to do its job are there when Power and Water need to call on them.

The key levers Power and Water need in the NT have been explained throughout our consultation process, and are linked to dispatchability and predictability. Throughout the rest of this paper, we elaborate on why these are needed and how Power and Water are proposing to ensure they remain present amid our transition to a greater level of asynchronous renewable generation.

The reasons Power and Water are updating the GPS are twofold:

- If we do nothing, we will rapidly lose dispatchability and predictability across the available generation fleet, and consequently:

- be required to constrain the dispatch of asynchronous renewable generators and thereby frustrate the transition to renewable energy generation; or

- be required to operate higher levels of spinning reserve which will, at times of low load, require asynchronous renewable generators to be constrained and thereby frustrate the transition to renewable energy generation; or

- be unable to perform our role of keeping the lights on; and

- Action 4(c) of the NT Government's Renewable Energy and Electricity Market Reform Implementation Plan 2018-2020 requires us to do so, to play our important technical power system security role in our renewable energy transition.

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[12] Applicable provisions on power system security have been moved to the SCTC as the appropriate code for power system security matters.

2.3.1 What do the GPS do?

The GPS describe the technical capability requirements for generators that, if met, mean the generator will automatically be connected to the power system. The GPS are the NT equivalent of the National Electricity Rules (NER) chapter 5 Schedule 5.2.

The GPS can be broadly grouped as:

- Capability to remain in continuous operation under prescribed system normal and abnormal conditions;
- Capability to support power system security during abnormal conditions; and
- Meeting a prescribed level of predictability and dispatchability.

Each of the GPS requirements, whether meeting the automatic standard or a negotiated standard, will be documented (between the generator and Power and Water) and compliance must be maintained for the duration of the connection.

The GPS provide the System Controller with the necessary supply side levers to manage power system security. However, the GPS: do not describe how a generator is dispatched; do not describe power system security constraints; and do not rely on the presence or absence of an energy or ancillary services market.

The SCTC and SSG describe the framework for dispatch of generators to meet both system demand and power system security reflecting NT Government electricity market policy decisions for each regulated power system. The SCTC is the NT equivalent of NER chapter 3 and 4 (Market Operations and Power System Security).

2.3.2 What is not being updated?

Power and Water is not updating its processes for dispatching generation beyond what is required in terms of forecasting to accommodate intermittent renewables as discussed during consultation.[13] The methods of dispatch are an important consideration to maintain system security and to the economics of generators' current and prospective investments. They are thus relevant to many of the issues discussed in the GPS review consultation. However, they are unaffected by the proposed code amendments arising from this GPS review.

The proposed GPS will continue to apply to all NT regulated power systems. This means their design continues to be fit for use with and without a competitive wholesale energy market.

For potential industry initiated code changes *other than* those directly required to implement the GPS, Power and Water has developed an improved process for dealing with stakeholder code change requests. This is summarised in Appendix F.

2.4 Policy context and intent

These GPS address two important policy drivers:

[13] Updates on both security and market dispatch arrangements are likely to be required in the future to facilitate competitive tensions between generators of varying technology in a secure manner.

1. Establishing fit-for-purpose NT regulatory instruments amid the transition of various aspects of NT energy regulation to the national regime; and

2. Implementing a key action from the NT Government’s Roadmap to Renewables.

It also seeks to support development of the competitive NT electricity market.

2.4.1 Establishing fit-for-purpose NT regulatory instruments

On 1 July 2015, the NT Government introduced the *National Electricity (Northern Territory) (National Uniform Legislation) Act 2015* (the Application Act), which transferred economic regulation of prescribed electricity networks from the Commission to the Australian Energy Regulator (AER), and provided for the adoption of the National Electricity Law, the NER and the National Electricity Regulations on 1 July 2016.

Consequently, the NT Government has been progressively applying the NER, with necessary derogations and transitional arrangements, through a series of reform packages comprising regulations under the NT Application Act. Package 3, which included the application of the NER Chapter 5 third party access framework, came into force on 1 July 2019, to align with the repeal of the NT Third Party Access Act.

Because related (NT and national) reform programs were ongoing during the development of Package 3, NER arrangements for generator technical standards were not applied in the NT in Package 3, and are to be deferred for consideration in a future NER application package.[14]

A number of sections of the NER have been deferred for consideration. These include:

- rule 5.3.4A, which allows for negotiation of access standards;
- rule 5.3.4B, which concerns system strength remediation for new connections;
- rules 5.20A-5.20C, which concern frequency management planning, inertia sub-networks and requirements, and system strength requirements; and
- schedules 5.1a-5.3a, which set out system and technical access standards.

However, to ensure a functional framework, existing generator technical standard arrangements in the NT will continue to be relied on. As an interim measure, where relevant, references to schedules 5.1a-5.3 and Chapter 4 are replaced with references to ‘jurisdictional electricity legislation’ and explanatory notes clarify the subject matter of the relevant jurisdictional arrangements to ensure alignment between the NER third party access arrangements and supporting technical standards.

As a result of these progressive changes, Power and Water must incorporate equivalent NT requirements fit for our NT power systems into the jurisdictional instruments (i.e. the NTC and SCTC).

Power and Water recognise that divergence from NEM or WEM requirements can create challenges for generators and generator proponents. Our GPS development approach has therefore been to adopt new standards based on the equivalent NER Chapter 5 Schedule 5.2 requirements, except

[14] Chapter 4 of the NER addresses Power System Security, and currently states that "[t]his Chapter has no effect in this jurisdiction (see regulation 5A of the *National Electricity (Northern Territory) (National Uniform Legislation) (Modification) Regulations).* The application of this Chapter will be revisited as part of the phased implementation of the Rules in this jurisdiction."

where adoption in the NT would prevent System Control having the necessary levers of predictability and dispatchability to ensure power system security in the NT power systems.

In addition to the changes arising from the GPS review, Power and Water notes that the heads of power referred to in several places in the NTC and SCTC and SSG change with the repeal of the *Electricity Networks (Third Party Access) Act 2000* (and the Third Party Access Code that is a Schedule to that Act) with effect from 1 July 2019. Where applicable, Power and Water have updated references in the NTC and SCTC and SSG to refer to the NT NER, *Electricity Reform Act* or Electricity Reform (Administration) Regulations as appropriate.

2.4.2 Implementing the Roadmap to Renewables

The NT Government is undertaking a suite of reforms to promote renewable energy in the NT electricity supply industry, and to accommodate the growing number of proponents who have expressed interest in connecting to the NT power systems.

One of the short-term actions is to modify the network connection process to accommodate the characteristics of large-scale renewable technologies and increasing penetration of renewable energy while maintaining power system security and reliability. This action was specified in 4(c) of the NT Government's Renewable Energy and Electricity Market Reform Implementation Plan 2018-2020. Power and Water was assigned this action.

Among the key principles of the NT Government's Roadmap to Renewables are:

- a requirement to maintain energy security, reliability and stability during the transition to renewable energy; and
- a commitment to implement the transition at least cost to customers.

This was reflected in the NT Government's response to the recommendations of the Roadmap to Renewables, wherein on the recommendation of policy alignment the NT Government stated:

> *While government will seek to utilise renewable energy, subject to its availability and ability to deliver secure, reliable and least-cost electricity, policy initiatives will need to be carefully managed to avoid unintended consequence such as price increases for other electricity consumers.*[15]

This guidance has informed our approach to this review as discussed in section 2.6, including our least cost approach to maintaining current levels of energy security, reliability and stability in the absence of a formal standard, during the transition to asynchronous renewable energy.

During our second round consultation process, some stakeholders still questioned the alignment of the proposed GPS with the Roadmap to Renewables policy position. Tetris Energy stated:

> *The roll out of the new GPS should integrate with the Road Map to Renewables Policy*

The GPS as proposed facilitate high penetration of renewable energy generators into the energy supply industry at the least cost to consumers. This is achieved by ensuring the system can technically support a high penetration of PV generation rather than relying on synchronous generation to off-set

[15] https://roadmaptorenewables.nt.gov.au/roadmap-to-renewables-expert-panel-report/government-response.

intermittency and provide all 'non-energy' services. The GPS also seek to facilitate least cost outcomes by placing the risk with those best placed to manage it.

NT Solar Futures sought an obligation on System Control to maximise renewable energy, and further stated that System Control's dispatch management focus should not be on system security and reliability to the detriment of renewable energy.[16]

The Codes must reflect the underlying legislative framework, including the rights, obligations and objectives of market entities. The NT Solar Futures proposal is inconsistent with the framework governing the system control function and the industry more broadly, and paramountcy of system security and economic efficiency requirements. Power and Water believes that the proposed inclusion would require government policy and amendments to the *Electricity Reform Act 2000*.

2.4.3 How the GPS will fit in the NT Electricity Market (NTEM)

The GPS will affect the costs of generators seeking to connect to the system. Because these commercial drivers will affect generators' investment decisions, it is important that this round of GPS changes considers how the standards can support certainty over the foreseeable future.

We have therefore considered the three key phases of the NT energy market, these being:

- the current Interim NT Energy Market or I-NTEM;
- the proposed transitional I-NTEM 2.0 amendments; and
- the future state NTEM.

Power and Water continues to work with the Department of Treasury and Finance in the GPS development to ensure alignment with the I-NTEM 2.0 and NTEM designs. This impacted the wording for provisions such as C-FCAS capability which has had its operation under the I-NTEM and the transitional path to the NTEM explained for clarity in the consultation material.

The majority of the GPS are unrelated to market reform as they relate to the adequate performance and capabilities of generators to ensure plant operates in a stable manner and there are appropriate security reserves to call upon.

2.5 NT context and consequences

To establish fit-for-purpose NT GPS requirements, their development must be firmly grounded in the physical realities of our regulated NT power systems. These differ markedly from those in the NEM and WEM.

Some of the key differences to the NEM include:

- *Apply to multiple power systems* | The NT GPS apply to both the Darwin Katherine Interconnected System (DKIS) which has a competitive wholesale market (the I-NTEM), as well as the Alice Springs and Tennant Creek power systems that do not operate wholesale markets. This means they must provide robust minimum requirements that provide our system control the capability to ensure secure, reliable and stable system operation under both types of generation dispatch environment.

[16] Submission by NT Solar Futures dated 18 July 2019, at pages 2 and 3

- *Scale* | The size of individual generators as a proportion to the total system load is significantly higher in comparison to the NEM, which means a single generator can significantly impact system security. For example, in relative terms given the size of maximum demand between the NEM and the DKIS, a 20 MW generator on the DKIS is equivalent to a NEM generator of approximately 2,200 MW. This is three times larger than the largest single NEM generation unit (Kogan Creek – 744 MW). We note that some of the proposed PV generators (solar farms) in the NT are in the order of 50 MW in size. Given their relative size these asynchronous generators present unique issues for NT system security.

- *No ancillary service market* | There is currently no market for power system security services in the DKIS and there is no intention to introduce a market in the Alice Springs or Tennant Creek systems.

- *No interconnection* | There is no interconnection to other geographically or energy source diverse markets, which means the NT systems have to be self-reliant for all system security requirements

- *PV is the dominant form of renewable generation* | The current pipeline of renewable technology is PV so there is limited diversity in energy source. Diversity from different generation sources will often result in generators naturally offsetting system limitations and energy intermittency, whereas our lack of diversity in renewable energy sources will mean our system cannot benefit from such off-setting effects.

- *Hydro is non- viable* | There are limited economically viable opportunities as the NT terrain does not lend itself to long term hydro based energy storage technologies. In the NEM hydro is used for energy storage to offset intermittent sources. This is demonstrated by Tasmania's proposed 'battery for the nation' and Snowy 2.0, and underpins the NEM system security.

Power and Water operates the networks and controls the systems for three regulated power systems and operates the I-NTEM, which only operates on the DKIS.

The challenges of our NT power systems and requirement for a bespoke system security solution in the GPS design was explained during our June 2019 engagement workshop by energy expert David Swift as follows:[17]

> *The NT system is quickly moving to the leading edge of world experience with high levels of [variable renewable energy (**VRE**)] VRE.*
>
> *That VRE is likely to be dominated by solar PV, which is the most variable.*
>
> *NT systems are islands (unable to draw on external support) and there is no known potential for pumped hydro storage. These are important in many international examples with high VRE.*
>
> *Efficiently maintaining security and reliability requires end-to-end attention – from the generator performance standards through to the market arrangements.*
>
> *Need to balance use of regulation and standards with financial incentives*
>
> *Recognise that the scale of the NT systems make it difficult to justify the cost and complexity of the systems operated by AEMO and other leading International operators.*

[17] David Swift, *Lessons from the NEM,* workshop presentation, 26 June 2019

They were also acknowledged by Proa Analytics in its submission:

> *Power systems of the size of the NT would certainly need greater reliability requirements than a system such as the NEM.*[18]

2.5.1 How the system is run now

The way Power and Water currently maintain power system security reflects lessons from the past and our deep knowledge of the capabilities of the system. The current SSG was developed following a period of significant outages in 2014, and represent the results of collective learning about the levels of reserves required and reasonable contingencies management practices in our circumstances.

Two key requirements of the SSG relate to spinning reserve:

- A minimum of 25 MW of spinning reserve; and
- A minimum of two Channel Island Frame 6 turbines spinning at 26 MW or below, on different electrical points of connection.

These requirements were adopted following the December 2014 system black (and following a period of about 17 under frequency load shedding events during the previous 12 months caused by a single generator contingency). Since that point the incidence of under frequency load shedding due to a single generator contingency has dropped to on average less than 1 per year.

As our modelling conducted during this development shows clearly, the current SSG spinning reserve requirements will be unfit in a new industry with large amounts of intermittent generation, Power and Water will need to transition to the more sophisticated approach based on managing Contingency Frequency Control Ancillary Services (C-FCAS).

With that said, for modelling purposes a base case needs to be taken and options reviewed against it, and hence Power and Water are using the existing requirements for spinning reserve contained within the SSG.

Managing for credible contingency events

Our system control practices have to recognise that the incidence of individual generator units tripping off-line is quite frequent – multiple times per week. A generator trip can be caused by a wide range of incidents, and is one of the primary contingency events Power and Water manage from a secure system perspective.[19]

Although the SSG requires that a minimum of 25 MW of spinning reserve is held, due to the size of the generators in the system and their minimum safe loadings (and other constraints on operation), the system is actually generally operated with a higher level of spinning reserve – at an average level of around 40 MW.

There have been occasions where short term changes in roof-top solar production were sufficiently large that had Power and Water been running at 25 MW of spinning reserve at the time, System Control would have had to take rapid action to avoid customer outages. As we discuss at length later

[18] Submission by Proa Analytics dated 18 July 2019, at page 1.
[19] As opposed to managing network outages or the islanding of the system due to the 132 kV line, which are significant causes of customer events, but are not relevant events for the purpose of considering the SSG and new solar generation, given that such a network event will affect all generation in a similar manner.

in this document, as the level of solar penetration increases, the SSG will need to be significantly altered, and larger spinning reserves (or other similar contingency management actions) will be required. There is currently approximately 50 MW of rooftop solar in the DKIS which is all asynchronous generation. The growth of rooftop solar has led to short term (< 5 minutes) large swings in demand. This has resulted in the spinning reserve requirements being breached on multiple occasions.

With increasing levels of large-scale asynchronous penetration, the risk of an unexpected output reduction on a PV generator due to cloud coverage occurring simultaneously with a contingency event on another generator becomes increasingly likely. This coincident event would likely cause significant disconnection of customers. A credible example of this would be if a synchronous generator dispatched at 30 MW trips at the same time as a cloud causes a 25 MW drop in an asynchronous generator's output. This would result in a 55 MW drop in production and would (to a high likelihood) cause load shedding under the current spinning reserve arrangements. This would have a similar customer impact to a recent event where two generators were tripped, losing a similar level of output, which resulted in over 9,000 customers losing power.

If you take this to the extreme of the largest proposed asynchronous generator and the largest synchronous generator dropping output simultaneously, the system could see more than 90 MW reduction in output.

We have conducted modelling to understand the risk and consequences as follows:

- We have conducted a simulation of 2017, using actual demand and offers from Territory Generation (TGen) and EDL units, and then included indicative asynchronous solar production (including solar forecasts) for the asynchronous generators that have applied to connect—totalling about 120 MW in capacity.
- We have then looked at the number of daylight 30 minute periods where the SSG would have been breached[20] due to the error between the forecast and actual production for these asynchronous generators, at different levels of assumed forecast accuracy.
- It should be noted that this modelling provides 'best case' outcomes as it does not assume any relationship between the forecasting errors of different generators. The modelling outcomes further trend towards 'best case' outcomes by assuming that the additional spinning reserve above the minimum that was available in 2017 as a result of the size and merit order of dispatch of the existing generators continues.
- We have set out the results in Table 1.1.

[20] A breach in this case simply means that we had less than 25MW of remaining spinning reserve.

Table 2.1: Percentage of Daylight Periods with SSG breach

		Percent of periods accurately forecasted			
		95%	90%	80%	50%
Maximum Error magnitude	5%	0.76%	1.52%	3.42%	6.84%
	10%	0.76%	3.04%	3.80%	6.84%
	20%	1.52%	3.04%	4.18%	13.31%
	50%	4.18%	7.22%	16.35%	41.44%

Implications

The above 'do nothing' analysis is simply illustrative because clearly Power and Water would not allow the increase in load shedding to occur from coincident forecasting errors and generator contingencies. It illustrates that relying on the current Spinning Reserve arrangements is not sufficient and Power and Water need to act now to ensure we have the levers to maintain power system security. The questions is: what should we do?

The fundamental issue is that Power and Water require high levels of predictability and dispatchability from all generators:

- To achieve high levels of predictability and dispatchability, Power and Water propose short term forecasting requirements on all materially large generators.
- We will aim over time to move to a C-FCAS based security management regime, which Power and Water has already foreshadowed in the SSG.
- We will require all generators to be capable of participating in the FCAS arrangements – this is already a requirement included in the proposed NTC 3.3.5.11 (generators need to demonstrate capability for all forms of FCAS).

2.6 Regulatory requirements for the GPS review

The code amendments that give effect to the generator performance standards must be approved by the NT independent regulator, the Commission. This process is outlined in section 1.2.

The Commission will consider our amendments under the *Utilities Commission Act*. Relevantly, section 6(2) of the Act states:

> *'In performing the Utilities Commission's functions, the Utilities Commission must have regard to the need:*
>
> *(a) to promote competitive and fair market conduct;*
>
> *(b) to prevent misuse of monopoly or market power;*
>
> *(c) to facilitate entry into relevant markets;*
>
> *(d) to promote economic efficiency;*
>
> *(e) to ensure consumers benefit from competition and efficiency;*

(f) to protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries;

(g) to facilitate maintenance of the financial viability of regulated industries; and

(h) to ensure an appropriate rate of return on regulated infrastructure assets.'

The Commission has also relevantly foreshadowed in its 2016-17 Power System Review that it will:

'consider the cost trade-offs between GPS, ancillary services and network investment as part of its assessment of System Control's proposed GPS'.[21]

In developing, consulting on and refining our proposed amendments Power and Water have considered these requirements and guidance, and pursued an approach that Power and Water consider will best achieve them. Indeed, several of these considerations are of key importance to the GPS Power and Water have developed and to how Power and Water have considered evidence and feedback in arriving at the proposed code amendments. The table below explains what Power and Water consider to be the implications of these threshold provisions for our approach to this review.

Table 2.2: Complying with the regime that governs our code amendments

Utilities Commission Act requirement	Implications and resulting principles for how Power and Water approach the GPS review[22]
Promote competitive and fair market conduct	The GPS should: • Be technology agnostic as far as practicable and thereby not create market power for one generator over another based on technology • Not raise the costs of subsequent renewable generators based on the treatment of first entrants i.e. not create market power based on the order in which proponents connect to the NT grid (i.e. beyond the competitive advantage that first movers may gain in a competitive market)
Prevent misuse of monopoly or market power	Well-designed grandfathering and transitional arrangements for existing and inflight renewable proponents, ensuring arrangements do not become a source of market power
Facilitate entry into relevant markets	Notwithstanding the necessary timing of this review, Power and Water is seeking to establish GPS that provide certainty to potential investors by taking a long term / 'no regrets' view to establish a 'Framework for the Future', through being: • Clear about obligations • Forward-looking to support GPS that can be stable over the foreseeable future • Transparent about the technical challenges in the NT system and the relative cost/viability of alternative options considered • Intent on having standards in place prior to the connection of first mover renewable proponents

[21] Commission, Power System Review 2016-17, p. iv.
[22] These elaborate on the principles that have previously been presented in our public consultation.

Promote economic efficiency	The GPS should support the lowest total cost of reliably providing energy whilst facilitating the connection of asynchronous renewable energy technologies The total costs should be considered having regard to cost trade-offs between GPS, ancillary services and network investment Risk should be placed with those best able to manage it at least cost
Ensure consumers benefit from competition and efficiency	Our Framework for the Future means Power and Water are facilitating renewable generation entry in a manner that minimises the total cost of reliably providing energy whilst facilitating a greater share of renewable generation
Protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries	Our primary focus is keeping the lights on while facilitating increased connection of asynchronous renewable energy and storage technologies

These *Utilities Commission Act* requirements have also informed our approach to assessing alternatives, in particular our least cost approach rather than net benefits approach.

Some stakeholders submitted to our second round consultation[23] that Power and Water should have performed a cost benefit study of alternatives. For example, EDL submitted that:

> *meaningful assessment of the net costs of the GPS changes doesn't yet appear to have been undertaken*[24]

We have developed our analytical approach in line with our statutory function and the *Utilities Commission Act* requirements. As system controller, Power and Water must monitor and control the operation of the power system with a view to ensuring that the system operates reliably, safely and securely in accordance with the System Control Technical Code.[25] As a licensed network provider, Power and Water must comply with all applicable regulatory instruments, and operate, maintain and protect the network in accordance with the Network Technical Code.[26]

We understood the *Utilities Commission Act* requirements to promote economic efficiency and protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries, as supporting adopting a least cost approach to performing our system control functions.

Under the NT's regulatory framework, the inherent cost benefit analysis (i.e. in choosing between security and reliability, and the regulated power systems' shares of dispatched renewable energy) does not lie with Power and Water. Neither Power and Water nor the Commission has any legislated head of power to value renewable energy over other energy sources when discharging our power system security and reliability functions. As such, the generator performance standards were assessed on a basis of '*least cost to maintain security, reliability and stability of the NT power systems*'. This

[23] See submissions by EDL, Tetris Energy, and Darwin International Airport.
[24] Submission by EDL dated 26 July 2019, at page 1.
[25] Section 38(1) of the *Electricity Reform Act* 2000
[26] Clauses 10 and 16, Network Licence issued to Power and Water Corporation

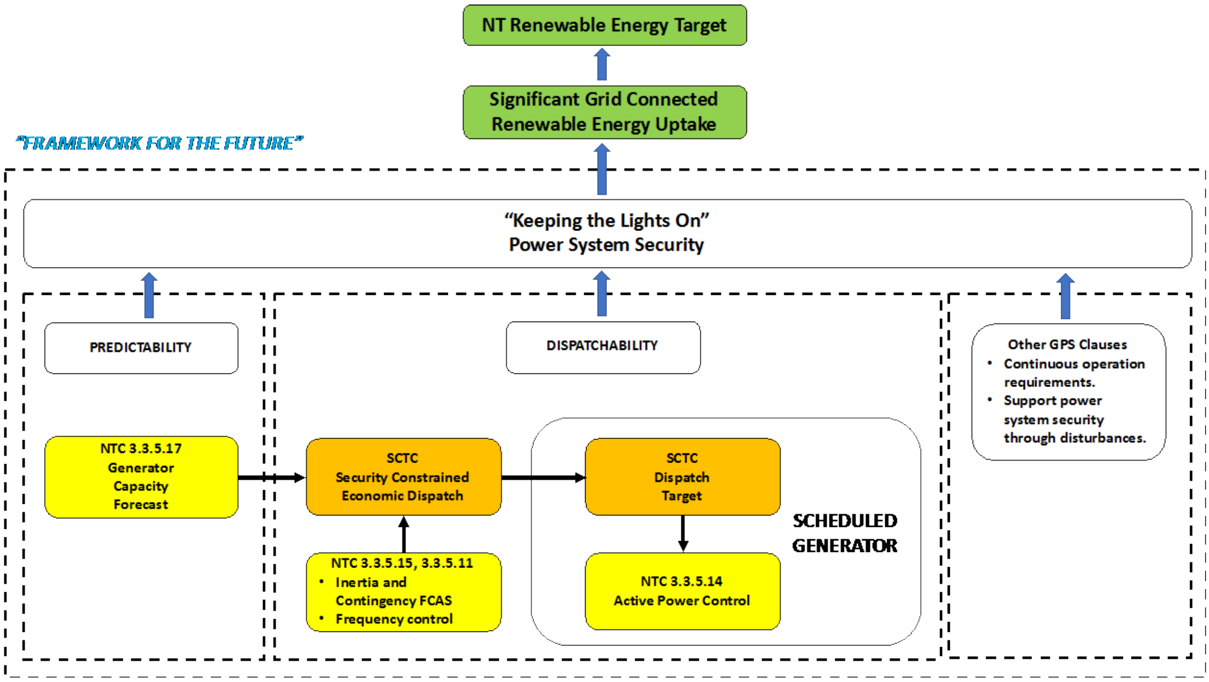
differs from a formal cost benefit analysis that would be needed to justify a policy change in the relative priorities of system security and renewable energy.

We note that under this least cost approach, our proposed GPS is consistent with some of the market solutions stakeholders have cited as preferable alternatives in their opinions (notably, a centralised battery solution). The only area that forms a non-negligible generator cost is in the capacity forecasting requirements. As batteries are well established to provide short term reserves rather than spinning reserve held by gas turbines, generators are able to advance these as market solutions where they are a more commercial compliant alternative to individual GPS compliance solutions.

2.7 GPS framework for the future

The considerations in the preceding sections, their interrelationship with this GPS review and the instruments Power and Water are amending (including the specific clauses that relate to key issues covered in sections 5 to 8 of this paper) are illustrated in the following figure. This framework for the future was the focus of our March 2019 Supplementary Consultation Papers and remains relevant to the content of this application.

Figure 2.1: Framework for the future overview



3. Power and Water's consultation on GPS

3.1 The consultation process

The consultation process to date for incorporating the GPS in the NTC and SCTC (the codes) has included:

- 18 December 2018 – Release of the proposed changes to the codes and overarching consultation paper
- 18 February 2019 – Public information session held for stakeholders on proposed code changes

- 12 March 2019 – Release of a supplementary consultation on removal of semi-scheduled generator classification and capacity forecasting
- 20 March 2019 – Release of a supplementary consultation on contingency FCAS (C-FCAS) / Inertia proposed standard
- 29 March 2019 – Round 1 consultation closed, with 13 submissions received from 10 stakeholders
- 21 June 2019 – Release of round 2 consultation pack, including Entura's technical verifier's report
- 26 June 2019 – GPS round 2 consultation workshop
- July 2019 – Published responses to workshop questions, conducted one-on-one meetings with stakeholders, and received 11 stakeholder submissions.

Power and Water acknowledges and appreciates the effort of stakeholders in participating in and making submissions to our consultation on the proposed Code changes. This consultation has informed the proposed NTC and SCTC amendments in this application.

3.2 Approach to feedback

As highlighted above, our approach has been to seek the least cost way to continue to meet our statutory functions to achieve the safety, security, reliability and efficiency of power system operations, now and in the transition to a renewable energy future.

We carefully and objectively considered all feedback from stakeholders, and accommodated proposals where practical and sensible applying a 'no regrets' philosophy. We obtained independent advice and technical verification where warranted, and assessed the best way forward based on:

- our deep understanding of the NT system;
- effects on system security and reliability; and
- consideration of the objectives set out in the *Utilities Commission Act,* including:

- promoting a competitive and fair market;
- preventing misuse of monopoly or market power;
- facilitating entry into relevant markets;
- protecting the interests of consumers with respect to reliability and quality of services and supply; and
- promoting economic efficiency through minimising total costs by placing risks with the parties best placed to manage them.

We are confident that our proposed GPS code changes are necessary, reasonable, and appropriate for implementing in the NT.

Stakeholder feedback received up to June was considered and addressed in our round 2 consultation pack, and is not addressed further in this application. Submissions in response to round 2 consultation pack are summarised in Appendix D which sets out our responses or cross references where they are addressed within this application or earlier papers.

4. Overview of proposed code changes

4.1 NTC

The proposed changes to the NTC can be categorised thematically as:

- Establishment of a dedicated section 3.3 for the new proposed GPS to enable high penetration of variable renewable energy while maintaining reliability at the lowest cost to customers. This was the primary driver for changes to both of the Codes.
- Clarity around the application of the proposed NTC changes for existing generators (grandfathering), modifying existing generators and generators connecting after 1 April 2019 including transition to compliance arrangements.
- Removal / transfer of power system security related clauses so they are consolidated in the SCTC.
- Removal of metering clauses (section 10) as they are now covered by the NT NER Chapter 7A.

The proposed section 3.3 specifies the 'Requirements for the Connection of New Generators', and largely follows the NER Schedule 5.2.5 which can be characterised as set out in Table 4.1.

Table 4.1: Network Technical Code clause 3.3 requirements

Requirement	Provisions
system normal operation	3.3.5.1 - Reactive power capability** 3.3.5.2 - Quality of electricity generated
generating systems to remain in continuous operation	3.3.5.3 - Generating system response to frequency disturbances** 3.3.5.4 - Generating system response to voltage disturbances** 3.3.5.5 - Generating system response to disturbances following contingency events** 3.3.5.6 - Quality of Electricity Generated and Continuous Uninterrupted Operation 3.3.5.12 - Impact on Network Capability 3.3.6.1 - Remote Monitoring and Control 3.3.6.2 - Communications Equipment
generating systems to support the power system during disturbances	3.3.5.7 - Partial Load Rejection 3.3.5.8 - Protection of Generation Units from Power System Disturbances 3.3.5.9 - Protection Systems that Impact on Power System Security 3.3.5.10 - Protection to Trip Plant for Unstable Operation 3.3.5.11 - Frequency Control 3.3.5.13 - Voltage and Reactive Power Control 3.3.5.15 - Inertia and Contingency FCAS 3.3.5.16 - System Strength
predictability and dispatchability	3.3.5.17 – Capacity Forecasting** 3.3.5.14 – Active Power Control**

** *Clauses that have been modified following stakeholder feedback during the consultation process*

To provide flexibility during the transition to renewable energy and encourage innovative solutions, Power and Water have deliberately departed from the NER only in defining automatic access standards. We have then taken selected clauses from the NER 5.3.4 and applied these to NTC clause 3.3.5 regarding a framework for proposing a negotiated access standard that is as close as possible to the outcomes sought under the automatic standard.

4.2 SCTC

The changes to the SCTC are relatively minor and principally around providing greater clarity around any power system security matters that were duplicated in both Codes and had the potential to conflict including:

- Alignment to the correct jurisdictional legislation following repeal of the Third Party Access Act;
- Clarity regarding the respective roles and responsibilities of the Network Operator and Power System Controller;
- Clarity regarding the classification of new generators and the application of the materiality threshold for automatic application of the GPS; and
- 30 day ahead generator capacity forecast requirements.

Relevant clauses were either modified, transferred or created as a result of the above matters.

Appendix C provides a list of the respective Code specific clause changes proposed.

Part B | Statement of approach to key issues

In support of our application for approval of proposed code amendments, this section provides information on the following key issues that were of particular interest to stakeholders during the consultation process:

1. Application of GPS, grandfathering provisions, and the call for a more staged implementation;
2. Forecasting requirements, and consideration of other options;
3. Removal of the semi-scheduled generator classification; and
4. Requiring C-FCAS capability.

In this part Power and Water discuss each key issue in depth, outlining

- The proposed code amendments and their effect;
- Rationale for the changes and preferred approach, including where relevant:
  - What problem the amendment seeks to address;
  - Why Power and Water considers the proposed amendment is preferable to alternatives it considered and stakeholders raised;
- How the proposed amendment aligns with the requirements that the Commission must consider under section 6(2) of the *Utilities Commission Act*.

5. Application of Generator Performance Standards – Grandfathering and modifications to existing generators

5.1 Proposed code amendments and their effect

New provisions are set out in clause 12 of the NTC, and supported by a new clause 6.14(l) in the SCTC, and NT NER clause 5.3.9.

These code provisions provide as follows.

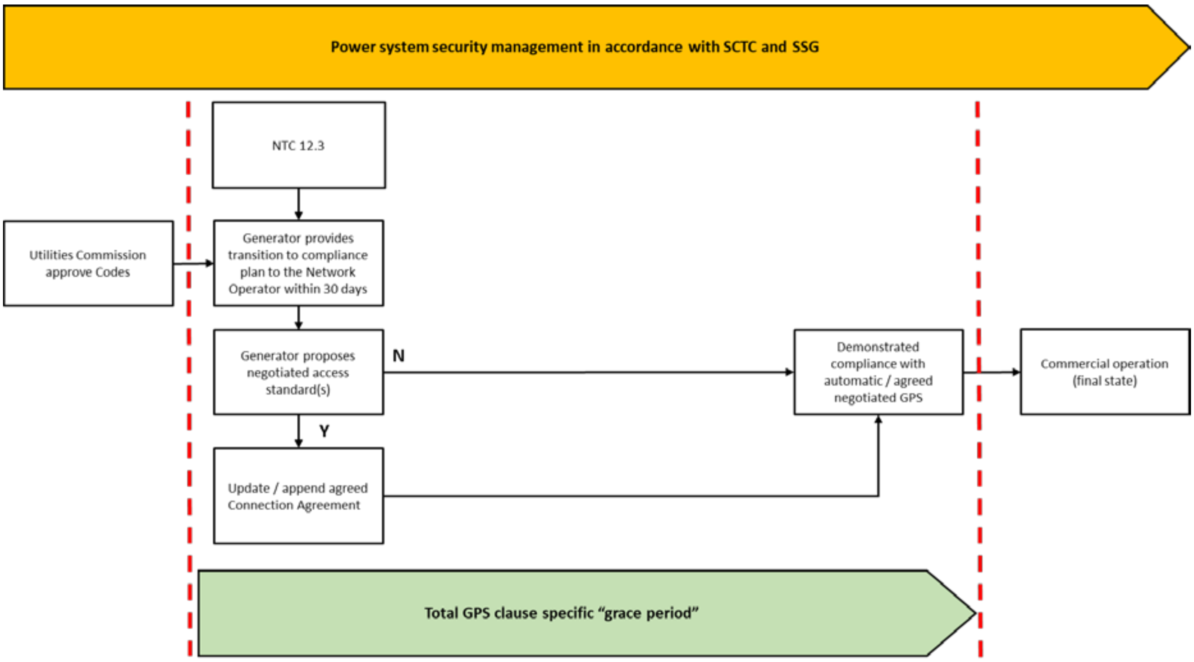
- **Existing connection pre 1 April 2019** - Grandfathering provisions apply to generators physically connected prior to 1 April 2019 (i.e. they do not apply to connection applications, but only to a generating system that is electrically connected).

- These generators will be assessed without modification against the proposed GPS, but need only meet NTC Version 3, as in force immediately prior to the date when Version 4 comes into effect.

- Post April 2019 modification of plant that has been grandfathered will have the 'ratchet' approach i.e. it may not reduce capability for any performance standard to below its pre-modification state, but it could remain the same. That is, like for like replacements are accepted. As per NT NER clause 5.3.9, System Control (NTESMO) should be notified of any proposed alteration to generating systems, so as to assess the impact of proposed changes and decide whether they should be approved.

- **Interim connections between 1 April 2019 and code approval –** There will be a grace period for generators who physically connect during this interim period, during which such generators are not required to comply with agreed components of the GPS, for periods specified in a schedule to the NTC. The grace period extends beyond the code approval date, in accordance with documented arrangements for specific technical obligations and connections. During this period, the
  - New provisions in NTC clause 12.3 provide that, where a grace period for a technical requirement is specified in a new Schedule S4, a generator will not be regarded as in breach of the NTC if:
    - within 30 days of the new code commencing, it submits a plan setting out how it will ensure compliance with technical requirement(s) from the end of the applicable grace period, and it complies with that plan; and
    - it complies with that technical requirement after the relevant grace period.
  - There are new provisions in clause 12.3(b) and (c) regarding the content of that plan.

Figure 5.1: New grace period provisions



- **Post code approval connections -** Generators (including newly created or additional generating systems at any point in the power system and 'behind the meter') physically connected after code changes are approved must comply with the new GPS obligations.

The grandfathering and transitional provisions have been added in response to stakeholder feedback. Power and Water believes that it can accommodate these further transitional provisions, provided that it can deal adequately with system security both in the short and long term. This means that:

1. Though a generator that connects in the interim period may be protected from rule, code and licence non-compliance with the GPS during a transition period, the level of performance compliance and capability will drive the level of constraint required to maintain

system security. Hence, a non-conforming generator is more likely to be constrained by the system controller in order to ensure system integrity.

2. Each new generator should be aware of the proposed GPS obligations and their commencement, and required to transition to compliance. The generator should make an informed decision about the optimal timing of that compliance.

Any future derogations would be considered only if they will not adversely affect network capability, power system security, quality or reliability of supply, intra-regional power transfer capability or the use of a network by another User. Where agreed, temporary derogations would be set out in the relevant connection agreement.

5.2 Rationale for the changes and our preferred approach

The problems that the GPS and any transitional or grandfathering arrangements must address are:

- Legacy generators need clarity on how upgrades to their assets will interact with the GPS grandfathering provisions.
- The new GPS have been developed in order to facilitate the transition to renewables, so it is logical to confirm the capabilities of existing generators against the GPS and therefore System Control would need compliance data measured against the new standards.
- The conditions that have given rise to the need to adopt these new GPS are equally applicable to the new generation currently under construction.
- Providing certainty to new generators under construction as well as future connecting generators.

Power and Water considers that the proposed amendments are preferable to alternatives it considered and stakeholders raised. At a high level, the alternatives available were:

- apply the new GPS to all generators without exception, from the outset;
- apply the GPS only to future generators seeking connection;
- some grandfathering, and a path to alignment or
- staged adoption or trials.

To meet the 50% renewable energy target, Power and Water must plan for managing our power systems where potentially more than 100% of the system demand is being delivered by asynchronous energy at points of the day, with surplus being stored for later use. We must also plan for managing our power systems where a significant component of the generation is asynchronous solar.

Within this paradigm it makes little sense to create default rules for traditional (gas) generation, and to then depart from those requirements as required to enable asynchronous new entrants. Asynchronous renewables will no longer be the ‘new technology’, but will in fact, for significant periods of the time, be the backbone and dominant energy source for operating our power systems.

Power and Water has applied a 'no regrets' philosophy and holds the view that it is essential to set the 'Framework for the Future' such that the outcomes are consistent with the NT objectives insofar as:

- promoting a competitive and fair market;
- preventing misuse of monopoly or market power; and
- facilitating entry into relevant markets.

In this context, the treatment of generators that are under construction and commenced amid this current review should not face an outcome that creates market power for them, or raises barriers to entry for subsequent generators. Early mover renewable generators should not get an unfair advantage of lower access standards that result in higher entry barriers to subsequent generator developments and higher costs to consumers. Further, our approach will maximise the chances of the available renewables actually being used, rather than constrained off to enable synchronous stabilisation.

Because the system security issues that have driven these GPS changes apply equally to in-flight projects, Power and Water have tried to take a 'no surprises' approach to developing the GPS. This was on the expectation (communicated prior to licences being issued and during the connection process) that the new standards would need to apply to projects under construction.

The impacted generators have been aware from the outset that the GPS were being developed and that they would need to meet those requirements once finalised. In considering the revised position as a result of round 2 stakeholder feedback, Power and Water is of the view that subject to temporary derogations available for generators that connect in the interim period between 1 April 2019 and code changes, the NTC and SCTC changes approved by the Commission will apply to all generators that were not connected at code change commencement.

Staged adoption or trials were considered. Some submissions suggested that the NT follow the developments of other jurisdictions:

> *"In the years ahead as RE and enabling technologies such as solar forecasting and control battery storage continue to develop and improve, the Codes may be reviewed and updated at the appropriate time with contemporary information. This also allows the NT to benefit from experience in other jurisdictions, as they also increase their RE penetration. The current Code reviews would put the NT at a technologically theoretical position, well in advance of the proven approaches of other jurisdictions including the NEM and WEM."*[27]

Or similarly, to trial obligations:

> *"Trial – The current draft standards appear to require an accuracy of forecasts that are based around a much higher level of solar penetration than will occur over the coming years which provides an opportunity to trial and implement these measures over a greater timeframe."*

Put simply, given the small scale of the NT power systems against the rate of renewable energy uptake, the NT simply does not have time to undertake trials or delayed implementation of the GPS that would expose customers to high cost and increased reliability risk. The quantity of Solar PV

[27] Submission by NT Solar Futures dated 18 July 2019, at page 2.

generators that are sufficiently progressed in the connection process such that they are likely to connect in the next 12 months accumulate to ~58 MW. This is compounded by over 50 MW of behind the meter PV, which continues to grow rapidly, seeing the DKIS minimum daytime demand of ~95 MW. Trials or a staged approach to obligations relies on the uptake of the new technology being immaterial to power system security, which is not the case based on the above.

Behind the ~58 MW likely to connect in 12 months there is a further ~200 MW of Solar PV currently under connection application for the DKIS. For this quantity of PV proposed to connect in the near future, it needs to be suitable for operation under arrangements where solar PV is the dominant energy supplier as this will be the case in the immediate future.

Solar PV is the only proposed renewable energy connecting and is the most intermittent of variable renewable energy (VRE) sources. In the DKIS, this means there is no diversification of VRE in current connection applications and the power system is subject to similar weather patterns (geographic dispersion has limited effect on the variability). It also has limited coping mechanisms with no interconnectors and limited economic potential for pumped hydro.

Operating a system with these characteristics is as yet an unsolved technical problem that is not likely to be experienced and resolved by another jurisdiction in the near future – The NT is leading the challenge and must lead in delivering a solution or bear the consequences.

In contemplating the feasibility of staging obligations, Power and Water considered the objectives under the *Utilities Commission Act* and identified the following issues with a staged approach.

- It is likely to significantly increase the cost of connecting future generators (barrier to entry).
- Low utilisation due to higher level of constraint applied to early mover PV (stranded assets not supporting economic efficiency).
- Lack of dispatchability and predictability impede dispatching 100% of demand from solar PV for periods of time (barrier to 50% renewable energy).

5.3 Alignment with *Utilities Commission Act* objectives

The proposed solution aims to:

- promote competitive and fair market conduct;
- prevent misuse of monopoly or market power;
- protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries; and
- promote economic efficiency.

6. Forecasting requirements, and consideration of other options

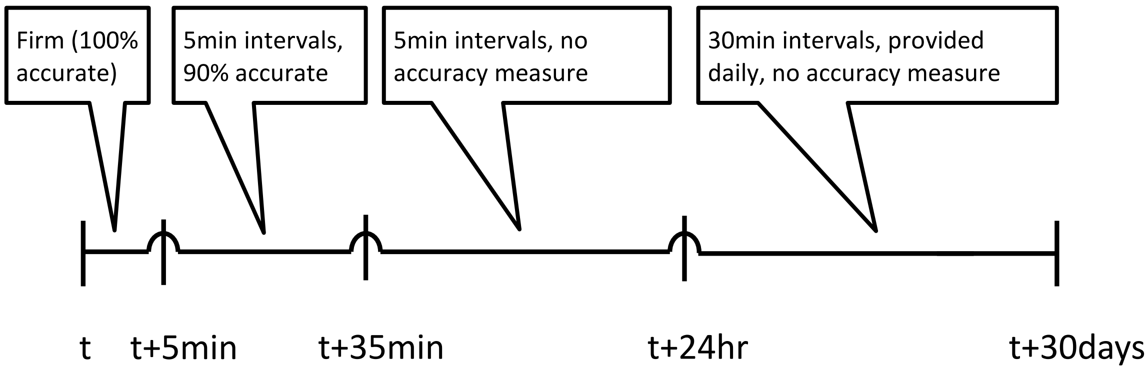
6.1 Proposed code amendments and their effect

New capacity forecasting obligations are set out in NTC 3.3.5.17 under the suite of proposed amendments to NTC clause 3.3.5 that form the GPS.

Our proposed forecasting requirements – which would apply to all generators – and the interactions with the dispatch process are summarised below and illustrated in Figure 6.1.[28] All generators are to provide:

- a rolling 5 minute ahead capacity forecast for 24 hours in 5 minute intervals; and
- a rolling 30 day ahead forecast for capacity in 30 minute intervals, updated daily

Figure 6.1: Timeline of forecasting requirements



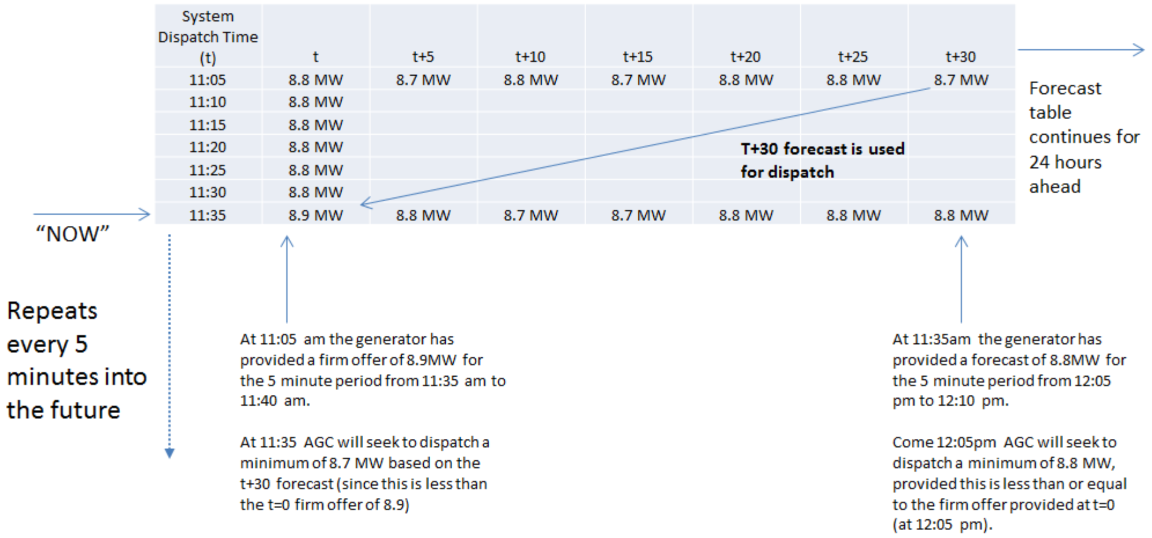
Notice that the forecast provided at t+30 is used in the pre-dispatch decisions, and is the basis on which decisions about the mix of generation to be started and operated are made. It is this quantity that will (potentially) be dispatched at t=0.

In our example below, at 11:05 am the generator forecast provided a 30 minute ahead forecast of 8.7 MW for the 5 minutes from 11:35 am to 11:40 am.

However, at 11:35 am the generator now indicated that their capacity was in fact 8.9 MW. In this case they would (normally) be dispatched to 8.7 MW.

[28] In the following, the term "t" means "the time at which physical dispatch instructions for the next 5 minutes occurs".

Figure 6.2: Forecasting example



The t=0 forecast provided is treated as a **firm offer** of capacity. This means that the plant may be dispatched up to this level, although under normal arrangements it would only be dispatched to the level provided in the t+30 forecast which was used in the pre-dispatch process.

Any additional capacity offered at t=0 may be applied by the system controllers to meet contingency events.

Once a dispatch instruction is sent (at t=0), the plant is expected to meet the dispatched level for every 15 second period within the 5 minute period.

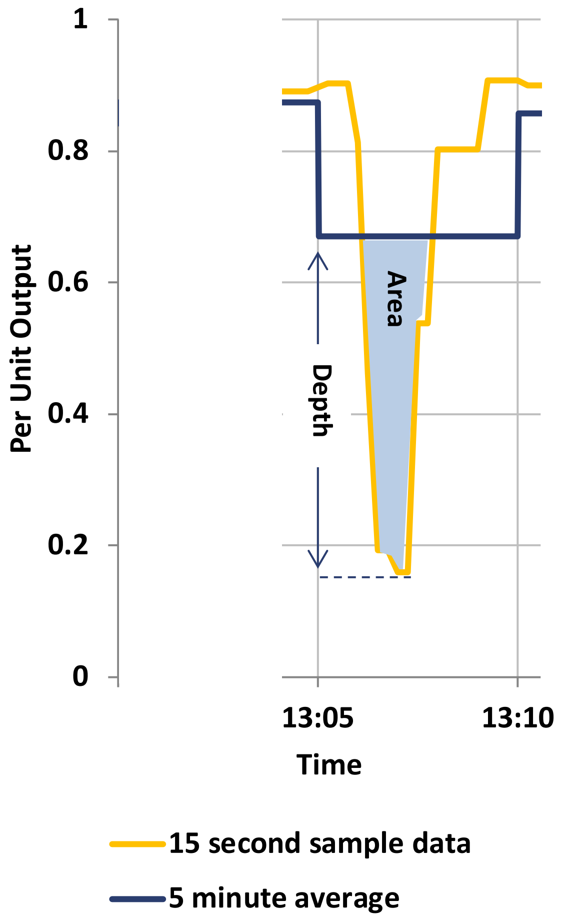
Failure to achieve this means that in future periods dispatch may be de-rated compared to the t+30 forecast and t=0 offers provided by the generator. We note that it is consistent with NT NER 5.7.3 (f)(2) to apply operational restrictions on generators unable to meet the GPS, with the potential to adversely affect power system security.

The proposed obligation is for capacity forecasts not energy forecasts

The proposed requirement is for all generators to provide a capacity forecast, on a rolling 5 minute basis for 24 hours ahead. We are also requiring a 30 day ahead capacity forecast on a 30 minute basis. The forecast is proposed as a capacity forecast. The key difference is that power is an instantaneous physical quantity at a given point in time and measured as mega watts, whereas energy is the average power over a given period of time and measured as mega watt hours.

Figure 6.3 illustrates instantaneous power compared to the 5 minute average (energy).

Figure 6.3: Solar output comparison



A capacity forecast means forecasting a level (for example the blue line[29]) to which the generator is prepared to manage their output for the 5 minute period, continuously supplying this level within the period. That is, a level at which the orange line will never fall below the blue line.

For solar generators, this implies that they need to have some form of smoothing for dealing with the short term power swings (the 'depth'). In the example, a battery that charged when the blue line is above the orange line, and discharged when it is below. In energy terms, smoothing required is represented by 'the area' as shaded in Figure 6.3.

We are requiring that all generators manage (either themselves on-site, or in some other manner) the short term power swings such that the instantaneous power does not drop below the 5 minute forecast provided at dispatch time.

We anticipate that for a PV generator providing this generation capacity forecast is likely to involve a mix of inputs including:

[29] This was the average energy production in Figure 6.4, but here it is used to illustrate a minimum capacity forecast

- A solar forecast – possibly obtained by the generator from a 3rd party - which forecasts the level of solar energy being received;
- A risk management model for that farm – presumably specifically developed by the farm itself – which takes into account the historical performance and known maintenance and other factors of that farm;
- Some form of energy storage or smoothing to enable the short term power flows to be managed to the 5 minute forecast level.

6.2 Rationale for the changes and our preferred approach

The proposed forecasting standard sets a capability requirement for a connecting generator to deliver predictable and dispatchable supply. This requires a connecting generator to predict in advance the capacity of the plant that can be supplied 'continuously' within each forecast period: firmly for 5 minutes ahead, to a high degree of accuracy for the first 30 minutes and indicatively for 24 hours ahead.

This approach was adopted as:

- It allows for a dispatch system that is scalable for dispatch of up to 100% PV generation to deliver power at any point in time, supporting the achievement of the NT Government's 50% renewable energy target.[30]
- The large volume of PV generation connection applications currently underway and expected to connect prior to sophisticated causer pays mechanisms for system security services and interventions are introduced.
- Stress testing of the technical viability and cost of our proposed forecast obligation by our independent technical experts Entura verified that such forecasting is technically feasible and economically viable and the costs are likely to be lower than alternative options. This was reconfirmed by Entura after review of all submissions to the round 2 consultation process.[31]
- Being an outcome based standard, it allows the connecting generator to achieve this requirement in many different ways including permitting generators to negotiate meeting the connection requirement over multiple connection points by proposing a negotiated equivalent standard via NTC 3.3.5.
- Even though it departs from the NEM practices of AEMO (because the NEM is a much larger electricity market than the NT market, and has a much larger diversity of fuel sources, generation types, and geographical distribution), with increasing penetration of renewables the GPS in the NEM, it is now evolving in directions consistent with our approach, including trialling models of generator self-forecasting being used in central dispatch.

In developing and consulting on the GPS Power and Water developed our problem statement, and then considered various options to address it, including:

[30] Note, Power and Water will still need to address technical system strength and inertia requirements to achieve 100% PV generation output.

[31] Entura's report is attached as Appendix E.

- Having System Control perform the forecasting role equivalent to how AEMO currently operates
- Having battery solutions on the power system (centralised or geographically dispersed)
- Running greater gas-fired spinning reserve or FCAS to manage renewable production volatility
- Using market signals to achieve the required system security outcomes.

We also considered various accuracy requirements and forecasting intervals. We tested the adequacy of these by considering a range of forward looking economic dispatch modelling of the DKIS under scenarios where there are high levels of asynchronous solar penetration to see the dispatch needed for secure operation.

The following sections provide a summary of the problem, options considered and responses to new issues raised in the round 2 consultation.

6.2.1 What problem does this proposed generator obligation seek to address?

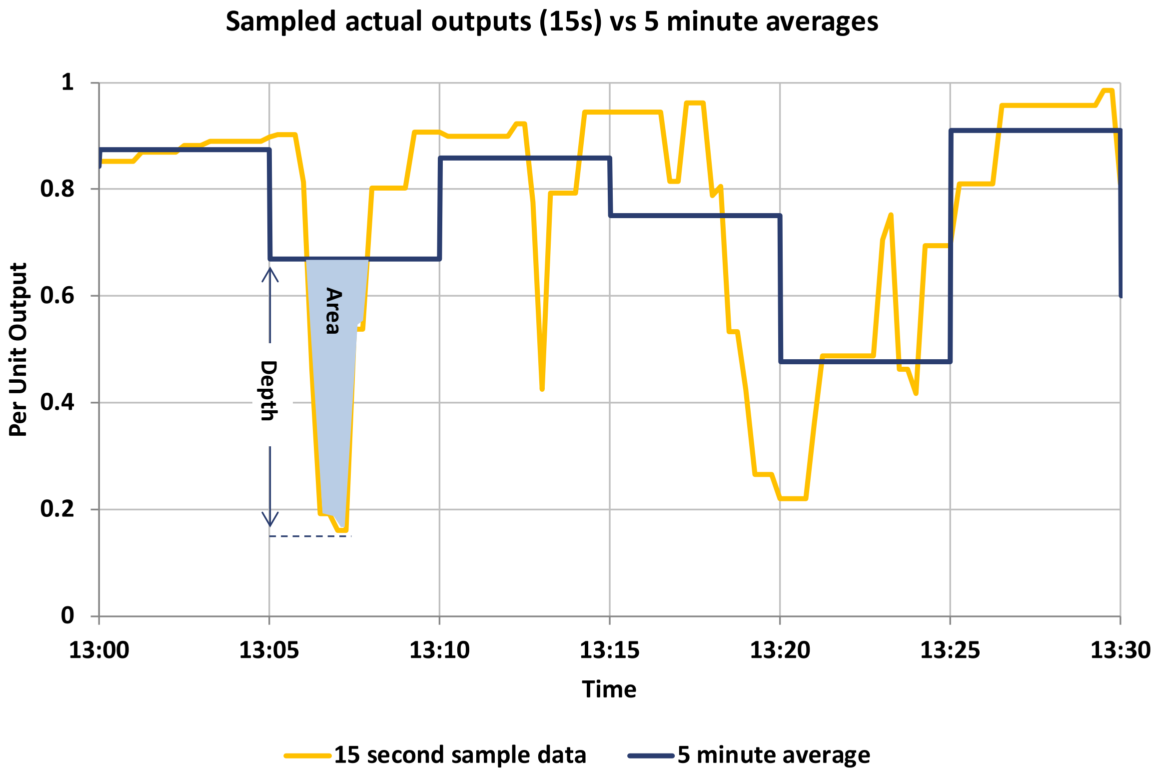
There are two forms of operational power output volatility Power and Water are seeking to manage:

- *Short term output volatility* | Power swings within a 5 minute period, which must be managed by arrangements that are already in-place and operational (such as spinning reserves, battery storage, or other firming arrangements), since this timeframe is too short for additional synchronous generating plant to be brought on line.
- *Medium term output volatility* | Changes slow enough to be included in a pre-dispatch/dispatch process – meaning on a time scale in the order of 30 minutes

Managing short term power output volatility

For example, Figure 6.4 shows the instantaneous (on a 15 second basis) power output (orange line) from an **actual** solar generation facility (in per-unit or 'PU' terms – meaning "1" represents 100% of possible output), compared to the 5 minute average power output (the blue line).

Figure 6.4: Solar output comparison



It can be seen for example that between 1:05pm and 1:10pm the average power generated was around 0.67PU, however after starting at a PU output of 0.9, subsequently for a period of around 2 minutes the instantaneous power was as low as 0.18PU.

To put this in numerical terms, if this were a 100 MW rated PV generator, the power output would have started at 90 MW, and then dropped by about 80 MW (to about 20 MW) over a period of 1 minute, before recovering to around 90 MW by the end of the 5 minute period. This scale of short term power swing (moving from 90% rated output to 20% rated output and back) must be considered in the context of there being around 120 MW of asynchronous PV generators applying for application in the DKIS, and with an expectation of further PV generators making applications.

In addition to large stand-alone PV generators, there is also currently in the order of 50 MW of 'behind the meter' roof-top solar that has already been installed in the DKIS area, with residential and commercial roof-top solar installations expected to continue to increase.

Whilst Power and Water do not have detailed production metering for these roof-top panels (and so cannot clearly identify the exact aggregated scale of the power production swings), it is clear from the wholesale demand observed on the system that similar swings in production are occurring. These kinds of sudden changes have on occasion already challenged the System Controller's ability to maintain the stability of the DKIS, because Power and Water see significant demand 'drop' on or off the system as clouds move through the Darwin area in a period of minutes.

Power and Water is itself now procuring solar forecasting services to provide information on a real time basis about this. However, with no requirement for firming on these roof-top units in the short term, they will present a growing challenge from an overall system control perspective.

The nature of the challenge is further complicated due to the relatively small number of existing gas generators in the DKIS which, for a range of reasons, are experiencing a large number of trip events where a generator has dropped off-line unexpectedly. The Commission reported 98 separate generation trip events during 2017-18.[32] These issues are separately being addressed, but remain an operational reality.

Accordingly, to ensure that consumers are not exposed to load-shedding, System Control plans on the basis of meeting a contingency event where:

1. not only has solar production momentarily dipped (not itself a contingency event);

2. but at that same moment, a generator trip event (a contingency event) occurs.

This can be particularly important in the circumstances where Power and Water are running gas generators specifically to provide support services to the solar production. At these times, if a generator trip occurs there can be relatively little other 'spinning reserve' immediately in the system.

This is currently done by way of the SSG's spinning reserve requirements. Although as Power and Water have noted in this document, these spinning reserve arrangements will rapidly become inadequate as asynchronous solar penetration increases. Hence over time Power and Water are proposing to move to a more sophisticated C-FCAS arrangement. This change is not part of the current GPS arrangements, but has been previously flagged and will be progressed by Power and Water.

Under the proposed GPS arrangements managing the short term power volatility will involve requiring all generators to provide System Control a firm 5 minute **capacity** offer at dispatch time, which is the minimum level of power output that the generator can supply **continuously**[33] during the coming 5 minutes.

Managing medium term power output volatility

System Control can manage power output changes that occur on the timescale of 30 minutes by starting additional generation plant. The existing generation mix in the NT is primarily gas turbine based. Whilst there is some variation, it generally takes approximately 30 minutes to start an NT gas turbine and have it available to contribute to meeting demand. This is the practical minimum when allowing for the time required for human decision making as well as resolving any immediate issues that may occur as a given turbine is started. It should be noted that this is the minimum – it may be insufficient if multiple technical issues occur in the turbine start-up process, which would result in holding insufficient contingency reserves associated increased risk of Under Frequency Load Shedding (UFLS).

In operational terms, System Control must observe multiple timeframes – considering up to a month ahead any known maintenance or other plant outages, and then a day ahead having a proposed set of dispatch arrangements to meet forecast load. The current system operation – and the possible need to start or stop plant - is then closely observed about an hour ahead, with final dispatch

[32] Commission, Northern Territory Power System Performance Review 2017‐18, (June, 2019), p.8.

[33] This is discussed further in the next section, but in summary, 'continuous' here means "at the measuring resolution of the Power and Water systems, nominally SCADA", which is about 15 seconds. So a firm offer of '10MW' given at dispatch time really means "I can generate at least 10MW for every 15 second period over the next 5 minutes". Additionally, high speed data recordings may be used on an ad hoc basis where sampling frequency of SCADA is insufficient.

instructions being made 30 minutes ahead, and any 'starting' issues being finally resolved during that last 30 minutes.

The proposed GPS arrangements are thus intended to be consistent with, and support this timeline, having a requirement for capacity forecasts from all generators on a daily basis, and in particular a rolling-5-minute capacity forecast, with an accuracy requirement being applied for the last 30 minutes ahead of dispatch. It is for this reason that a 90% level of accuracy is proposed over the 30 minute ahead time period. (more on this in section 6.2.6.)

6.2.2 Options considered:

We considered alternative firming options including a centralised battery

The provision of a mandated central battery solution was considered, however Power and Water could not demonstrate that it would be the least cost option. In fact, our modelling indicated that alternate options could be achieved at a lower cost. Additionally, the economics of the various options will change over time as technology develops, thus it is our view that this would also be inconsistent with the *Utilities Commission Act* objectives and regulatory framework with regards to both competitive and fair market conduct and economic efficiency. As such the obligation was structured to allow for a centralised battery solution via the negotiated access provisions for the generator performance standards, but it is at the generator's discretion rather than a mandated service. Should a generator choose to adopt this solution it will be the generator's responsibility to develop the proposal.

The reasons for this approach are:

- It puts the obligation upon those best informed to make the required decisions, which is consistent with the policy objective of driving least cost outcomes as well as technological innovation.
- It places competitive pressure to innovate and improve the forecasting and management of the generation assets.
- It provides a causer pays mechanism, which would otherwise require significant market reform ahead of the new generator connections to ensure that the impact of variable supply is not placed on another user without compensation, which is not deliverable in a practical timeframe.

Our round 2 consultation paper made it clear to stakeholders that the required smoothing did not necessarily need to be provided at each generator, stating that:

> *We intend to set a technical standard for the firmness of offers provided to the market, and not to constrain the manner in which any required smoothing is achieved.*
>
> *For example, a group of generators could engage an outside party to provide firming capability, be that via a centralised battery or providing additional spinning reserve generation, or in some other manner. The proposed solutions would need to be demonstrated through the negotiated connection process.*[34]

[34] Power and Water, *Review of the Northern Territory Generator Performance Standards – Consultation* Paper, June 2019, section 3.7 at page 34

It also explained that our options analysis of onsite (or near-onsite) firming, firming from existing gas turbines, and a centralised battery suggested that the most likely economic response will be at (or near to) the individual asynchronous generation sites. This option analysis is provided in Box 1 below.

Box 1 | Options analysis

Having onsite (or near-onsite) firming | Under this option a PV generator has small on-site batteries for providing firming within 5 minute periods, or other local firming arrangements (possibly shared with other local generators).

This on-site option allows for a relatively small capacity battery on the DC side of the plant, before the existing inverter.

- Based on public information, Power and Water estimate this firming capacity would require around 0.2 MWh of battery for each MW of installed solar.
- No additional network augmentations are required
- No additional inverter is required

Accordingly, Power and Water consider (using public information) this is likely to be the least cost option.

Firming from existing gas turbines | Under this option a PV generator would contract for an existing generator to cover any short term variations

We note however that:

- Existing connected synchronous generators are not designed to accommodate ramps of 10-20 MW over ~1 minute as a regular event, and that is probably the required scale of operation as Power and Water move to having 100 MW + of solar in the DKIS.
- Network stability and transfer limits mean that additional network augmentation is likely to be required, and this will need to be paid for.
- Generation capacity used for this purpose cannot also be counted for system C-FCAS or spinning reserve purposes.

As long as their effectiveness can be demonstrated, there are no barriers to individual parties negotiating these arrangements under NTC 3.3.5 should they wish to do so.

Centralised battery | Under this option a PV generator arranges for a centralised battery owner to inject/absorb from the grid the instantaneous unders/overs of production within the 5 minute period to cover any of these short term variations, in a manner that satisfies System Control.

We note however that:

- A centralised battery for managing these short term variations requires a relatively large inverter (and a relatively small battery), which will be a significant cost due to relative size of storage required for short term variation management.
- Using public data Power and Water estimate the additional costs of doing this service using a centralised battery to be in the order of a 20% premium compared to the 'on site' firming. This additional cost is mostly in the need for a dedicated high-capacity inverter.
- As with using turbines, the centralised approach raises issues of network stability and transfer limits (with the likely result that additional network augmentation would be required).

However as long as their effectiveness can be demonstrated, there are no barriers to individual parties negotiating these arrangements under NTC 3.3.5 should they wish to do so.

6.2.3 Testing that forecasting obligation was technically viable

Testing the technical feasibility and cost effectiveness of PV generators providing capacity forecasts

Our round 2 consultation stepped through how Power and Water had tested technical feasibility and least cost and remains relevant for this submission:

On the basis of our review of the data [insolation forecasts from third party providers], we believe that there is no technical barrier to forecasting to the required level of accurate 90% of intervals, and within 5% of power production for the remaining 10% of intervals. We note that within the sample sets we reviewed there was only 1 period that exceeded the error threshold.

To manage the transformation from a solar forecast to a capacity forecast is likely to involve using smoothing services from a small amount of battery storage or generation. To verify that this requirement is not overly onerous we have conducted some analysis of the amount of energy storage required to achieve this short term smoothing. Our desktop analysis suggests that on reasonable assumptions such a smoothing requirement could be achieved with in the order of 0.2 MWh of storage capacity for each 1 MW of installed solar capacity (on an assumption of the battery being oversized somewhat to allow for the relatively high instantaneous power flows). This is a relatively small battery, and we anticipate on the basis of our desktop research into pricing would not increase the capital cost of the farm beyond the point of economic viability. [35]

An independent consultant's review of the proposed standard supports this analysis:

"Forecasting requirements proposed by PWC have been assessed by Entura for their implications on solar PV generators. Entura supports the view that mature technical solutions are available to meet these requirements. Likely cost (or revenue) implications for generators is estimated in the order of about $320-480/kWac of PV installed or 20-30% of the cost of the solar PV plant, plus a similar ratio of ongoing operations and maintenance cost."[36]

When asked to update their report based on the submissions received the independent consultant maintained the same view:

"A number of submissions cite limitations in forecasting accuracy as a barrier to the proposed plant output forecasting requirements. Entura understands that these submissions relate to the accuracy of technologies to forecast solar PV output due solely on irradiance variation. Entura's baseline position in its report is that the proposed forecasting requirements can be met through the implementation of energy storage (thus providing sufficient backing for plant output forecasting), and as such are not reliant on irradiance forecasting."[37]

Further stakeholder views after round 2 consultation

Concerns were received in some submissions that the forecasting requirements were not achievable:

"Accuracy and Forecasting Requirements Unachievable - Our understanding of the 5% accuracy target was that it achieved a desired level of stability for a given solar penetration based on modelling undertaken. While, the technology of forecasting remains nascent and will improve over time with greater experience and implementation, the physics, technology

[35] Power and Water, *Review of the Northern Territory Generator Performance Standards – Consultation* Paper, June 2019, section 3.4 at page 32

[36] Entura, NT generator performance standards code review - Technical advice, 20 June 2019, section 4, p.7.

[37] Appendix E - APPENDIX E. ENTURA REPORT UPDATE 29 AUGUST 2019

> *and systems currently available to provide this forecasting accuracy 30 minutes out from dispatch is not available at this time."*[38]

If a generator does not have confidence in their chosen solar forecast, backup firming arrangements could be provided for 30 minutes ahead to ensure forecasts were 100% accurate; which would clearly address any technical viability concerns. Although Power and Water's modelling showed this was clearly not required and could be achieved in a more economical manner with a combination of an appropriate sized battery and insolation forecasting.

The availability of technical solutions was further confirmed by Proa Analytics in its round 2 submission, which stated:

> *Proa Analytics agrees that power systems of the size of the NT would certainly need greater reliability requirements than a system such as the NEM. As solar forecasters, we would not seek to comment on the reliability requirements calculated by PWC, other than to note we believe that commercially available state-of-the art forecasts will substantially assist generators to meet such requirements.*[39]

6.2.4 Modelling the required level of forecasting accuracy, and addressing stakeholder questions on compliance and interpretation

Setting the required forecasting accuracy standard

System Control conducted a series of simulations including from 50 MW up to 250 MW of solar generation into the generation mix, and examined the resulting system wide impacts on the levels of spinning reserve required and probabilities of forecasting inaccuracies leading to customer outage events.

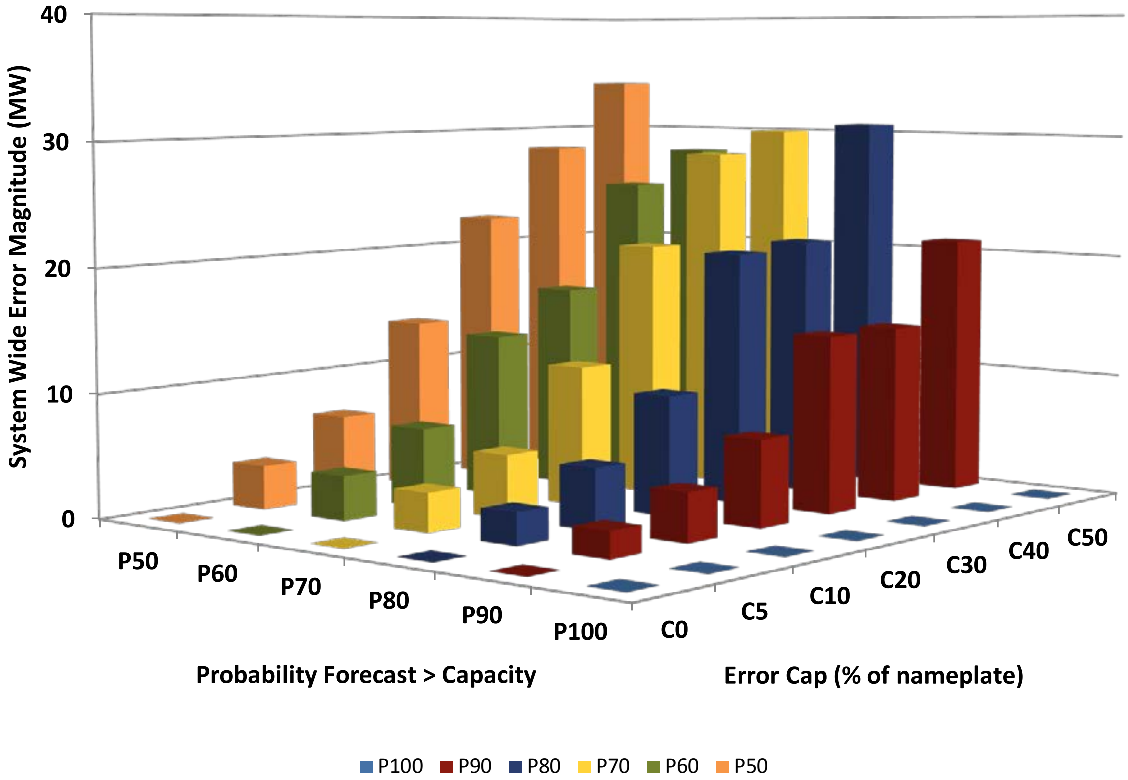
Taking the case considering 120 MW of actual PV generator connection applications, Power and Water found the relationship between the number of daylight 30 minute dispatch periods where the SSG were breached[40], and the accuracy requirement on the solar capacity forecasts to be as shown in Table 2.1: Percentage of Daylight Periods with SSG breach on page 19 above.

The coloured cell in Table 2.1: Percentage of Daylight Periods with SSG breach represents the proposed accuracy standard. It is observed that the number of periods where the SSG are breached due to inaccuracy in provided forecasts increases rapidly as the accuracy requirements are decreased.

A similar message can also be seen from looking at the largest estimated MW error in forecasting that is propagated onto the network at different levels of forecasting accuracy requirement on individual generators. This is presented graphically in Figure 6.5 – where again the proposed accuracy standard is coloured green, and is based on the case of all currently proposed PV generators proceeding (totalling about 120 MW of installed solar capacity)

[38] Submission by Assure Energy dated 19 July 2019, at page 1.
[39] Submission by Proa Analytics dated 18 July 2019, pages 1 and 2.
[40] A breach of the SSG means operation below the minimum level of spinning reserve which increases the risk of customer load shedding following a generator trip contingency event.

Figure 6.5: Forecasting accuracy, worst error



Stakeholders views on the accuracy of the forecasting requirements

Power and Water explained the forecasting requirements and why the accuracy levels were set as proposed in depth in its round 2 consultation paper and stakeholder workshop. It asked for any alternative options that stakeholders considered could meet the system security and *Utilities Commission Act* requirements. We received one proposed alternative:

> *"Tetris suggests that PWC should modify the proposed forecast to 50% probability of exceedance (POE) forecasts, with a pre-determined maximum and minimum bound. Tetris suggests that given the geographical distribution of solar farms, the impact to the Darwin Katherine Interconnected System (DKIS) system from simultaneously incorrect solar forecasts is likely to be minimal. Tetris' approach would utilise leading solar forecasting technologies, removing the need to invest in co-located batteries, which come at considerable cost to solar project for minimal system benefit."*

The modelling undertaken and presented in the round 2 consultation overview paper (replicated above) demonstrates that the increase in system wide error is quite significant when adjusting from P90 to P50. Furthermore, the assertion that this different requirement would be deliverable by insolation forecasts alone without supporting technology does not appear to be reflective of the nature of insolation forecasting providing average power output predictions which is unable to directly address the short term power output volatility issues of solar PV.

The submission from Proa Analytics supports Power and Water's understanding:

> *"We note that even perfect forecasts will not remove the need for such dispatchable compensating technology. To take an example from the GPS Consultation Paper, under the solar generation in figure 3.1 on page 24 (reproduced below), the solar generation varies*

> *from 90% output to 18% within a five minute period. Even with perfect forecasts the solar farm would need to either curtail generation or use storage to meet the GPS requirements under these conditions."*

Stakeholders asked, What happens when there is non-compliance with the forecasting requirements?
Throughout Power and Water's consultation process, stakeholders sought details regarding how capacity forecast accuracy would be measured and if errors exceeded the capacity forecast accuracy requirement how they would be dealt with.

In line with the treatment of other generator non-compliance instances, and consistent with NT NER 5.7.3 (f) (2) Power and Water will proactively work with the generator and may direct the generator to operate at a reduced output in order to manage system security.

The proposed process of managing forecasting non-compliance is broadly outlined below:

1) System Control's dispatch system will include automatic identification of non-compliant forecasts and automatically issue constraints.
    a) This will be a function of the received forecast and errors identified to target the forecasting requirements set out in the NTC if possible.
    b) It is likely that this will be somewhat conservative to minimise risk of a system event as a result of forecasting non-compliance
2) The on shift controller will attempt to communicate with the generator's owner (station operator equivalent) to:
    a) Obtain a preliminary understanding of the likely cause of the non-compliance;
    b) Using the available information from the generator, determine if or how the constraint could be relaxed or removed as appropriate;
    c) If necessary, trigger the generator to commence with the formal outage process with respect to the non-conforming equipment.
3) The formal outage process can apply to a part of plant or a function and involves:
    a) Generator submitting a Generator Outage/Test Request form to system control that identifies the issue (root cause or symptomatic) and investigations, outages or testing required;
    b) System Control assesses the outage and testing requirements.
        i) The ongoing constraints until rectification may be revised here – better information may allow further relaxation of constraint until rectified;
        ii) Testing may require additional security measures;
    c) Rectification and testing undertaken as required;
    d) Generator submits return to service form to system control with results of the investigation, work or testing for approval to recommence normal operation;
    e) System Control reviews the return to service and if approved the constraint is lifted.

Stakeholders asked, How will behind the meter load arrangements be treated?
A topic raised in Power and Water's Round 2 consultation was how loads co-located behind the meter with generators would be treated. We published a response to this after Power and Water's workshop and received a further query on it:

> *"Following the PWC Responses for Questions Taken on Notice, it is noted that an embedded generator that exports surplus energy to the grid will be able to provide a gross generation forecast and are not required to forecast their load. As such their firm offer for dispatch will*

be on the basis of gross supply and not net, that is not taking into account the load. We support this decision.

If Embedded Generators are not exporting to the grid, since only a net load will be visible to the PWC System what are expected to be the dispatching arrangements in this regard (noting an Embedded Generator that is not exporting to the grid can only dispatch up to the total load)?"

Also…..

"If embedded generators are required to forecast generation and comply with dispatch instructions, but can only generate up to the level of site load, there is a high likelihood of significant curtailment. This would be required on a consistent basis to comply with the GPS forecast accuracy requirements and the terms of a non-export connection agreement."

As stated at the workshop, all generators greater than 2 MW even if 'behind the meter' will be required to meet the GPS and as such will be classified as scheduled generators and need to meet capacity forecasting requirements. Dispatch arrangements will be the same regardless of the load. The complexity is introduced in the capacity forecasting where an export limiter is in place.

The forecast will be assessed on the capability of the generating system to continuously deliver active power up to the forecast capacity (gross production capability). As such, if it is under any practical restriction as part of the connection arrangements (such as an export restriction or plant thermal limits) it must be taken into account in the forecast. The assessment of whether an export limit is appropriate would be assessed during the connection process, however Power and Water understand it is unlikely to be adopted by large generators who the GPS would apply to.

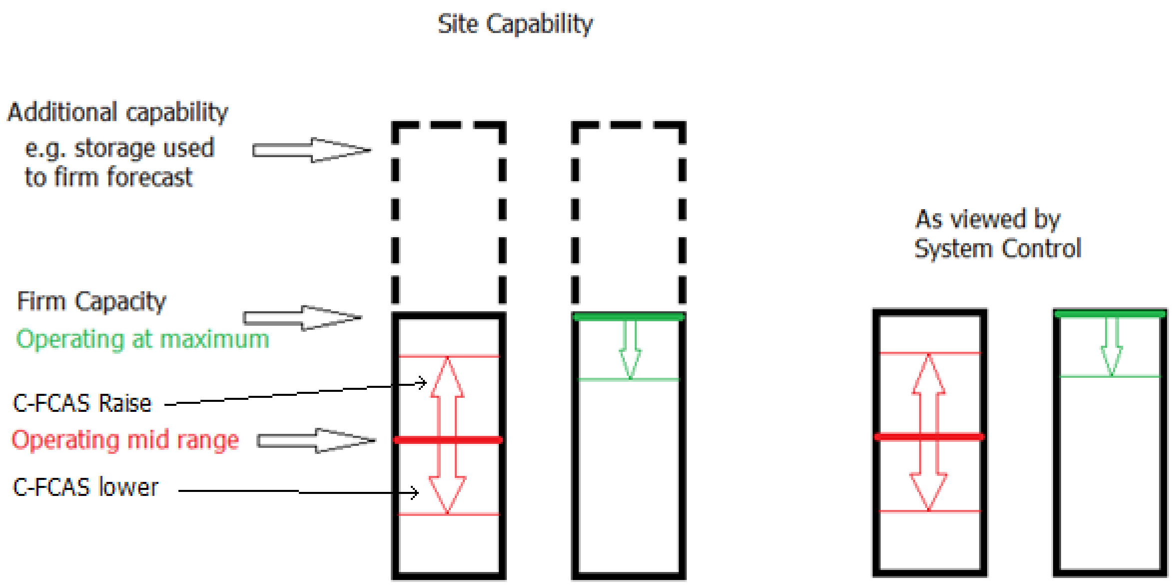
We have clarified C-FCAS and forecasting interactions

C-FCAS capability is required to be delivered subject to energy availability, hence subject to the capacity forecasts. That means that the delivery of C-FCAS can be restricted to maintain the plant within the firm offer/ capacity forecasts and when a site delivers C-FCAS it does not impact capacity forecasts.

The C-FCAS accreditation for each generating system is a function of the operating level of the generating system as a whole and its available capacity at a given point in time. The system controller will thus know from capacity forecasts and dispatch levels what C-FCAS reserves are available at any point in time.

Although a generating system may be comprised of multiple pieces of equipment such as battery and PV inverters, these are expected to provide C-FCAS response within the firm capacity, but not above it. A generating system using a storage device to achieve the capacity forecast obligations should have the appropriate controls in place to ensure excess C-FCAS is not delivered to the detriment of compliance with other NTC provisions including capacity forecasts.

The interaction between C-FCAS and capacity at different levels of firm offer of a generating system is illustrated below.



6.3 We have developed a technology agnostic standard aligned to the *Utilities Commission Act* objectives

The proposed solution aims to:

- promote competitive and fair market conduct;
- prevent misuse of monopoly or market power;
- protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries; and
- promote economic efficiency by placing forecasting risk with the parties best placed to manage it at least total cost.

We achieve this by adopting a standard that does not discriminate between generation technologies and does not prescribe how generators achieve the firming requirements needed for system security.

Stakeholders asked, What infrastructure do I need to meet this requirement?

The proposed GPS does not specify what infrastructure should be used to meet the requirement. There are proven tools and systems to achieve the performance requirement, which Power and Water's independent technical reviewer, Entura, has verified.

The GPS are set to replace the existing generator connection requirements that were written specifically for synchronous generators and were not applicable to new technologies. The proposed code changes deliberately specify the outcome (e.g. capacity forecasts), not the means of delivering that outcome. It is envisaged that this will facilitate technology innovation in a framework that can last longer through this period of rapid technology development.

Stakeholders asked, What arrangements do I need to 'trade' away my firming obligation to another party?

The proposed GPS does not specify how this should be done as Power and Water do not intend to restrict the commercial and technological approaches developed by connecting generators. It is up to the connecting generator to come forward with a proposal that delivers the same outcome for technical assessment by Power and Water. It is worth noting that for a negotiated arrangement, there are many considerations Power and Water may have including but not limited to responsibility of the generator to perform, system security, market arrangements and integration into dispatch systems that will need to be evaluated on receipt of an application.

7. Generator classifications

7.1 Proposed code amendments and their effect

Generator classification proposed amendments can be found in NTC 3.3.5.14. NTC 3.3.5.17, and SCTC 3.2.3 (b).

As per the materiality threshold outlined in 3.3.1 of the NTC, the intent is that all generators 2 MW or larger will be classified as scheduled. Those generators who are smaller than 2 MW will be assessed on a case by case basis and may still be classified as scheduled. As a principle Power and Water are seeking to allow for technological innovation and competition to drive the transformation of the NT power systems, in particular by providing for a consistent set of requirements for major generation plant within the NT industry.

7.2 Rationale for the changes and our preferred approach

Our approach has been driven by the principles and objectives set out in section 2.6 that the Commission is to apply, in particular to:

- promote competitive and fair market conduct;
- prevent misuse of monopoly or market power;
- protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries; and
- Promote economic efficiency by placing risk with the parties best placed to manage it at least cost.

The following sections provide a summary of the problem, options considered and responses to new issues raised in the round 2 consultation. Section 7.3 sets out how the proposed approach achieves the relevant *Utilities Commission Act* objectives.

7.2.1 What problem must the GPS address?

The NT's extremely small power systems will rapidly move to the point where renewable generators represent a majority of the generation producing at certain times. The 'semi-scheduled' status in the NEM reflected the historically 'new entrant' and marginal nature of NEM renewables.[41]

[41] Even so, we note that with the increasing penetration of renewables policy discussions in the NEM are now evolving in directions consistent with the principles underpinning the proposed application here – namely that renewables are moving from the margins into the centre of energy generation, and will be performing the role of the dominant form of energy generation at some time.

It has always been the approach that the application of the NER to the NT would be tailored to the specific conditions that are found here. In the matter of generator classification, this has required recognition that the NEM is a much larger electricity market than the NT market, with a larger diversity of fuel sources, generation types, and geographical distribution.

With the maturing of the renewable industry, and the central role it is being called on to play in meeting the energy demands of the NT power systems, it is not appropriate to maintain this distinction. The distinction only works when asynchronous renewables are not a material share of the generation pool. In effect the 'semi-scheduled' status pushes the risk of generation not performing in the manner forecast to the power system as a whole. This outcome would lead to the costs of addressing this to be borne by those who are not causing it, whereas Power and Water's analysis suggests that generators have access to the least cost ways of addressing it and Power and Water's proposal places the responsibility with them to do so.

7.2.2 We considered if NEM or WEM arrangements would work

The initial stage of Power and Water's consultation process delivered considerable discussion around the potential classifications within the NT electricity sector, with some evidence of an expectation that NER arrangements as applied in the NEM would be applied automatically in the NT.

Our Round 2 consultation paper and workshop examines the issue of fit-for-purpose generator classifications in the NT, including addressing the following questions:

How can PV generators that are inherently intermittent be classified as scheduled?

Capacity forecasting (that is, with a small amount of firming capacity) to the proposed accuracy level 30 minutes ahead provides a sufficient level of predictability for a generator to be classified as dispatchable, based on Power and Water's current modelling.

Is there or should there be a materiality threshold?

It is proposed that the GPS will apply to all generators that are 2 MW or greater. For those generators below 2 MW Power and Water will consider applying a moderated set of technical standards which may give effect to performance that is more akin to semi or non-scheduled. However, this will depend on the relative size of the generator to the system demand in the regulated power system where they are connected.

Round 2 consultation submissions

In response to Power and Water's round 2 consultation paper NT Solar Futures submitted:

> *The semi-scheduled generator classification must be retained to facilitate intermittent renewable energy generation. Definition of semi-scheduled should be similar to the NEM and/or the WEM (intermittent generator). Proposed removal of this classification places an unnecessary cost burden on new intermittent generators entering the market. In both the National Electricity Market (NEM) and the Wholesale Electricity Market (WA) (WEM) there are semi-scheduled and non-scheduled classifications that work well to enable intermittent generation. The removal of the semi-scheduled generator classification will make the NT unattractive for investment due to complexity and cost.*[42]

The connecting generators are significantly different in relative size when compared to the NEM and WEM. For connecting generators of equivalent relative size to the WEM or the NEM minimum

[42] NT Solar Future, July 2019, p.3.

demand, the generator classification would undoubtedly be scheduled, so it is not entirely inconsistent as presented. For example, the equivalent of 30 MW sized generator on the DKIS in comparison to the NEM would be 3,300 MW. Furthermore, the NEM and WEM have markets to manage the intermittency, whereas the NTC GPS provides a framework that allows for appropriate cost allocation and the generator capabilities that would be necessary for operation with 100% of demand supplied by solar PV at some periods of the day.

7.3 Alignment with *Utilities Commission Act* objectives

Consistent with the principles set out in section 2.6 that the Commission will apply, Power and Water consider that this approach:

- ensures that there is a consistent incentive across all forms of generation and thereby promotes competitive and fair market conduct;
- promotes economic efficiency by supporting the lowest total cost of reliably and securely providing energy whilst facilitating the connection of asynchronous renewable energy technologies because it ensures the system security risk associated with increasing levels of asynchronous generation is placed with those best able to manage it;
- protects the interests of consumers with respect to reliability and quality of services and supply by:

- maintaining the system security levers of predictability and dispatchability that System Control needs to perform its function; and
- learning from the lessons currently being experienced in the NEM.

8. Requiring the ability to have inertia and/or C-FCAS capability

8.1 Proposed code amendments and their effect

Proponents of new generating systems will be required to connect in accordance with the proposed NTC clause 3.3.5.15 'Inertia and Contingency FCAS'. Although the GPS specifies that to meet the automatic standard the performance is to be achieved at the point of connection, it does not prohibit that the proponent may negotiate for the standard to apply across more than one connection point if it benefits the system.

This would be through the process outlined in the proposed NTC clause 3.3.5 on the basis that the connecting generator retains responsibility at all times.

The NTC clause 3.3.5.15 requires that a generator is *capable* of supplying both C-FCAS raise and lower (subject to control mode and dispatch level), the NTC contains no obligations with regards to *enablement, provision* or *delivery* of C-FCAS. C-FCAS lower refers to the service where a generator reduces output in response to high frequency. C-FCAS raise refers to the service where a generator raises output in response to low frequency. The italicised terms are defined in Box 2.

However, during the connection process, the various performance requirements (including C-FCAS) would require testing to demonstrate capability by actually delivering the service; this does not influence the normal mode of operation for the generating system following the connection process.

Although batteries and other technical solutions may be used, an inverter with a droop frequency control could also meet this capability requirement. The incremental cost for an inverter based generator to obtain this capability by droop frequency control is minor.

An independent consultant's review of the proposed standard supports this analysis:

> *"This definition is consistent with Entura's view of the capability of typical inverter based solar PV plant. System Control could only call on raise capacity from systems with no storage if they were known to already be curtailed. A requirement for 'enablement' of automatic frequency control is expected to add no significant additional cost to a typical inverter solution in the market now."* [43]

Box 2. Our terminology

To ensure adequate distinction between connection requirements and operational requirements such that the matters discussed in this document are clear and unambiguous, the following terms relating to C-FCAS are defined:

- *Capability* | Connection requirement (NTC): Connecting parties are to demonstrate that plant can supply C-FCAS services if the generator is in the appropriate control mode to do this and with appropriate headroom/floorroom. It does not specify a generator will be obligated to operate in this mode or curtailed to ensure provision.
- *Enablement* | Operational requirement (SCTC): If the System Controller requires a generator to be enabled for C-FCAS it will only supply it if it has the headroom (for raise) or floorroom (for lower) to do so. A generator operating at maximum output can be enabled for C-FCAS, but be unable to supply C-FCAS raise as it has no headroom. In regards to lower service, a generator can provide C-FCAS lower if it is enabled and it is dispatched above its minimum stable load.
- *Provision* | Operational requirement (SCTC): If the System Controller requires a generator to be enabled for C-FCAS services AND its dispatch level has the headroom or floorroom to supply the C-FCAS service it is providing C-FCAS. For example, a generator dispatched below maximum capability that is enabled for C-FCAS is able to provide a C-FCAS raise service. This service is the quantity referred to in any market payment arrangements.
- *Delivery* | Operation is the result of provision when a service is used. For instance if a generator tripped, other generators providing C-FCAS raise would then deliver this service by increasing their output in response to the low system frequency.

8.1.1 Use of C-FCAS

The initial feedback received on the proposed C-FCAS requirements suggested to us further clarification was required about the intended difference between all generators:

1. having the technical capability of providing C-FCAS, as compared to
2. being called upon to actually provide this service.

Under the current commercial arrangements in the NT (the I-NTEM) there is no mechanism to facilitate ancillary service payments to generators other than TGen.

The I-NTEM was designed as a fit for purpose short-term market arrangement on the principle of TGen being the primary provider of ancillary services. System Control have managed the system utilising

[43] See Appendix C, section 3.1, Page 6.

these principles for the past four years, and accordingly it would be an unusual situation where System Control actually constrained down a non-TGen generator to provide C-FCAS raise. In the I-NTEM, Power and Water will continue to operate all generators with C-FCAS enabled, with the provision of C-FCAS based on the principles of:

- security constrained economic dispatch; and
- in normal situations, any C-FCAS provision from non-TGen generators results in their dispatch being equal to or higher than it would otherwise be.

How do we operate C-FCAS lower?

Generators will operate in a frequency droop mode (C-FCAS enabled). This means whenever a generator is dispatched above its minimum stable loads it provides C-FCAS lower. This is beneficial for generators to do as it avoids displacement (curtailment/constrained off) by TGen plant that would be required to operate with sufficient 'floor room' necessary to perform this service.

How do we operate C-FCAS raise?

Under the auspices of security constrained economic dispatch, when a generating system is offered in at a lower price for energy it will be dispatched in preference to higher cost generating system subject to security requirements. Operation in this way will mean lowest cost facilities (e.g. solar) will have no 'headroom' and therefore will be unable to provide C-FCAS raise. This is expected to be the most common situation and mean under normal circumstances, TGen will be the primary provider of C-FCAS raise.

Situations where TGen facilities may not have sufficient headroom will require low cost facilities to be constrained below output to leave headroom. Alternatively situations such as islanding may arise where there is insufficient demand to allocate headroom to generating systems owned by TGen after using more efficient energy sources. To use these more efficient energy sources, these generating systems such as solar PV must be providing C-FCAS Raise or be constrained further to allocate load to TGen generating units so they could provide the service. It is clearly more desirable to dispatch the lowest cost sources of energy in preference; hence under these circumstances it will be efficient that these generators provide C-FCAS Raise. Note that in these circumstances, some load may be required to be allocated to synchronous generation for inertia purposes.

8.2 Rationale for the changes and our preferred approach

The following sections provide a summary of the problem, options considered and responses to new issues raised in the round 2 consultation.

8.2.1 What problem must the GPS address?

Without all generators being C-FCAS capable, Power and Water cannot effectively manage frequency control under all possible operating conditions and dispatch scenarios, whilst facilitating high levels of PV generation dispatch. The principle behind the proposed GPS clause on C-FCAS is to 'do no harm' in regards to reducing the power system's technical capability to maintain power system frequency by ensuring a sufficient level of services being available to be dispatched.

Renewable plant having the technical capability to provide FCAS is a required step to enable the power system to support a significant penetration of PV generation.

As discussed earlier in this consultation paper, the level of new generation coming into the NT power system means that over coming years asynchronous solar generation will at certain times be the dominant form of generation. Clearly as the NT sector evolves so will the manner in which FCAS is provided.

8.2.2 What are the key benefits?

We have for example discussed in previous sections that the SSG, which currently work mostly on the basis of minimum spinning reserve requirements at Channel Island, will need to be replaced by an FCAS based contingency regime, and having the dominant generators operating at that time as participants will clearly be required.

The requirements outlined in the GPS are intended to:

- 'Future proof' the equipment installed by ensuring that the underlying capabilities to (at least potentially) participate in future (as yet unspecified) commercial arrangements exists.
- Ensure that the system is capable of being operated safely even in circumstances where TGen's ability to provide FCAS has been constrained in some manner.
- Ensure that new entrants are not required to be constrained down pre-emptively in order to ensure that TGen plant is operating with sufficient 'floor room' to provide C-FCAS lower. We consider on a practical basis that this is the major factor that should actually be encouraging all participants to ensure they are FCAS capable.

It is Power and Water's expectation that the proposed connection requirement can be met with minimal cost, since most inverters on the market have the required capabilities

Only under abnormal circumstances, such as islanding where TGen are unable to provide adequate C-FCAS raise is it expected that non TGen generators may be dispatched at a level such that they provide C-FCAS raise, the less desirable alternative is to not dispatch these (or significantly constrain) asynchronous generation sources. We are not able to provide guidance at this time as to the likely frequency of these events, since it is at least in part determined by the exact location and timing of connections of new generation to the grid. We will be conducting further modelling on this question of the likely practical number of events as asynchronous generation rises.

8.2.3 The AEMC ruled against similar requirements proposed for the NER, what is different here?

The expected rapid high penetration of asynchronous generation in the NT, and the sizing of NT generators being extremely large relative to the system demand (compared with their counterparts in the NEM), mean Power and Water face both large contingency sizes and lower inertial frequency response.

Thus these provisions for C-FCAS capability are of critical importance in the NT power systems, which due to generation characteristics already operate with low levels of frequency control.

The large size of units compared to the system means that if significant generation is dispatched without frequency control enabled, in the event of a contingency it would not respond to the frequency and would maintain existing loading levels. This significant quantity of energy would be held by these generators until a dispatch signal is received, which takes minutes to manage loading levels on generators, far too slow in an emergency event.

In this case it is possible (and has occurred in the past) that following a contingency event and under frequency load shedding (UFLS), the remaining TGen units online would not have sufficient loading levels to operate in a stable manner. They would thus try to increase their loading level by pushing the system frequency up. With the generators operating with C-FCAS disabled, the frequency could go out of bounds in the high range which would likely result in cascading failure and complete loss of supply to all customers (i.e. a System Black event). This is a much more credible scenario in the NT than it is in the NEM, which necessitates a different approach.

In the scenario described above, the normal C-FCAS arrangements were insufficient to accommodate the contingency event. The desirable outcome from new generators is that they have C-FCAS capability and operate with C-FCAS enabled to provide C-FCAS lower when operated at maximum output, such that they can share loading with the synchronous generators following operation of UFLS to dampen the unstable frequency oscillations, that could otherwise cause a system black.

8.2.4 Enabling this mode is in a generator's self-interest anyway

Although enabling C-FCAS lower will result in the normal provision of C-FCAS lower from non-TGen generators, in practice it allows greater dispatch levels for these generators that would have been achieved if they were not delivering C-FCAS lower.

Under normal circumstances, the only impact to energy production for these generators is following a load contingency; these generators will have delivered C-FCAS lower by temporarily (typically less than 15 minutes) reducing their output, but overall have been dispatched at a greater quantity for a longer period of time.[44] The reliance on new generators to provide contingency lower service will increase significantly as the share of energy available to TGen reduces due to this service requiring the generators have a share of energy reduce on demand.

During stormy periods, the contingency lower requirement is approximately 30% of system demand,[45] so constraint levels could be significant if C-FCAS is not enabled and provided.

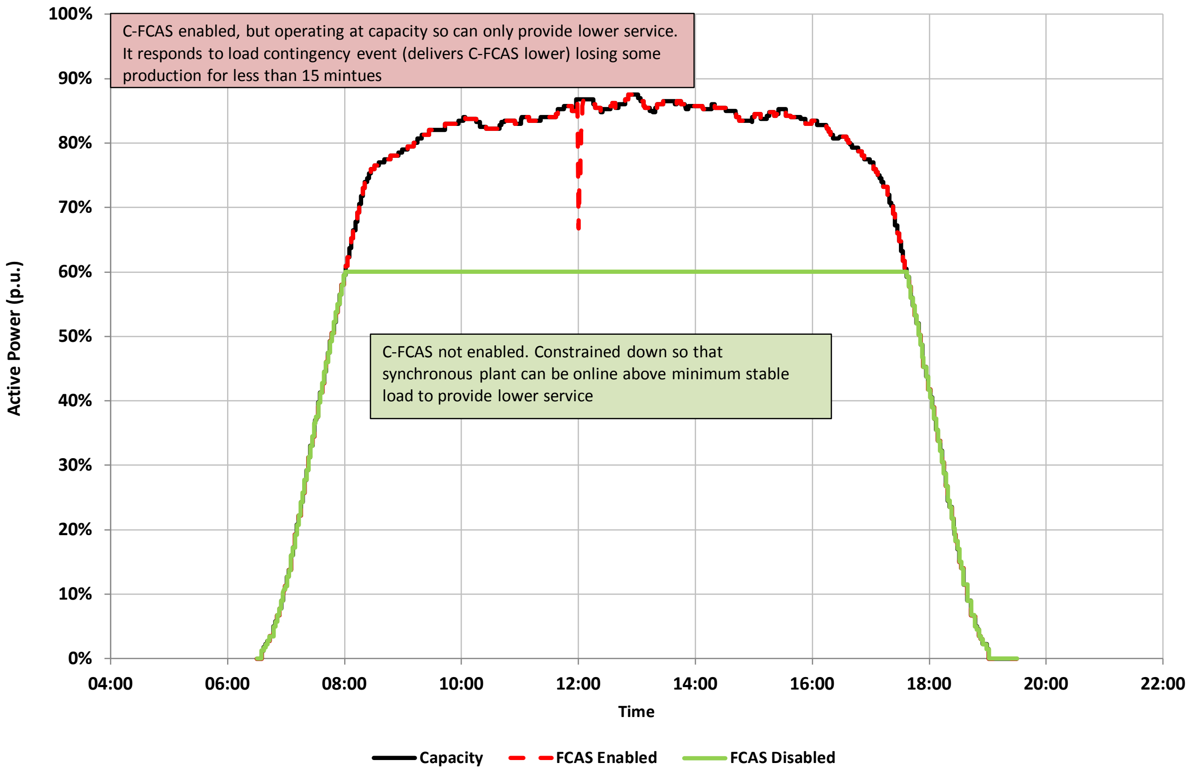
If this service is not provided by these generators, they will with increasing frequency be constrained down to allow a TGen unit online (with sufficient floorroom) to provide FCAS lower services as new generators increase their market share.

Figure 5.1 below shows an example of the difference between a generator enabled and providing C-FCAS lower or not, in the circumstance where it would be constrained to allow another unit to perform this service.

[44] The greater quantity of dispatch is due to the likelihood of being constrained down or offline to facilitate energy dispatch on T-Gen units to have those units providing C-FCAS lower

[45] This is due to load relief following a lightning caused voltage surge. The load relief is understood to be from power electronic devices 'protecting' themselves from unstable voltages.

Figure 8.1: Comparison of dispatch options



An emergency scenario raised in the previous section that requires C-FCAS lower provision for all generators is during an UFLS event generators must share load to stabilise the system. The outcome of not providing C-FCAS lower is high risk of a system black event due to cascading failure with insufficient stabilising load on synchronous plant. The primary benefactor of this is the customers' continued supply, although another benefit is the temporary reduction in load from providing C-FCAS lower would naturally be less impactful to these generators than the impact to production when restoring from a system black.

8.2.5Transition to competitive market sourcing of C-FCAS

It is anticipated that as the I-NTEM is reformed to adopt competitive ancillary service mechanisms, that compensation for the provision of these services will be available. Although this is anticipated and will change how C-FCAS is used into the future, the proposed approach is expected to provide least cost outcomes in both the short to medium term as well as over the life of the generator. This is due to a combination of the immaterial cost of being capable of providing this service and the self-interest of providing the service under the current I-NTEM arrangements. Power and Water is working with DTF to transition to NTEM as fast as possible such that the value of ancillary service providers addressed by quid pro quo in the I-NTEM can be directly recognised.

8.3 Alignment with *Utilities Commission Act* objectives

The proposed solution aims to:

- protect the interests of consumers with respect to reliability and quality of services and supply in regulated industries; and
- promote economic efficiency by enshrining the causer pays principle.