UTILITIES COMMISSION
OF THE NORTHERN TERRITORY

POWER AND WATER CORPORATION'S PROPOSED AMENDMENTS TO CODES - GENERATOR PERFORMANCE STANDARDS

FINAL DECISION

29 February 2020

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Purpose of this paper

The purpose of this paper is to communicate the Utilities Commission's (commission) Final Decision on the Power and Water Corporation's application to the commission to approve proposed amendments to the Network Technical Code and System Control Technical Code.

Further, this paper provides the commission's associated considerations and reasons in relation to its Final Decision.

Any questions regarding this Final Decision should be directed to the commission by telephone (08) 8999 5480 or email utilities.commission@nt.gov.au.

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Glossary

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
BESS	Battery energy storage system
C-FCAS	Contingency Frequency Control Ancillary Services
Commission	The Utilities Commission of the Northern Territory, as established by the *Utilities Commission Act 2000*
DKIS	Darwin-Katherine Interconnected System
EMT	Electromagnetic transient
ER Act	*Electricity Reform Act 2000*
FCAS	Frequency Control Ancillary Services
Generator	A business (or a component of a business) which holds a licence authorising the generation of electricity
GPS	Generator Performance Standards
Hz	Hertz
IP	Intellectual property
mA.h	Milliamp hours
Minister	The Minister to whom the *Utilities Commission Act 2000* is committed, currently the Treasurer
MW	Megawatt
NEM	National Electricity Market
NER	National Electricity Rules
NTC	Network Technical Code Version 3.1, approved by the commission and published by Power and Water Corporation in December 2013
NT NER	Means the National Electricity (Northern Territory) Rules as defined in the *National Electricity (Northern Territory) (National Uniform Legislation) Act 2015*
NTSF	Northern Territory Solar Futures
OEM	Original Equipment Manufacturers
PV	Photovoltaic
PWC	Power and Water Corporation, a government owned corporation established in accordance with the *Government Owned*

	Corporations Act 2001 and the *Power and Water Corporation Act 1987*
Regulations	Utilities Commission Regulations 2000
RMS	Root Mean Square
RoCoF	Rate of change of frequency
SCTC	System Control Technical Code, version 5.0 approved by the commission and published by Power and Water Corporation in May 2015
SSG	Power and Water Corporation's Secure System Guidelines
SWIS	South West Interconnected System
System Controller	Means a person licenced under the *Electricity Reform Act 2000* to exercise system control over a power system
TGen	Territory Generation
UC Act	*Utilities Commission Act 2000*
WEM	Wholesale Electricity Market

COMMISSION OVERVIEW

The electricity industry in the Territory, like that in the rest of Australia and across the world, is evolving whereby renewable and other technologies are seeking to replace, or at least operate in parallel with, traditional synchronous generation. This evolution provides exciting opportunities for the Territory and its power systems, but also presents significant challenges, particularly in relation to affordability and reliability.

The challenges in the Territory are possibly greater than in other jurisdictions. The Territory's power systems are small and islanded, and rely on asynchronous solar photovoltaic (PV) to provide renewable generation, with no wind generation or pumped hydro storage to cover periods of low or intermittent solar irradiance.

It is these challenges that the Power and Water Corporation's (PWC) proposed generator performance standards (GPS) and this, the commission's Final Decision, seek to address.

As discussed in the commission's Draft Decision on the proposed GPS, the Network Technical Code (NTC) currently includes generator technical requirements that are largely written for a power system with a generation fleet dominated by gas fired synchronous generators. These technical requirements need revision to make them technology neutral and therefore suitable and applicable for the Territory's power systems as they transition to significant levels of renewable generation, including new large scale solar PV power stations.

PWC estimates that in the next 12 months over 60 megawatt (MW) of solar PV generation will be connected to the Darwin-Katherine grid and has indicated that it has received enquiries and/or applications in relation to connecting more than double this amount. The commission considers PWC's claims and associated concerns are reasonable given 55 MW of large scale solar PV generation is already licensed by the commission to operate in the Darwin-Katherine system[1] with further generation licences approved, subject to conditions, for the export of surplus behind the meter solar PV generation into the Darwin-Katherine grid.

Indeed the growth in behind the meter solar has exceeded most expectations with around 15 MW added in 2018-19 resulting in a total of approximately 59 MW of behind the meter solar in the Darwin-Katherine system. These are significant changes in a system with a maximum system demand of 287 MW in 2018-19.

While Alice Springs has not seen the same interest from potential new large scale solar PV generators, there are already challenges to the operation of the system as highlighted by the commission's investigation of the Alice Springs System Black on 13 October 2019, noting the system includes a 4 MW solar power station, Territory Generation's (TGen) battery energy storage system (BESS) and significant behind the meter solar PV generation. In addition to this, there is a proposed virtual power plant currently under consultation for a generation licence.

[1] As at 12 February 2020, only the 25 MW Katherine Solar power station is built, noting it has not yet commenced operations.

In light of the above, the commission's Draft Decision sought to address previous feedback and inform stakeholders the reasons why the commission considers the GPS are necessary now and cannot wait, and why the standards proposed, with the commission's revisions, are appropriate for the Territory's current circumstances.

Nonetheless, feedback from stakeholders on the Draft Decision is generally consistent with previous feedback including that the forecasting requirements will significantly increase solar generators' costs and thus deter investment, and that it does not explicitly provide for arguably more efficient solutions to address system security and reliability concerns, such as the provision of a central battery.

The commission acknowledges that there may be more efficient solutions than that required under the automatic standards in the GPS. It is for this reason that the new framework includes a process for negotiated access standards where generators are able to negotiate alternatives if they can demonstrate that adopting those standards does not adversely affect power system security or the quality of supply to Territory electricity consumers, such as a central battery if it makes commercial sense to do so.

As there is no central battery (or other alternative solutions such as a centrally controlled distributed battery solution) currently in the Darwin-Katherine system, the commission cannot rely on this for the automatic standard in this Final Decision, nor can the commission compel a party to build a central battery or compel other proposed alternatives such as upgrades to existing generation plant. Given the lead times to construct, connect and test a battery, even a commitment to build a central battery by a public or private party as soon as possible would not address the immediate issues for at least the next two years. The commission considers that serious reliability and security issues would arise in the Darwin-Katherine system in a much shorter timeframe than that in the absence of new GPS requirements.

The commission notes that the Territory Government has been contemplating further electricity market reforms for a number of years that, if committed to and implemented prior to this point, may have alleviated at least some of the issues now being faced by the industry. Notably, the Territory Government commenced consultation in early 2019 to determine the form of a potential reliability standard, which is necessary to ensure there is an independent, objective way to determine whether the combination of generating units is sufficient to meet the desired standard for customers[2]. The commission is not aware of any progress made in relation to this matter.

Another on-going issue is the current approach to providing and paying for ancillary services in the Territory whereby the many services that make up ancillary services, such as voltage control, frequency control and black start services, are provided by TGen as a 'bundled' service at a set price. The lack of a competitive ancillary services market whereby other

[2] Department of Treasury and Finance, Consultation on the Form of Reliability Standards for the Northern Territory's Regulated Power Systems Consultation Paper, page 5, viewed 13 February 2020 https://utilicom.nt.gov.au/__data/assets/pdf_file/0008/742472/Consultation-Paper-Reliability-Standard-Form-Final-Jan-2018.pdf

parties can be paid for providing at least some of these services, means that the provision of a centralised battery solution by a private party would be less profitable than if provided by TGen and may not eventuate. Notably, the unbundling and eventual competitive procurement of ancillary services was discussed in the Territory Government's Consultation Notes on the Northern Territory Electricity Market Consultation Draft Functional Specification[3], also in early 2019. Again, the commission is not aware of any progress made in relation to this matter. The commission notes that if the Territory Government was to progress these ancillary services reforms they could assist in delivering more efficient negotiated alternatives to meet the GPS requirements.

The commission's Final Decision in relation to PWC's proposed new GPS follows two years notice (including the publication of proposed draft standards) to the industry that new standards were to be introduced for the Territory's regulated power systems, over 12 months formal consultation by PWC and consultation by the commission on its Draft Decision. This is in addition to advice to new licensees that they should take into consideration the changing framework when designing connection infrastructure and clear associated licence conditions that require compliance with regulatory instruments, including any new requirements that come into force when instruments are amended from time to time. PWC's submissions to generation licence applications over the last two years included draft GPS so that new entrants were aware of the potential new obligations.

The commission notes a number of submissions indicate that the GPS will negatively impact the commercial viability of their projects or future investment. Given the significant notice provided, the commission considers that a prudent investor would have factored this risk into their associated contracts, noting some of the standards in this final decision are less onerous than originally proposed in 2018.

In terms of future investment, through this Final Decision, the connection framework is clear. This provides the certainty needed for industry to determine whether it makes commercial sense to invest in new generation, whatever the technology. Further, it provides the opportunity and incentive for generators to look for more efficient alternatives than the automatic standard.

The commission notes that in the absence of the certainty that the GPS will provide, it would be highly likely that solar generators would suffer considerable periods of being constrained off to protect system security, as is happening in the National Electricity Market (NEM), exposing those generators to significant loss of revenue. This would also be the case if the new large scale solar PV projects that have been committed to, and in some cases built, were grandfathered, as proposed by some stakeholders. Accordingly, grandfathering the 'early movers' is not considered by the commission a reasonable or efficient option.

[3] Department of Treasury and Finance, Northern Territory Electricity Market Consultation Draft Functional Specification Consultation Notes, viewed 13 February 2020, https://utilicom.nt.gov.au/__data/assets/pdf_file/0010/742474/NTEM-Draft-Consultation-Functional-Specification.pdf

The commission notes that adopting a GPS framework in the Territory power systems is consistent with reforms either recently completed or underway in other power systems across Australia. In September 2018, the Australian Energy Market commission (AEMC)[4] completed a review of GPS for the NEM and in Western Australia reforms are underway to replace the technical requirements for transmission connected generators participating in the Wholesale Electricity Market (WEM) with a GPS framework. Relevantly, even with GPS, the Energy Security Board's recent annual Health of the National Electricity Market[5] reported new renewable generators are experiencing some difficulties with network constraints in the NEM jurisdictions, which highlights the importance of appropriate GPS in the Territory to, among other things, ensure the greatest amount of renewable energy is able to be dispatched and subsequently consumed, and thus ensure generators are recovering the cost of their investments to the greatest extent possible.

While the commission remains firm on the need to introduce appropriate GPS in the Territory power systems immediately, feedback provided by stakeholders in response to the Draft Decision has assisted in identifying areas requiring modification. This includes revisions to the NTC to provide further clarity to generators regarding performance requirements, to require PWC to consult and consider feedback in relation to making various procedures, to require PWC to commence recording fault information to, among other things, enable them to analyse and provide evidence of the need to make further changes and to make clear that any grace periods only commence from the date PWC provides the necessary information and guidelines to generators. These and other final revisions are discussed in detail by clause within the 'Amendments to Network Technical Code' chapter.

The commission thanks stakeholders for their engagement and input in relation to the GPS. In making this Final Decision, the commission has had regard to the *Utilities Commission Act 2000* and *Electricity Reform Act 2000*, and has been assisted through feedback from stakeholders and GHD Advisory's (GHD) technical advice. The result is, in the commission's opinion, GPS for the Territory's power systems that appropriately balance the desire for system security, the costs imposed on generators required to conform to the GPS and the allocation of risk and cost among connecting generators, the Network Operator and System Control.

[4] https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

[5] Health of the National Electricity Market, http://www.coagenergycouncil.gov.au/publications/health-national-electricity-market-0 , viewed 28 February 2020.

FINAL DECISION

In accordance with Part 8 regulation 25(5)(b) of the *Electricity Reform (Administration) Regulations 2000* (the Regulations), the commission requires PWC to alter its proposed amendments to the NTC (as proposed in PWC's September 2019 submission to the commission) as detailed in this Final Decision document.

In accordance with clause 1.8.2(e) of the SCTC, the commission approves that the Power System Controller to amend the SCTC as proposed in PWC's September 2019 submission to the commission.

INTRODUCTION

Background

On 5 September 2019, PWC submitted to the commission proposed amendments to the NTC and SCTC (the codes) which, along with PWC's Secure System Guidelines (SSG), seek to introduce new GPS for generating systems connecting to the regulated networks, being

- Darwin-Katherine interconnected system (DKIS)
- Alice Springs power system
- Tennant Creek power system.

PWC states that the proposed new GPS will enable third-party private generators of generation assets to connect those assets to the power system and sell their energy, and will ensure 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.

Under the relevant legislative instruments, prior to making amendments to the codes, PWC must, among other things, consult with relevant stakeholders and consider feedback. PWC states that it has undertaken nine months of formal consultation with stakeholders, considered all feedback and obtained independent advice and technical verification where warranted in finalising its proposed code amendments.

Legislative framework

The commission is an independent statutory body established by the *Utilities Commission Act 2000* (the UC Act) with defined roles and functions for economic regulation in the electricity, water and sewerage industries and declared ports in the Northern Territory[6].

The commission seeks to protect the long-term interests of consumers of services provided by regulated industries with respect to price, reliability and quality.

The commission aims to ensure consumer requirements are met by enhancing the economic efficiency of regulated industries through promoting competition, fair and efficient market conduct and effective independent regulation.

The commission has functions under various Acts (and associated regulations) including the UC Act, *Electricity Reform Act 2000* (the ER Act), *Water Supply and Sewerage Services Act 2000* and the *Ports Management Act 2015*.

Section 6(1) of the UC Act provides the commission with functions, including to perform licensing functions under relevant industry regulation Acts, to provide and require consumer

[6] Regulated industries for the purpose of the *Utilities Commission Act 2000* are declared by section 13 of the *Electricity Reform Act 2000*, section 7(1) and (2) of the *Water Supply and Sewerage Services Act 2000* and section 119(1) of the *Ports Management Act 2015.*

consultation processes in regulated industries, to assist consumers and others with information and other services and any other function assigned by or under the Act or any other Act or conferred by the Minister.

In performing its functions, the 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

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

Network Technical Code

Section 111 of the ER Act provides that the Administrator may make regulations that may deal with the preparation or amendment of a network technical code and associated network planning criteria for a network by a network provider. Accordingly, Part 8 regulation 25 of the Regulations provides for the preparation of network technical codes.

Subject to regulation 25, the network provider may amend the NTC at any time. However, before amending a network technical code in a material way, regulation 25(6) requires that a network provider publish a draft of a proposed amendment on the network provider's website, invite submissions from interested parties within a reasonable time specified by the network provider and consider any submissions from interested parties.

Further, regulation 25(5) states that before amending a network technical code, the network provider must consult with the commission and alter the proposed network technical code or amendments if required by the commission.

System Control Technical Code

Section 38(1) of the ER Act states that subject to the Regulations, a system controller for a power system has the function of monitoring and controlling the operation of the power system with a view to ensuring that the system operates reliably, safely and securely in accordance with a technical code (the SCTC) prepared by the system controller and approved by the commission.

Regulation 5A(3) states that the commission must not approve a code, or any amendment to a code, under section 38(1) of the ER Act, 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.

Clause 1.8.2(e) of the SCTC states that the system controller may amend the code at any time, but only with the prior written approval of the commission. Clause 1.8.2(f) requires the system controller to consult with all licensees when amending the code.

Commission's scope and process

In considering PWC's proposed amendments to the codes, the commission must have regard to the matters set out in the UC Act, as discussed above. Further, the commission is cognisant of, and will have regard to, the objects of the ER Act, including to promote safe and efficient generation, transmission, distribution and selling of electricity, to establish and enforce proper standards of safety, reliability and quality in the electricity supply industry and to protect the interests of consumers of electricity.

Accordingly, on receipt of PWC's proposed code amendments, the commission engaged GHD as its technical advisor, to assist it in making its draft and final decisions, through assessing and making recommendations where appropriate with regard to the UC Act, stakeholder feedback provided to PWC as part of its second round of consultation and stakeholder feedback provided to the commission in relation to its Draft Decision, among other things.

The commission's Draft Decision, and GHD's associated report to the commission, was published on 4 December 2019. The Draft Decision invited interested stakeholders to provide feedback through submissions, which were due by 29 January 2020. Six submissions were received, from Assure Energy Asset Pty Ltd (Assure Energy), Eni Australia Limited (Eni), Jacana Energy, NT Solar Futures (NTSF), PWC and TGen.

GHD has considered the matters raised in the submissions and provided a further report to the commission, which is published on the commission's website together with this Final Decision. The commission's views and associated Final Decision have been informed through, among other things, advice from GHD following its comprehensive review.

Structure of Final Decision paper

The next chapter of this Final Decision paper details the commission's decision in relation to introducing GPS in the Territory power systems at this time. Further, it summarises the commission's decision in relation to whether PWC's proposed code amendments to introduce new GPS are appropriate for the Territory's systems.

The final chapter of this Final Decision paper discusses each of the key amendments to the NTC proposed by PWC to implement GPS and provides the commission's associated Final Decision for each of these, including required amendments to the NTC. It also addresses PWC's proposed transitional arrangements and alignment between the NTC and SCTC and further amendments proposed by PWC, including in relation to definitions.

Each section in the final chapter is organised as follows:

Discussion and Final Decision – discusses PWC's proposed amendments, from its 5 September 2019 submission and its more recent 10 January 2020 submission, feedback from stakeholders through written submissions to the commission, the commission's assessment of that proposed and its associated Final Decision, as informed by advice from GHD.

Some of the commission's discussion is based on a comparison of PWC's proposed amendments to that in the National Electricity Rules (NER) as applied in the Northern Territory (NT NER). While the commission notes that the equivalent standards included in schedules 5.1, 5.2, 5.5 of the NT NER are not currently in effect in the Territory, and are expected to be revisited by the Territory Government in the future as part of the phased implementation of the NER in the Territory, the comparison is nonetheless considered useful.

Final Decision NTC wording – presents the drafting required to implement the commission's Final Decision. Highlighting is provided to identify the nature of the change, noting where no wording changes are necessary, this is noted in the discussion section:

- yellow highlight – indicates required formatting to identify defined terms which should be included in the glossary of terms - Attachment 1 of the NTC
- green highlight – indicates required changes to PWC's proposed wording (as proposed in the 5 September 2019 submission).

SUMMARY OF CONSIDERATIONS AND REASONS

This chapter details the commission's views in relation to introducing GPS in the Territory power systems at this time. Further, it summarises the commission's Final Decision in relation to whether PWC's proposed code amendments to introduce new GPS are appropriate for the Territory's systems.

Introducing GPS in the Territory power systems at this time

The Territory power systems, like many across Australia and around the world, are undergoing a period of significant change driven by the desire to reduce greenhouse gas emissions, while balancing affordability and reliability. In the Territory, significant growth in the amount of generation from solar PV power is expected in the near term, noting the Territory Government's 50 percent renewable energy by 2030 policy and that PWC have identified that over 120 MW of new solar generation has applied to connect to the DKIS[7].

The NTC currently includes generator technical requirements that are largely written for a power system with a generation fleet dominated by gas fired synchronous generators. The commission's view is that those technical requirements need revision, to remove technology bias and provide requirements that are applicable for future power systems incorporating significant levels of renewable generation such as large-scale solar PV power stations.

Several stakeholders have raised concerns in their submissions to the commission in relation to the Draft Decision, and to PWC prior, that the introduction of the proposed GPS to Territory power systems is not justified or that it is not necessary to make the proposed changes at this point in time. The submissions cite a number of concerns including:

- the cost of complying with the automatic access standard proposed for a number of technical requirements, in particular the forecast accuracy proposed in NTC clause 3.5.17, threatens the commercial viability of new solar generation projects
- the forecast accuracy requirement prevents the adoption of other more efficient measures, such as central batteries shared by a number of generators
- the forecast accuracy requirement is difficult to meet for generators developed behind the meter and operating with a zero-export connection agreement
- renewable generators may be constrained to provide frequency control services suffering lost revenue from energy sales.

However, as stated in the Draft Decision, the framework does allow for generators to negotiate alternate performance standards if they can demonstrate that adopting those standards does not adversely affect power system security or the quality of supply to Territory electricity consumers, such as a central battery if it makes commercial sense to do so. The commission's Final Decision NTC wording changes, which are discussed in the next

[7] PWC application to the Utilities Commission, page 18.

chapter, should facilitate generators who wish to negotiate a performance standard to build the necessary arguments and evidence.

In terms of forecast accuracy requirements, the commission considers that further clarity is needed regarding the manner in which PWC will assess and respond to any failure to meet the forecast accuracy requirements to allow generators to assess the investment required to achieve an appropriate level of compliance. This is achieved through this Final Decision, which includes an obligation for System Control to consult on and publish the associated process. With that information available, generators should be able to develop the most efficient solution for meeting the accuracy requirements and, where necessary and appropriate, build the case to negotiate alternate performance standards.

Consequently, the commission, with GHD, has considered stakeholder feedback, some of which is discussed above, and the case for introducing GPS and are of the view that the introduction of an appropriate GPS framework is justified at this time.

The commission notes that adopting a GPS framework in the Territory power systems is consistent with reforms either recently completed or underway in other power systems across Australia. In September 2018, the AEMC[8] completed a review of GPS for the NEM and in Western Australia reforms are underway to replace the technical requirements for transmission connected generators participating in the WEM with a GPS framework. The new GPS framework will be specified in the WEM Rules replacing the requirement currently specified in the Western Power Technical rules. In 2018, Western Power and the Australian Energy Market Operator (AEMO) developed a generator performance guideline describing the proposed arrangements[9] which leverage the work undertaken by the AEMC.

By specifying appropriate performance requirements for all significant generators, a GPS framework provides greater certainty over the technical capability of the power system, particularly as the generation mix evolves to include greater levels of solar generation. In the absence of a GPS framework, uncertainty in generation performance leads to uncertainty in the system operator's assessment of system capability, which is likely to lead to either:

- conservative operating limits leading to constraints on solar generation, or
- unexpected insecure operation, risking customer load shedding.

PWC has proposed that the GPS framework apply to all generators exceeding 2 MW. Given the size of the Territory power systems, and consistent with advice from GHD, the commission considers this threshold is appropriate.

[8] https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

[9] https://westernpower.com.au/media/3226/generator-performance-guideline.pdf

Appropriateness of proposed GPS for Territory circumstances

The commission has found that the majority of the technical performance requirements proposed by PWC for the Territory power systems reflect the equivalent provisions in the NT NER. This approach leverages the insights gained through the AEMC's assessment of GPS completed in September 2018.

While some of the performance standards proposed by PWC differ from the NT NER, a review of the basis for those differences by GHD on behalf of the commission has found that the changes proposed are appropriate, given the technical characteristics of the Territory power systems and the key differences between the Territory power systems and those in the NEM.

The commission notes that the following aspects of the GPS proposed by PWC are quite different to those in the NEM:

- the GPS specifying minimum capacity forecast accuracy requirements (NTC Clause 3.3.5.17) - There is no such requirement in the NEM. PWC has identified that the relatively high probability of thermal generation failures in the Territory power systems means that it is reasonably probable for cloud cover events and the resulting forecast errors to occur at the same time as generator failures. The capacity forecast accuracy requirements are considered a reasonable approach to minimise the risk of cloud cover events yielding forecast errors. The accuracy requirements have been selected so that even with increased levels of solar generation there should be no deterioration in supply reliability. As discussed later in this Final Decision, PWC has selected accuracy thresholds that should deliver supply reliability at historical levels

  The key area of concern with the capacity forecast performance standard is that there is no documented procedure available that describes how PWC intends to assess compliance and the sanctions PWC will impose for compliance breaches. Without this information generation developers will find it very difficult to make appropriate commercial decisions regarding the efficient investment required to meet the performance requirements. The commission therefore requires a change to the proposed NTC amendments to require PWC to consult on and publish this procedure

- the requirement for permanently enabled frequency response capability (NTC Clause 3.3.5.11) and inertia and contingency frequency control ancillary services (FCAS) capability (NTC clause 3.3.5.15) - These GPS provisions impose mandatory frequency response capability whereas the NER only requires generators provide such capability if dispatched to provide ancillary services. GHD's report to the commission proposed amending the GPS to clarify that the response requirements are subject to energy source availability. The commission agrees with this recommendation. That change coupled with drafting included in the SCTC makes it unlikely that PWC will constrain renewable generators to maximise the raise response they deliver following generator contingencies

  The commission, informed by GHD, considers that the proposed performance standards are appropriate for the isolated Territory power systems. The performance standards will in effect require renewable generators to contribute frequency control subject to energy source availability. This approach reflects good electricity industry practice, which has been adopted in a number of grid codes around the world. It reflects the approach proposed in the GPS for the South West Interconnected System (SWIS) developed by AEMO and Western Power. It is also consistent with rule changes proposed for the NEM that are currently being considered by the AEMC. Those changes to the NER seek to reintroduce a mandatory requirement for all generators to provide primary frequency

response[10]. The GPS as proposed should not impose a significant cost on renewable generators but will provide for more efficient control of frequency in the Territory power systems.

GHD has also recommended a number of revisions to the proposed GPS to clarify the performance requirements, which will allow generators to identify efficient options for meeting the standards and where appropriate negotiate alternate standards that lead to more efficient investment while delivering similar power system security and quality of supply outcomes. The commission supports these recommendations with the revisions described in this report.

[10] The AEMC is currently considering three rule change proposals that seek to improve frequency control in the NEM by reinstating a mandatory requirement for all generators to contribute primary frequency response https://www.aemc.gov.au/sites/default/files/2019-09/Primary%20frequency%20response%20rule%20changes%20-%20Consultation%20paper%20-%20FOR%20PUBLI....pdf

AMENDMENTS TO NETWORK TECHNICAL CODE

This chapter discusses each of the key amendments to the NTC proposed by PWC to implement GPS and provides the commission's associated Final Decision, including required amendments to the NTC. It also addresses PWC's proposed transitional arrangements, alignment between the NTC and SCTC and further amendments proposed by PWC.

NTC Clause 3.3 preamble and Clause 3.3.1 – Outline of Requirements

Discussion and Final Decision

The commission considers that the preamble included at the beginning of clause 3.3 is appropriate and explains the derivation of the GPS requirements from the relevant sections of the NER.

Clause 3.3.1 provides an outline of the requirements for generators negotiating their GPS. The commission agrees with GHD that the close alignment of the proposed drafting to NER S5.2.1 will help reduce the implementation costs as many generation developers will be able to leverage NEM experience.

No concerns were raised in submissions to the commission in relation to this clause.

The commission does not require any changes to these clauses.

NTC Clause 3.3.2 – Application of Settings

Discussion and Final Decision

The commission considers the proposed wording is appropriate. The commission agrees with GHD that the close alignment of the proposed drafting to the relevant schedule in the NER will help reduce the implementation costs as many generation developers will be able to leverage NEM experience.

No concerns were raised in submissions to the commission in relation to this clause.

The commission does not require any changes to this clause.

NTC Clause 3.3.3 – Technical Matters to be Co-ordinated

Discussion and Final Decision

The commission considers the proposed wording, which outlines the requirements for generators negotiating their GPS, is appropriate. The commission agrees with GHD that the close alignment of the proposed drafting to the relevant schedule in the NER will help reduce the implementation costs as many generation developers will be able to leverage NEM experience.

The commission notes that sub-clause (d) in the NTC does differ from the requirements in the NER, by requiring generators to produce a signed statement to certify that the equipment to be connected has been designed and installed in accordance with the NTC, all relevant standards, all statutory requirements and good electricity industry practice. As this reflects requirements that have historically been included in the NTC (clause 3.1.1.11(b) in the current version of the NTC), it should not impose any significant additional cost on generators seeking to negotiate a GPS.

No concerns were raised in submissions to the commission in relation to this clause.

The commission does not require any changes to this clause.

NTC Clause 3.3.4 – Provision of Information

Discussion and Final Decision

Clause 3.3.4 specifies the information generators are required to provide. This clause reflects the requirements previously specified in Clause 11 of the NTC and is similar in many respects to the requirements specified in NT NER S5.2.4, noting this schedule is not currently in effect. The key areas of difference are:

- the NT NER specifies additional details regarding when generator modelling information is to be provided and updated following plant commissioning tests
- the NT NER provides more detail regarding the modelling requirements. It specifies that generators must satisfy the modelling requirements in the Power System Model Guidelines that AEMO is required to develop via NER clause S5.5.7
- the NT NER clarifies that both electromagnetic transient (EMT) and Root Mean Square (RMS) models are required to be provided. In contrast the NTC provisions only explicitly mention the provision of a PSS/E model which is an RMS model.

In its Draft Decision, the commission did not require any changes to address the first two points as the NTC process generally lacks the timing details for the connection process included in the NT NER, and there are no power system model guidelines published for the Territory power systems.

However, the Draft Decision noted that, based on GHD advice, it is becoming increasingly important to have access to EMT models to be able to study the interactions of grid scale inverter connected renewable generating systems. EMT models are required to apply the detailed system strength assessment defined in the AEMO guidelines that are required to be applied under the system strength requirements of the GPS as proposed by PWC.

Accordingly, the commission's Draft Decision revised sub-paragraph (b) to clarify that both RMS and EMT models are to be provided if requested by PWC, noting PWC confirmed that it routinely asks connection applicants to provide both RMS and EMT models and as such, the recommended refinement should not add significant incremental cost to generation applicants.

<u>Further PWC proposed revisions and issues raised in submissions</u>

PWC's submission supports the adoption of the revisions proposed by the commission and suggests additional revisions to provide greater clarity regarding the information and model provision obligations.

In addition to the commission's amendments to paragraph (b), PWC seeks further amendments to clause 3.3.4 in order to:

- clarify that models are to be provided in both encrypted and unencrypted forms, and should be provided with a releasable user guide
- incorporate within this "Provision of Information" clause the commission's proposed amendments to clause 3.3.5(i) and (j) that relate to 'Network Modelling Information'
- create a head of power for Generator Modelling Guidelines and Generator Modelling Change Management Requirements
- strengthen provisions relating to sharing, confidentiality and use of information

- provide sub-headings for clarity.

In relation to the releasable user guide, PWC notes that there is useful guidance material available from AEMO in its Guideline for Preparation of a Releasable User Guide[11].

Eni's submission supports the provisions in the Draft Decision relating to information provision. In its submission Eni stated that, "The provision of full EMT and RMS models to the Network Operator is reasonable and consistent with the approach in other jurisdictions", and that the availability of a complete system model, "is critical to (Eni) and the absence of a proper system model has been a major impediment to work around for our investments in the NT".

NTSF's submission raised concerns that the proposed amendment suggested by PWC that requires the provision of both encrypted and unencrypted models to the Network Operator may be difficult to meet. Their submission raises a concern that Original Equipment Manufacturers (OEM) may be reluctant to provide such models due to concerns regarding insufficient confidentiality clauses to protect their Intellectual Property (IP).

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission notes that the provision of unencrypted models to the Network Operator as requested by PWC is somewhat consistent with the requirements that currently apply in the NEM. In the NEM generators are required to provide modelling data including unencrypted models to AEMO, which is treated as highly confidential. AEMO provides encrypted models to other participants.

The current process in the NEM was developed over many years and is designed to provide reasonable protection for OEM IP while still providing AEMO with sufficient model visibility to assess that the models provided are appropriate to assess the impact of the generator on the technical performance of the power system. It is understood that this process includes strict AEMO controls over the access to model source codes with access restricted to a few individuals.

GHD's view, which the commission agrees with, is that implementing the approach in the NEM to manage the IP issues regarding the use of unencrypted models is likely to add additional cost for the Territory power systems, which may not be justified if the OEM has already submitted unencrypted models to AEMO which have been accepted for use in the NEM. In that circumstance it may be more effective to allow generators to supply the Network Operator with an encrypted model and releasable user guide based on that accepted for use in the NEM.

There remains the potential that some equipment proposed for the Territory power system may not yet have had a model accepted by AEMO for use in the NEM. To manage this

[11] https://www.aemo.com.au/-/media/files/electricity/nem/network_connections/transmission-and-distribution/guideline-and-template-for-preparation-of-a-releasable-user-guide.pdf?la=en&hash=F91942CF96C7B502FBF16CD7DD7D94F4

situation, the commission considers it is appropriate to include the requirement to provide unencrypted models, but only in circumstances required by the Power System Model Guidelines.

The increased importance of those guidelines requires that there be a firm obligation placed on the Network Operator to develop and maintain those guidelines. The guidelines developed should reflect the approach described above, of removing the obligation to provide source code if the unencrypted model has previously been accepted by AEMO for use in the NEM. The guideline should clearly state the purpose for the provision of source code, how it will be used and who will have access to the source codes or un-encrypted models.

This “as and when required” approach is considered a pragmatic solution for the Territory, noting when developing the guidelines, PWC will need to consult with the commission and network users to ensure the guidelines comply with the above requirements, are well understood by all relevant parties and are able to be implemented.

GHD has reviewed the other revisions suggested by PWC and confirmed that the proposed revisions are consistent with the frameworks at play in the NEM. GHD advise that this alignment of model and information provision processes delivers consistency between the model and information provision processes applicable in the NEM and the Territory power systems. Accordingly, the commission agrees that the proposed revisions be adopted.

It is noted that the term “releasable user guide” is not italicised in the drafting provided by PWC. This term is defined in the NT NER however the definition in the NT NER contains references to NT NER clauses which have not been adopted in the NT. GHD has recommended an appropriate definition, developed from that in the NT NER with amendments to reflect arrangements governing the Territory power systems, be added to Attachment 1 of the NTC. The commission agrees with this recommendation.

Final Decision NTC wording

Clause 3.3.4

Data to be provided by Generators

(a) A Generator shall provide the data specified in clause 11.2.

(b) The *Generator* shall provide all other data reasonably required by the *Network Operator*. This data shall include, without limitation, full Electromagnetic Transient (EMT) and Root Mean Square (RMS) models (and all model parameters) of:

(1) the *generating units*;

(2) the excitation control systems;

(3) turbine / engine governor systems~~; and~~

(4) power system stabilisers; and

(5) inverter control systems

to enable the *Network Operator* to conduct dynamic simulations.

(c) These models shall be in a form which is compatible with the power system analysis software used by the *Network Operator* (currently PSS/E from Siemens PTI and PowerFactory) and shall be inherently stable. These models shall be provided in both encrypted and unencrypted form (in circumstances

required by the Generator Modelling Guidelines) and be supported by a separate *releasable user guide* for both the RMS and EMT models.

(d) Details of the kinds of data that may be required are included in Attachment 3 of this Code, specifically:

(1) Schedule S3.1 - Generating unit design data;

(2) Schedule S3.2 - Generating unit setting data;

(3) Schedule S3.5 - Network and plant technical data; and

(4) Schedule S3.6 - Network plant and apparatus setting data.

(e) Data provided by a *Generator* under this clause 3.3.4 may be shared by the *Network Operator* with other *Generators*, for the purposes of the *Code*, subject to the restrictions set out in the remainder of clause 3.3.4.

(f) The *Network Operator* must develop and publish Generator Modelling Guidelines and Generator Modelling Change Management Requirements for the purposes of this *Code*. The *Network Operator* must consult with the Utilities Commission and with *Users* before issuing or amending the guidelines or requirements.

Network modelling information for connection applicants

(g) A connection applicant for a new or modified *generating unit* or *generating system* seeking *connection* to the network, may request from the *Network Operator*:

(1) information that is reasonably required by the connection applicant to carry out power system simulation studies (including load flow and dynamic simulations) for planning and operational purposes; and

(2) operation and maintenance procedures and practices for network operation, sufficient to enable the *connection applicant* to carry out power system modelling under normal, outage and emergency conditions.

(h) If the *Network Operator* holds information requested under paragraph (i), the *Network Operator* must provide the requested information to the connection applicant as soon as practicable, subject to the following requirements:

(1) If the *Network Operator* holds and is required under this paragraph (j) to provide a releasable user guide that the *Network Operator* received from a *Generator*, the *Network Operator* must provide the releasable user guide to the connection applicant in an unaltered form.

(2) If the *Network Operator* holds and is required under this paragraph (j) to provide a form of the model source code that the *Network Operator* received from a *Generator* or from any other source, the *Network Operator* must provide that information:

(i) only in the form of, at the *Network Operator's* discretion:

(A) encrypted information; or

(B) a secured format agreed by the provider of the model source code,

unless the *Network Operator* has the written consent of the person who provided the information to the *Network Operator* to provide it in another form; and

(ii) in a form that can be interpreted by a software simulation product nominated by the *Network Operator*.

Confidentiality and use of information

(i) Any information provided by the *Network Operator* under paragraph (j) to a *connection applicant* must be treated as confidential information.

(j) A *connection applicant* who receives information under paragraph (h) may only use that information for the purpose of designing its *generating unit* or *generating system* and *connection* to the network, may only disclose such information to its employees and its external engineering advisors for use for such purpose and must not otherwise disclose or use the information.

(k) A connection applicant who receives information under paragraph (h) must ensure any employees and engineering advisors whom it discloses the information keep it confidential and only use it for the purpose referred to in paragraph (j).

The following definitions need to be added to the glossary of terms in Attachment 1 of the NTC:

confidential information

In relation to a *Generator* or *Network Operator*, information which is or has been provided to that *Generator* or *Network Operator* under or in connection with the *Code* and which is stated under the *Code* or by the *Network Operator* or by the *Utilities Commission* to be *confidential information* or is otherwise confidential or commercially sensitive. It also includes any information which is derived from such information.

releasable user guide:

A document associated with the data and model provided under clause 3.3.4 (combined, forming the **model**), that contains sufficient information to enable connection applicants for a new or modified *generating unit* or *generating system* to use the **model** to carry out *power system* studies for planning and operational purposes. The information in a *releasable user guide* must include, but is not limited to:

(1) the **model** parameters and their values;

(2) information about how the **model** parameter values vary with the operating state or output level of the *plant* or with the operating state or output level of any associated *plant*;

(3) instructions relevant to the use and operation of the **model**;

(4) settings of *protection systems* that are relevant to load flow or dynamic simulation studies;

(5) information provided in accordance with other provisions on the NTC only to the extent that the information is not a part of the **model** or the **model** parameters and that is reasonably necessary to allow modelling of the *generating unit*, *generating system* or related *plant* in *power system* load flow or dynamic simulation studies;

(6) *connection point* details including its parameters and values, location, network augmentations or modifications and other relevant connection information;

(7) in regards to any relevant *generating unit* or *generating system*, the date on which any of the following has occurred or is expected to occur:

(i) a *connection application* is made under clause 5.3.4(a) of the NT NER;

(ii) a *connection agreement* is entered into under clause 5.3.7 of the NT NER;

(iii) the *Generator* submits a proposal to alter a *connected generating system* or a generating system, for which *performance standards* have previously been accepted by the *Network Operator*, under clause 3.3.5;

(iv) the *Generator* is notified that the *Network Operator* is satisfied with the proposed alterations to the *generating plant* under clause 5.3.10 of the NT NER;

(v) *connection*;

(vi) commencement of commissioning; and

(vii) conclusion of commissioning; and

(8) the date this document was prepared or updated.

NTC Clause 3.3.5 – Technical Requirements

Discussion and Final Decision

The commission notes that the proposed NTC clause 3.3.5 allows for a negotiated performance standard to be proposed by a connection applicant but places no obligation on PWC with respect to how it responds to the proposed standard. In contrast, the NER process requires the network service provider (NSP) to consider various matters in developing its response and to respond providing specific information and meeting a specified timeframe. The NER process helps to progress to a negotiated outcome. The commission considers that the absence of such provisions is a deficiency likely to add cost to generation developers. Accordingly, the NTC should be amended to include a provision requiring PWC to provide adequate feedback in response to any submitted GPS.

This clause assumes the generator is able to provide evidence to support a proposed negotiated standard. A similar process exists in the NEM and is facilitated by intending participants accessing modelling data via various rule provisions. Those NER provisions in Clause 3.13.3 k (2) are missing in the NT NER. The lack of any such provision in the NTC may impede generators from accessing the information required to efficiently negotiate a generator performance standard.

Accordingly, the commission advised in its Draft Decision that the NTC should be amended to include provisions providing adequate access to power system modelling information to generation proponents, with appropriate confidentiality arrangements surrounding such information.

In its Draft Decision, the commission advised that it agreed with GHD's recommended revisions (set out below), as they are likely to deliver a more efficient connection process, noting the addition of a definition for confidential information into the NTC glossary is also required.

<u>Further PWC proposed revisions and issues raised in submissions</u>

In response to the commission's Draft Decision, PWC requested that the wording specifying the maximum time frame of 30 business days for the Network Operator to either accept or reject a negotiated access standard proposed by a connection applicant be modified to one which "meets the requirements of clause 5.3.6 of the NT NER". Clause 5.3.6 of the NT NER specifies timelines that the Network Operator must adhere to when assessing a connection

application and making an offer to connect. This clause allows a maximum of four months for a connection offer to be made for an application to connect a generator to the distribution network.

The commission notes that two submissions, from Eni and NTSF, supported the commission's inclusion of a firm deadline and did not support PWC's proposed revision:

- Eni state it "endorses the principle that specific timeframes should be imposed on the Network Operator to accept or reject a negotiated access standard. 30 business days appears to be more than sufficient for this purpose and Eni does not understand PWC's request in their subsequent submission to remove this timeframe, as they have the final say over negotiated access standards."
- NTSF state: "PWC have removed the requirement to respond in 30 days and instead refer to timeframe to meet NT NER 5.3.6 (which deals with the timeframe to provide an offer to connect). NT NER 5.3.6 (a)(1) states "The Network Service Provider may amend the time period referred to in paragraph (a)(1) to allow for any additional time taken in excess of the period allowed in the preliminary program for the negotiation of access standards, where allowed under jurisdictional electricity legislation." A reasonable conclusion upon reading this is that PWC can delay as long as they "reasonably" like. There is no definition or limits on what "reasonably" might consist of. Such an approach is clearly counterproductive to encouraging investment in this industry, and the 30-day requirement should remain.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission has considered PWC's feedback, that it may not be able to meet the 30-day timeframe because the GPS are new and a significant change for the Territory, and there is uncertainty regarding the volume and nature of proposed negotiated standards to be considered by PWC. However, as noted by Eni and NTSF, the flexibility requested by PWC would create additional uncertainty for generator developers regarding the time for assessing any proposed negotiating access standard.

Based on GHD's advice, which is further detailed in its separate report, and noting there is a need to strike the right balance between providing sufficient time for the assessment process and minimising delays in the connection process for new generators and providing certainty regarding the expected timeframe, the commission does not accept PWC's further proposed revision.

It should be noted that consistent with the Final Decision in relation to clause 3.3.4 (Provision of Information), the network modelling information part of this clause has been moved to clause 3.3.4.

Final Decision NTC wording

Clause 3.3.5

> The following technical requirements describe the *automatic access standards* for new or modification of existing, *generating units* or *generating systems* seeking connection to the network. A connection applicant may propose an alternative *negotiated access standard* by applying the following:
>
> (a) A *negotiated access standard* must:
>
> (1) be set at a level that will not adversely affect power system security;

(2) be set at a level that will not adversely affect the quality of supply for other *Network Users*.

(b) When submitting a proposal for a *negotiated access standard*, a connection applicant must propose a standard that is as close as practicable to the corresponding automatic access standard, having regard to:

(1) the need to protect the plant from damage;

(2) power system conditions at the location of the proposed connection;

and

(3) the commercial and technical feasibility of complying with the *automatic access standard* with respect to the relevant technical requirement.

(c) When proposing a *negotiated access standard* under paragraph (b), the connection applicant must provide reasons and evidence to the *Network Operator* and *Power System Controller* as to why, in the reasonable opinion of the connection applicant, the proposed *negotiated access standard* is appropriate, including:

(1) how the connection applicant has taken into account the matters outlined in subparagraphs (b)(1), (b)(2) and (b)(3); and

(2) how the proposed *negotiated access standard* meets the requirements of paragraph (a).

(d) Within 30 business days following the later of:

(1) receipt of a proposed *negotiated access standard*; and

(2) receipt of all information required to be provided by the connection applicant,

the *Network Operator* must accept or reject a proposed *negotiated access standard*.

(e) The *Network Operator* must reject the proposed *negotiated access standard* where in the *Network Operator's* reasonable opinion, one or more of the requirements at subparagraphs (a)(1) and (a)(2) are not met.

(f) If the *Network Operator* rejects a proposed *negotiated access standard*, the *Network Operator* must, at the same time:

(1) subject to obligations in respect of *confidential information*, provide to the connection applicant:

(i) where the basis for the *Network Operator's* rejection is lack of evidence from the connection applicant, details of the additional evidence of the type referred to in paragraph (c) the *Network Operator* requires to continue assessing the proposed *negotiated access standard*;

(ii) detailed reasons in writing for the rejection, including the extent to which each of the matters identified at subparagraphs (a)(1) and (a)(2) contributed to the *Network Operator's* decision to reject the proposed *negotiated access standard*; and

(2) advise the connection applicant of a *negotiated access standard* that the *Network Operator* considers meets the requirements of subparagraphs (a)(1), and (a)(2).

(g) The connection applicant may in relation to a proposed *negotiated access standard* advised by the *Network Operator* in accordance with subparagraph (f)(2):

(1) accept the proposed *negotiated access standard*;

(2) reject the proposed *negotiated access standard*;

(3) propose an alternative *negotiated access standard* to be further evaluated in accordance with the criteria in paragraph (b); or

(4) elect to adopt the relevant *automatic access standard* or a corresponding plant standard.

(h) An *automatic access standard* or if the procedures in this clause 3.3.5 have been followed a *negotiated access standard*, that forms part of the terms and conditions of a *connection agreement*, is taken to be the performance standard applicable to the connected plant for the relevant technical requirement

NTC Clause 3.3.5.1 – Reactive Power Capability

Discussion and Final Decision

The commission notes that this clause differs from the NT NER by the absence of guidance regarding the basis for negotiation or ability for a connecting party to meet requirements by funding network investments. Revising the NTC to address these issues provides greater flexibility for generators when deciding on how best to achieve compliance with reactive power requirements. Greater flexibility has the potential to lead to more efficient connection options.

Accordingly, in the Draft Decision, the commission agreed with GHD's recommendation that wording be added to provide guidance for the negotiation of access standards and that a connecting party has the ability to meet the performance standard by funding network investments to achieve the required outcome.

The wording proposed by PWC (in its September 2019 submission) reflects the automatic access standard specified in the NT NER. This level of reactive power capability is generally able to be delivered by generating systems, but will often involve additional capital expenditure. Should those costs threaten the commercial feasibility of the project, the generator may seek to negotiate a lower level of performance via the process described in clause 3.3.5 of the NTC.

GHD's review as part of the Draft Decision proposed additional amendments to provide further opportunities to optimise the investment necessary to provide reactive power capability. The commission agreed with GHD's recommendation on the basis that it balances the costs imposed on generators and the system security benefits achieved by having generators provide adequate reactive power capability to control voltage.

Further PWC proposed revisions and issues raised in submissions

In response to the commission's Draft Decision, PWC raised concerns with the proposed drafting including:

- the positioning of sub-clauses (d) and (e) within clause 3.3.5.1 may create ambiguity over the specification of the automatic access standard

- the guidance provided by the proposed drafting is unnecessary as clause 3.3.5 already allows a connection applicant to propose the arrangements described as a negotiated access standard
- the reference within clause (d)(1) paying compensation to the Network Operator may create ambiguity regarding the Network Operator's prescribed revenue allowance.

PWC has recommended that the proposed clauses 3.3.5.1(d) and (e) either be deleted or revised and moved to the beginning of clause 3.3.5, with revisions proposed to address the identified ambiguity.

A number of submissions have also raised issues with the reactive power access standard:

- Assure Energy suggests revisions to the automatic access standard to confirm that the generator is not required to provide additional reactive power if it provides additional active power to support power system frequency control
- Eni suggests revisions to the reactive power access standard to limit the ability of the Network Operator to reject a negotiated access standard if the reactive power deficit is not required or is a pre-existing condition of the network, rather than being caused by the connection of the generator.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission notes that the existing drafting of 3.3.5 allows connecting parties to propose negotiated standards, however they provide little specific guidance for generators regarding the sort of changes to automatic access standards that may be accepted. Accordingly, the commission considers there is value in retaining within the NTC explicit provisions similar to sub-clauses (d) and (e).

The commission agrees that the revisions proposed by PWC provide greater clarity while not reducing the guidance provided to connection applicants. However, they are to be retained within 3.3.5.1, and not moved to clause 3.3.5 as proposed, noting the wording of clause 3.3.5.1(a) appears to clearly define the automatic access standard as the standard specified in this sub-clause.

In relation to Assure Energy's suggested revisions, GHD reviewed clause 3.3.5.1(a) and found it difficult to envisage how the automatic standard could be interpreted as requiring an additional amount of reactive power capability. Nonetheless, the commission has decided to amend clause 3.3.5.1(a), to address Assure Energy's issue but with simpler wording, to make it clear that the performance is to be delivered at any level of active power output not exceeding the rated active power of the generating system.

The revisions suggested by Eni seek to prevent PWC requiring the generator to provide more reactive power range than that required to accommodate the generator connection. The commission considers that the proposed revision is unnecessary as NTC clause 3.3.5 as specified in this Final Decision allows a connection applicant to propose a negotiated access standard which is lower than the automatic access standard provided they can demonstrate that accepting that lower range would not adversely affect power system security or the quality of supply for other Network Users.

Final Decision NTC wording

Clause 3.3.5.1

(a) The *automatic access standard* is a *generating system* operating at:

(1) any level of *active power* output not exceeding the *rated active power;* and

(2) any *voltage* at the *connection point* within the limits established under clause 15.2 (a) without a *contingency event*,

must be capable of supplying and absorbing continuously at its *connection point* an amount of *reactive power* of at least the amount equal to the product of the *rated active power* of the *generating system* and 0.395.

(b) A performance standard must record the agreed value for *rated active power* and where relevant the method of determining the value.

(c) A performance standard for consumption of energy by a *generating system* when not supplying or absorbing *reactive power* under an ancillary services agreement is to be established under clause 3.6 as if the *Generator* were a load.

(d) If the *generating system* is not capable of the level of performance established under clause 3.3.5.1(a) the *Generator*, depending on what is reasonable in the circumstances, may request a *negotiated access standard* in accordance with clause 3.3.5(a) to (h), based on solutions including (without limitation):

(1) reaching a commercial arrangement with the *Network Operator* for the provision of the deficit of *reactive power* (supply and absorption) from within the *network*;

(2) installing additional equipment *connecting* at the *generating system's connection point* or another location, to provide the deficit of *reactive power* (supply and absorption), and such equipment is deemed to be part of the *generating system*;

(3) reaching a commercial arrangement with a *User* to provide the deficit of *reactive power* (supply and absorption); or

(4) if the inability to meet the performance level only occurs for particular operating conditions, agreeing to and documenting as part of the proposed *negotiated access standard*, operational arrangements by which the *plant* can achieve an agreed level of performance for those operating conditions.

(e) The *Generator* may select one or more options referred to in paragraph (d).

NTC Clause 3.3.5.2 – Quality of Electricity Generated

Discussion and Final Decision

The commission notes that this clause differs from the NT NER as the automatic access level does not define the process used to allocate the harmonic emission limits, or voltage unbalance limits for connecting generators. NTC clause 2.4.1 and 2.4.2 lack the specific details included in the corresponding sections of S5.1.5 of the NT NER, noting this schedule is not currently in effect. The presently proposed drafting risks creating ambiguity and confusion regarding the applicable performance requirement.

Consistent with that recommended by GHD, the commission agrees there is a need for PWC to allocate specific limits to individual generators. Consequently clauses 2.4.1 and 2.4.2 are to be revised to provide additional clarity.

As discussed in GHD's report to the commission to inform its Draft Decision, the revisions will provide a more efficient connection process by providing generators with greater clarity regarding the performance standards they need to meet. With the changes implemented, the performance standards may require a solar farm to install harmonic filters to meet the automatic access standard, however that cost is considered justified if it is required to ensure the system standards are met thereby avoiding exposing other connected parties to quality of supply issues.

Further PWC proposed revisions and issues raised in submissions

It has been identified that the term plant standard was italicised in the Draft Decision, which was incorrect.

The commission's Draft Decision highlighted in yellow revisions to Clause 3.3.5.2 to show terms that should be italicised, as they were italicised in the equivalent standard in the NT NER or were terms defined in Attachment 1 to the NTC. It is acknowledged that this resulted in the term plant standard being italicised, which is not appropriate as the definition in the NT NER is not directly applicable for the Territory power systems as it refers to sections of the NT NER which are yet to be adopted in the Territory.

Accordingly, the term plant standard should not be italicised in clause 3.3.5.2, as shown below. This term will rely on a plain English definition, which is unlikely to create any confusion.

No concerns were raised in submissions to the commission in relation to this clause.

Final Decision NTC wording

Clause 3.3.5.2

(a) For the purpose of this clause 3.3.5.2 in respect of a *synchronous generating unit*, AS 1359.101 and IEC 60034-1 are plant standards for harmonic *voltage* distortion.

(b) The *automatic access standard* is a *generating system* when generating and when not generating must not produce at any of its *connection points* for *generation*:

(1) *voltage* fluctuation greater than the limits allocated by the *Network Operator* under clause 2.4.1;

(2) harmonic *voltage* distortion greater than the emission limits specified by a plant standard under paragraph (a) or allocated by the *Network Operator* under clause 2.4.2; and

(3) *voltage* unbalance greater than the limits allocated by the *Network Operator* in accordance with clause 2.4.3.

Clause 2.4.1

2.4.1 Voltage fluctuations

A voltage disturbance is where the voltage shape is maintained but the voltage magnitude varies and may fall outside the steady state supply voltage range set out in clause 15.2 of the Network Planning Criteria. Short duration voltage disturbances of durations of up to one minute are termed voltage sags and swells.

The ENA publication Customer Guide to Electricity Supply contains information on the typical voltage sags experienced on Australian electricity networks and how customers can mitigate the risks of equipment maloperation because of sags.

Rapid voltage fluctuations cause changes to the luminance of lamps, which can create the visual phenomenon termed flicker.

(a) Under normal operating conditions, fluctuations in voltage on the network should be less than the "compatibility levels" defined in Table 1 of Australian Standard AS/NZS 61000.3.7 (2001).

(b) To facilitate the application of this standard Power and Water shall establish "planning levels" for its networks, as provided for in the Australian Standard.

(c) The *Network Operator* must allocate emission limits to a *connection applicant* that are no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.7:2001.

Clause 2.4.2

2.4.2 Harmonic distortion

2.4.2.1 Harmonic voltage distortion

(a) Under normal operating conditions, the harmonic voltage in the network shall be less than the "compatibility levels" defined in Table 1 of Australian Standard AS/NZS 61000.3.6 (2001).

(b) To facilitate the application of this standard Power and Water shall establish "planning levels" of harmonic distortion for its networks as provided for in the Australian Standard.

(c) Planning levels for harmonic voltage distortion are specified in clause 17 of the Network Planning Criteria.

(d) The *Network Operator* must allocate emission limits to a *connection applicant* that are no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.6:2001.

2.4.2.2 Non-integer harmonic distortion

Inter-harmonic or non-integer harmonic distortion may arise from large converters or power electronics equipment with Pulse Width Modulation (PWM) converters interfacing with the power system.

(a) Under normal operating conditions, the emission levels for inter-harmonic voltage in the network shall be less than the levels defined in section 9 of Australian Standard AS/NZS

61000.3.6 (2001).

(b) To facilitate the application of this standard Power and Water shall establish “planning levels” of inter-harmonic distortion for its networks as provided for in the Australian Standard AS/NZS 61000.3.6 (2001).

(c) Planning levels for inter-harmonic voltage distortion are specified in clause 17 of the Network Planning Criteria.

(d) The *Network Operator* must allocate emission limits to a *connection applicant* that are no more onerous than the lesser of the acceptance levels determined in accordance with either of the stage 1 or the stage 2 evaluation procedures defined in AS/NZS 61000.3.6:2001.

2.4.2.3 Voltage notching

Voltage notching may also arise from large convertors or power electronics equipment with Pulse Width Modulation (PWM) converters interfacing with the power system.

Voltage notching caused by a User’s facilities is acceptable provided that:

(a) the limiting values of harmonic voltage distortion as described in clause 2.4.2.1 are not exceeded;

(b) the average of start notch depth and end notch depth shall not exceed 20% of the nominal fundamental peak voltage; and

(c) the peak amplitude of oscillations due to commutation at the start and end of the voltage notch shall not exceed 20% of the nominal fundamental peak voltage.

2.4.2.4 Harmonic current distortion

(a) The harmonic voltage distortion limits of clause 2.4.2 apply to each phase and are not to be exceeded by a User injecting harmonic currents at any of its connection points.

(b) Any induced noise interference to telecommunications lines by a User’s load due to harmonic currents is not acceptable and the User is required to reduce the level of harmonic currents so as to contain such interference to limits considered acceptable by the telecommunication Network Operator.

(c) The User’s load shall not cause any harmonic resonance in other Users’ systems or the Network Operator’s network.

2.4.2.5 Direct current

(a) Users’ plant and equipment shall comply with the requirements on direct current components as stipulated in clause 3.12 of Australian Standard AS/NZS 3100:2009. In particular, the direct current in the neutral caused by the Users’ plant and equipment shall not exceed 120mA.h per day.

(b) Users shall ensure that all their plant and equipment is designed to withstand without damage or reduction in life expectancy the limits as specified in this clause 2.4.2.5.

(c) Responsibility of the Network Operator for direct current in the neutral outside the limits specified in this clause 2.4.2.5 shall be limited to direct current in the neutral caused by network assets.

(d) A User whose plant is identified by the Network Operator as not performing to the standards specified in this clause 2.4.2.5 shall take such measures as may be necessary to meet Australian Standard AS/NZS 3100:2009.

NTC Clause 3.3.5.3 – Generating Unit Response to Frequency Disturbance

Discussion and Final Decision

The commission notes that in this clause the performance requirement is not adequately defined, as terms that are referenced are not defined:

- abnormal frequency excursion tolerance limits
- operational frequency tolerance band.

The following defined terms should be used instead:

- "operational frequency tolerance band" replaced by "normal operating frequency band"
- "abnormal frequency excursion tolerance limits" replaced by "the limits of the abnormal operating frequency excursion band specified in 2.2.2(b)".

Other identified issues:

- stabilisation time is not defined in the frequency operating standard which according to the glossary is defined in clauses 2.2 and 2.4 on the NTC. The definition of stabilisation time should be amended to clarify that it is 10 minutes.
- rate of change of frequency (RoCoF) is not specified with any time dimension making the requirement more onerous than the automatic access standard specified in the NT NER, noting this standard is not currently in effect (the NT NER automatic requirement specifies generators ride though RoCoF of +/- 4Hz/s for 0.25s and +/- 3Hz/s for 1s).

The commission notes that RoCoF issues primarily affect synchronous generators, and are not a significant issue for solar PV inverter based generators due to their ability to respond rapidly to changes of frequency.

In discussing these proposed amendments with PWC, it has advised that the isolated nature of the Territory power systems means that following contingencies, the frequency changes more rapidly than in larger interconnected systems, such as the NEM. PWC have advised that the synchronous generators connected to Territory power systems have demonstrated an ability to ride through relatively high RoCoF events and furthermore at a RoCoF of 4Hz/s, the limits of the frequency ride through bands specified in NTC clause 3.3.5.3 are reached quickly. PWC have therefore suggested that specifying a time dimension for RoCoF performance is not necessary. GHD has advised the commission that there is merit in PWC's argument and that it does not recommend any change to the RoCoF provisions proposed by PWC. The commission accepted GHD's view in its Draft Decision.

<u>Issues raised in submissions</u>

TGen's submission states that as drafted, there is no requirement for any generator to remain on-line above 52 Hz and that its proposed 2016 changes, that were attached to its 2019 submission, should be revisited "so that all generators will be obligated to provide some over frequency protection settings, rather than relying on TGen historical settings that are servicing above the level required by the current code".

That submission proposes an amendment to NTC clause 2.2.2 adding a new subclause requiring generating units to remain connected to the Network Operator's network for a period of at least two seconds in the event of operation above 52 Hz, with an instantaneous trip allowed if the frequency exceeds 53.5 Hz. It also proposed altering the automatic access standard specified in clause 3.3.5.3 by extending the figure from 52 Hz to 53.5 Hz, for two seconds of continuous uninterrupted operation.

Eni's submission suggests that the 10 minute stabilisation time used in specifying the performance standard is too long, as it is expected that the frequency recovery should proceed more quickly in the Northern Territory power system than in the NEM.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

GHD has considered the concern raised by TGen and agrees that it is important to appropriately coordinate the over-frequency trip settings of generators to ensure all generators do not trip at the same point. However, GHD does not believe that the revisions proposed by TGen would offer any greater certainty of achieving this than the drafting of clause 3.3.5.3 proposed in the commission's Draft Decision, as the wording proposed by TGen simply moves the problem from 52 Hz to 53.5 Hz.

The risk can be addressed if over frequency trip settings are appropriately coordinated, noting there are provisions in the NTC which allow for this to occur, notably clause 3.3.3(3) and clause 3.3.5.9(d). The automatic access standard does not prevent a generator providing a greater level of performance. The obligation of the generator is to ensure its performance at least matches that in its performance standard. Accordingly, the commission does not consider that the automatic access standard as proposed in the commission's Draft Decision, and now approved as set out below, will impede appropriate coordination of generator over-frequency protection settings.

In relation to Eni's feedback, GHD reviewed the stabilisation time specified in the automatic access standard and compared it with the equivalent times specified in the frequency operating standards for the NEM. GHD considers the recovery time in the NEM frequency operating standards is the appropriate quantity to compare to the stabilisation time in clause 3.3.5.3 as both specify the time allowed to return the frequency to within the normal operating band. In the NEM under islanded conditions, the recovery time is 10 minutes for all mainland regions. Accordingly, GHD has advised that it considers 10 minutes is a reasonable timeframe for the Northern Territory power systems.

The access standard proposed by PWC is consistent with the automatic access standard specified in the NT NER allowing for changes to the frequency settings to reflect the frequency operating standards applicable in Territory power systems. GHD advise that the proposed access standards should not impose any significant cost on new generators, particularly inverter connected solar farms, and consider the Final Decision wording below provides an appropriate balance between the costs imposed on generators in meeting the standard and the system security benefit delivered.

Final Decision NTC wording

Clause 3.3.5.3

(a) For the purposes of this clause 3.3.5.3:

normal operating frequency band and abnormal operating frequency excursion band are references to the widest range specified for those terms

for any condition (including an "island" condition) in the *frequency operating standards* that apply to the *region* in which the *generating unit* is located.

stabilisation *time* means the longest times allowable for the *frequency* of the *power system* to remain outside the normal operating frequency band, for any condition (including an "island" condition) in the *frequency operating standards* that apply to the *region* in which the *generating unit* is located. The stabilisation time is 10 minutes.

transient frequency limit and transient frequency time mean the values of 45 Hz and 2 seconds respectively, or such other values determined by the *Power System Controller*.

(b) The *automatic access standard* is a generating system and each of its generating units must be capable of continuous uninterrupted operation for frequencies in the following ranges:

(1) the lower bound of the transient frequency limit for at least 2 seconds;

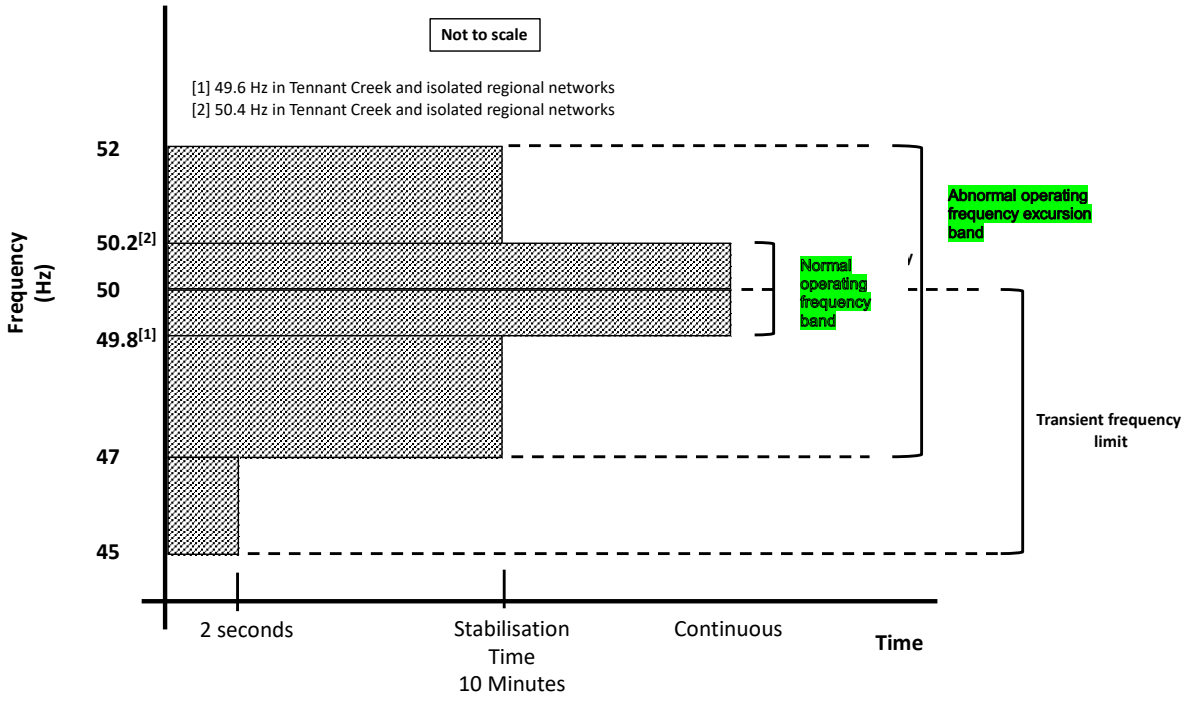
(2) the lower bound of the limits of the abnormal operating frequency excursion band specified in 2.2.2(b) to the lower bound of the *normal operating frequency band* for at least the stabilisation time;

(3) *the normal operating frequency band* for an indefinite period;

(4) the upper bound of the *normal operating frequency band* to the upper bound of the abnormal operating frequency excursion band for at least the stabilisation time,

unless the *rate of change of frequency* is outside the range of –4 Hz to 4 Hz per second.

The automatic access standard is illustrated in the following diagram on reflecting the frequency standards outlined in clauses 2.2.1 and 2.2.2.



NTC Clause 3.3.5.4 – Generating System Response to Voltage Disturbances

Discussion and Final Decision

The commission notes that in this clause the performance levels are specified with reference to the normal voltage, however that term is not defined in the NTC. In its Draft Decision, the commission agreed with GHD, that the NT NER definition be adopted (with appropriate wording to reflect the terminology used in the NTC):

"In respect of a connection point, its nominal voltage or such other voltage up to 10% higher or lower than nominal voltage, as approved by the Network Operator, for that connection point."

The wording proposed by PWC in its September 2019 submission reflects the automatic access standard specified in the NT NER. The review completed by the AEMC found that the over and under voltage levels specified in the automatic access standard were unlikely to impose significant costs on generators. The overvoltage levels being consistent with those adopted in a number of jurisdictions around the world.

Further PWC proposed revisions and issues raised in submissions

In addition to accepting the revisions to clause 3.3.5.4 proposed by the commission in the Draft Decision, including a definition for normal voltage, PWC has suggested including the following definition for the term nominal voltage in NTC Attachment 1:

"nominal voltage

The design *voltage* level, nominated for a particular location on the *power system*, such that power lines and circuits that are electrically *connected* other than through transformers have the same *nominal voltage* regardless of operating *voltage*."

Eni's submission raises a concern that the definition of normal voltage proposed in the Draft Decision allows the normal voltage to be up to 10% higher than the nominal voltage and that this increases the voltage ride through requirements specified in clause 3.3.5.4. Eni is concerned that the high and low voltage requirements may therefore exceed the capability of common inverters.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission agrees that PWC's proposed definition for nominal voltage be added to Attachment 1, as it will provide clarity for users of the NTC.

GHD considered Eni's concern, by first considering whether the use of the term normal voltage in clause 3.3.5.4 is appropriate and then considering whether the resulting voltage ride through requirement is appropriate given the capability of generating equipment. This consideration is detailed in GHD's report to the commission, including reference to work undertaken by the AEMC in relation to its 2018 review of generator technical performance standards.

Consistent with GHD's associated advice, the commission believes the use of the term normal voltage and the voltage ride through performance levels specified in clause 3.3.5.4 are appropriate, with no further changes to the wording considered necessary to address Eni's feedback.

It is noted that if the cost of meeting the voltage ride through requirements specified in this access standard threaten the commercial feasibility of a generation development, the negotiating framework specified in NTC clause 3.3.5 allows for potential negotiation of a lower standard. Accordingly, the commission agrees with GHD, that the access standard proposed by PWC, with the revisions discussed above, provide an appropriate balance between costs imposed on generators in meeting the standard and the system security benefit delivered.

Final Decision NTC wording

Clause 3.3.5.4

There are no changes to the wording of the clause, with only key words to be italicised. The clause will now read as follows:

(a) The automatic access standard is a *generating system* and each of its *generating units* must be capable of continuous uninterrupted operation where a power system disturbance causes the voltage at the connection point to vary within the following ranges:

(1) over 130% of *normal voltage* for a period of at least 0.02 seconds after T(ov);

(2) 125% to 130% of *normal voltage* for a period of at least 0.2 seconds after T(ov);

(3) 120% to 125% of *normal voltage* for a period of at least 2.0 seconds after T(ov);

(4) 115% to 120% of *normal voltage* for a period of at least 20.0 seconds after T(ov);

(5) 110% to 115% of *normal voltage* for a period of at least 20 minutes after T(ov);

(6) 90% to 110% of *normal voltage* continuously;

(7) 80% to 90% of *normal voltage* for a period of at least 10 seconds after T(uv); and

(8) 70% to 80% of *normal voltage* for a period of at least 2 seconds after T(uv),

where T(ov) means a point in time when the *voltage* at the *connection point* first varied above 110% of *normal voltage* before returning to between 90% and 110% of normal voltage, and T(uv) means a point in time when the *voltage* at the *connection point* first varied below 90% of *normal voltage* before returning to between 90% and 110% of *normal voltage*.

(b) The *access standard* must include any operational arrangements necessary to ensure the *generating system* and each of its *generating units* will meet its agreed performance levels under abnormal network or generating system conditions.

The following definitions are to be added to the glossary of terms in Attachment 1 of the NTC:

nominal voltage

The design *voltage* level, nominated for a particular location on the *power system*, such that power lines and circuits that are electrically *connected* other than through transformers have the same *nominal voltage* regardless of operating *voltage*.

normal voltage

In respect of a connection point, its *nominal voltage* or such other voltage up to 10% higher or lower than *nominal voltage*, as approved by the *Network Operator*, for that connection point.

NTC Clause 3.3.5.5 – Generating System Response to Disturbances following Contingency Events

Discussion and Final Decision

In this clause, the performance levels are specified with reference to maintaining continuous uninterrupted operation, however the commission noted in its Draft Decision that the term is not defined, creating ambiguity. The commission agreed with GHD that the NT NER definition for continuous uninterrupted operation be adopted:

In respect of a generating system or generating unit operating immediately prior to a power system disturbance:

a) *not disconnecting from the power system except under its performance standards established under clauses S5.2.5.8 and S5.2.5.9;*

b) *during the disturbance contributing active and reactive current as required by its performance standards established under clause S5.2.5.5;*

c) *after clearance of any electrical fault that caused the disturbance, only substantially varying its active power and reactive power as required or permitted by its performance standards established under clauses S5.2.5.5, S5.2.5.11, S5.2.5.13 and S5.2.5.14; and*

d) *not exacerbating or prolonging the disturbance or causing a subsequent disturbance for other connected plant, except as required or permitted by its performance standards,*

with all essential auxiliary and reactive plant remaining in service.

Cumulative time thresholds from the NT NER are missing, noting the Territory's progressive application of the NER is not complete. The lack of guidance in the NT NER may create an unrealistic expectation of generator performance. GHD advise that a worst case interpretation may require generators to ride through 15 faults resulting in near zero voltage at the connection point for 5 minutes, which is likely to be challenging for generators to meet.

Accordingly, in the Draft Decision, the commission proposed, as recommended by GHD, adopting a framework similar to the following provisions specified in the automatic access standard in the NT NER, noting this is not currently in effect:

(8) *the cumulative time that voltage at the connection point is lower than 90% of normal voltage exceeding 1,800 milliseconds within any five minute period; or*

(9) *the time integral, within any five minute period, of the difference between 90% of normal voltage and the voltage at the connection point when the voltage at the connection point is lower than 90% of normal voltage exceeding 1 pu second.*

The Draft Decision acknowledged that the NT experiences a high level of lightning activity compared to many regions of the NEM and it may therefore be appropriate for the cumulative thresholds to be varied from those in the NER. However, omitting any cumulative thresholds in the NTC is not appropriate, as this may result in unrealistic or very expensive performance

requirements. This position is supported by findings published by the AEMC[12] in their final report on the generator technical performance standards rule change. The AEMC found that:

- *"*the automatic access standard requirements was more arduous than the international jurisdictions considered, but noted that generator access standards in the NER are relatively unique compared to international standards in providing a negotiation range between different levels of performance" and
- *"*as part of the manufacturer survey, four out of five respondents (including manufacturers of both synchronous and asynchronous generating systems and units) claimed that their equipment could readily meet the updated minimum access standard (i.e. at little or no additional cost using 'off-the-shelf' equipment), and five out of six respondents claimed that their equipment could readily meet, or meet with modification (i.e. a likely material, but manageable additional cost), the updated automatic access standard.

The Draft Decision also noted that the term "transmission system" requires definition, "Table 5" in NTC clause 2.9.4 does not exist and this reference should be updated to "Figure 5".

Further, the Draft Decision discussed that the protection clearing times referenced are different to those in the NT NER but align with system standards in the clause 2.9.4 of the NTC and thus, concluded they were appropriate.

The rest of the wording proposed by PWC in its September 2019 submission reflects the automatic access standard specified in the NT NER, noting the relevant schedule is not currently in effect. The review completed by the AEMC identified that the automatic access standard is higher than the standard normally specified in other jurisdictions and may in some cases impose additional but manageable costs on generators. However, if those costs threaten the commercial feasibility of a generation development, the negotiating framework specified in NTC clause 3.3.5 allows for potential negotiation of a lower standard.

Further PWC proposed revisions and issues raised in submissions

PWC has proposed revisions to the drafting of clause 3.3.5.5 to clarify the multiple fault ride through requirements and to propose cumulative thresholds that are consistent with other provisions of the NTC related to maximum fault clearing times, post clearing time transient voltage dips and planning criteria for voltage sags and swells.

Eni raises concerns that the requirements specified in clause 3.3.5.5 including the revisions proposed by PWC impose a level of performance that existing inverters may not be able to meet.

NTSF, while not identifying any particular issues with the revisions proposed by PWC, note that these are new requirements which the private sector industry (and others) have had no opportunity to consider in detail.

[12] AEMC final report, page 212, https://www.aemc.gov.au/sites/default/files/2018-09/Final%20Determination_0.pdf

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The revisions proposed by PWC and relevant information published by the AEMC during its consideration of the revision to the generator performance standards for the NEM have been considered by GHD, with GHD's assessment enhanced by a meeting with PWC representatives on 8 January 2020, to clarify various aspects of their proposed revisions.

As detailed in GHD's attached report to the commission, GHD's key findings from the assessment are, in summary:

- the revised clause proposed by PWC presents provisions which describe a sequence of faults that generators may be exposed to when connected to Territory power systems
- the provisions generally align with those in the NT NER except for those limiting the accumulated time with the connection point below 80% and 90% of the normal voltage (i.e. sub clause (d)(5) and (d)(6))
- while the accumulated time threshold for voltage <80% proposed by PWC is significantly longer than that adopted in the NER and specified in the NT NER, PWC has provided evidence showing that the proposed time of 10,000 milliseconds is consistent with a fault sequence which would be permitted by the existing planning criteria in the NTC
- while this series of faults comply with the planning criteria, there is no data from fault recordings to determine if the proposed accumulated time threshold is typical for faults actually experienced with the Territory power systems
- the accumulated time thresholds are significantly greater than those adopted in the NEM. Subsequently, a review of the information considered by the AEMC as part of the NER rule change process has identified that some generators may have problems with meeting the accumulated time thresholds proposed by PWC.

GHD's review considered information gathered during the NEM rule change process to understand any issues raised with the ability of generators to meet the accumulated time thresholds proposed by PWC. Its considerations and associated findings are detailed in its attached report.

Based on GHD's assessment, it recommends accepting the revisions proposed by PWC for paragraphs 3.3.5.5(d)(1) to 3.3.5.5(d)(3), which better clarify the fault sequences. However, given that manufacturers would be unlikely to be able to meet the extended cumulative time thresholds proposed by PWC, GHD recommends that the commission continue to utilise the cumulative time thresholds proposed in the Draft Decision.

Subsequently, PWC should commence recording fault information for Territory power systems so that they are able to assess the likelihood of the cumulative time across any five minute period with the voltage at a connection point falling below the thresholds specified in the proposed automatic access standard. Once a sufficient set of actual fault records for Territory power systems have been collected and analysed, the cumulative time threshold specified in the automatic access standard can be reviewed. Until then, GHD recommends not including cumulative time thresholds in the automatic access standard. This is achieved by not including sub clauses (3.3.5.5(d)(5) and (6)) proposed by PWC.

The ability of generators to be able to remain in continuous uninterrupted operation in the Territory power systems is an important characteristic for PWC to understand. For this reason, the commission has included a new paragraph (l) in clause 3.3.5.5 requiring all generators to provide to the Network Operator details of the capability of their plant to

withstand accumulated times below 80% of normal voltage and 90% of normal voltage and remain in continuous uninterrupted operation. This will enable the Network Operator to collect this information and compare with recorded fault data to determine the actual risk faced during typical disturbances on the NT networks.

The commission considers that, consistent with GHD's advice and that discussed above, the access standard proposed by PWC with the revisions included below provide an appropriate balance between costs imposed on generators in meeting the standard and the system security benefit delivered.

Final Decision NTC wording

Clause 3.3.5.5

(a) In this clause 3.3.5.5 a fault includes a fault of the relevant type having a metallic conducting path.

(b) The automatic access standard is:

(1) for a *generating system* and each of its *generating units*, the requirements of paragraphs (c) and (d);

(2) for a generating system comprised solely of synchronous generating units, the requirements of paragraph (e);

(3) for a generating system comprised solely of asynchronous generating units, the requirements of paragraphs (f) to (i); and

(4) for a generating system comprised of synchronous generating units and asynchronous generating units:

(i) for that part of the *generating system* comprised of *synchronous generating units*, the requirements of paragraph (e); and

(ii) for that part of the generating system comprised of asynchronous generating units, the requirements of paragraphs (f) to (i).

All generating systems

(c) A generating system and each of its generating units must remain in continuous uninterrupted operation for any disturbance caused by:

(1) a credible contingency event;

(2) a three phase fault in a transmission system cleared by all relevant primary protection systems;

(3) a two phase to ground, phase to phase or phase to ground fault in a transmission system cleared in:

(i) the longest time expected to be taken for a relevant breaker fail protection system to clear the fault; or

(ii) if a protection system referred to in subparagraph (i) is not installed, the greater of the time specified in clause 2.9.4 Figure 5 (or if none is specified, 450 milliseconds) and the longest time expected to be taken for all relevant primary protection systems to clear the fault; or

(4) a three phase, two phase to ground, phase to phase or phase to ground fault in a distribution network cleared in:

(i) the longest time expected to be taken for the breaker fail protection system to clear the fault; or

(ii) if a protection system referred to in subparagraph (i) is not installed, the greater of 1500 milliseconds and the longest time expected to be taken for all relevant primary protection systems to clear the fault,

provided that the event is not one that would disconnect the generating unit from the power system by removing network elements from service.

(d) A generating system and each of its generating units must remain in continuous uninterrupted operation for a series of ~~up to 15~~ disturbances within any five minute period caused by any combination of the events described in paragraph (c) ~~where~~ without limitation on the time difference between successive disturbances, unless any of the following conditions are exceeded first:

(1) ~~up to~~ more than six of the disturbances cause the *voltage* at the *connection point* to drop below 50% of *normal voltage*;

(2) in parts of the *network* where three-phase automatic reclosure is permitted, ~~up to~~ more than two of the disturbances are three phase faults, and otherwise, ~~up to~~ more than one three phase fault where *voltage* at the *connection point* drops below 50% of *normal voltage*;

(3) ~~up to~~ more than one disturbance is cleared by a *breaker fail protection system* or similar back-up *protection system*;

~~(4) up to more than one disturbance causes the voltage at the connection point to vary within the ranges under clause 3.3.5.4(a)(7) and (a)(8); and~~

~~(5) the minimum clearance from the end of one disturbance and commencement of the next disturbance may be zero milliseconds; and~~

~~(6) all remaining disturbances are caused by faults other than three phase faults,~~

(4) there are more than 15 disturbances,

provided that none of the events would result in:

(5) the islanding of the generating system or cause a material reduction in power transfer capability by removing network elements from service.

Synchronous generating systems

(e) Subject to any changed power system conditions or energy source availability beyond the Generator's reasonable control, a generating system comprised of synchronous generating units, in respect of the types of fault described in subparagraphs (c)(2) to (4), must supply to or absorb from the network:

(1) to assist the maintenance of power system voltages during the fault, capacitive reactive current of at least the greater of its pre-disturbance reactive current and 4% of the maximum continuous current of the generating system including all operating synchronous *generating units* (in the absence of a disturbance) for each 1% reduction (from the level existing just prior to the fault) of *connection point* voltage during the fault;

(2) after clearance of the fault, reactive power sufficient to ensure that the *connection point* voltage is within the range for continuous uninterrupted operation under clause 3.3.5.4; and

(3) from 100 milliseconds after clearance of the fault, active power of at least 95% of the level existing just prior to the fault.

Asynchronous Generating Systems

(f) Subject to any changed power system conditions or energy source availability beyond the Generator's reasonable control, a generating system comprised of asynchronous generating units, in respect of the types of fault described in subparagraphs (c)(2) to (4), must have facilities capable of supplying to or absorbing from the network:

(1) to assist the maintenance of power system voltages during the fault:

(i) capacitive reactive current in addition to its pre-disturbance level of at least 4% of the maximum continuous current of the *generating system* including all operating asynchronous *generating units* (in the absence of a disturbance) for each 1% reduction of voltage at the connection point below the relevant range in which a reactive current response must commence, as identified in subparagraph (g)(1), with the performance standards to record the required response agreed with the *Network Operator* and *Power System Controller*; and

(ii) inductive reactive current in addition to its pre-disturbance level of at least 6% of the maximum continuous current of the generating system including all operating asynchronous *generating units* (in the absence of a disturbance) for each 1% increase of voltage at the connection point above the relevant range in which a reactive current response must commence, as identified in subparagraph (g)(1), with the performance standards to record the required response agreed with the *Network Operator* and *Power System Controller*,

during the disturbance and maintained until connection point voltage recovers to between 90% and 110% of normal voltage, or such other range agreed with the *Network Operator* and *Power System Controller*, except for voltages below the relevant threshold identified in paragraph (h); and

(2) from 100 milliseconds after clearance of the fault, active power of at least 95% of the level existing just prior to the fault.

(g) For the purpose of paragraph (f):

(1) the generating system must commence a response when the voltage is in an under-voltage range of 85% to 90% or an over-voltage range of 110% to 115% of normal voltage. These ranges may be varied with the agreement of the Network Operator and Power System Controller (provided the magnitude of the range between the upper and lower bounds remains at Δ5%); and

(2) the reactive current response must have a rise time of no greater than 40 milliseconds and a settling time of no greater than 70 milliseconds and must be adequately damped.

(h) Despite paragraph (f), a generating system is not required to provide a capacitive reactive current response in accordance with subparagraph (f)(1)(i) where:

(1) the *generating system* is directly connected to the power system with no step-up or connection transformer; and

(2) voltage at the *connection point* is 5% or lower of normal voltage.

(i) Subject to paragraph (h), despite the amount of reactive current injected or absorbed during voltage disturbances, and subject to thermal limitations and energy source availability, a generating system must make available at all times:

(1) sufficient current to maintain rated apparent power of the *generating system* including all operating *generating units* (in the absence of a disturbance), for all *connection point* voltages above 115% (or otherwise, above the over-voltage range agreed in accordance with subparagraph (g)(1)); and

(2) the maximum continuous current of the *generating system* including all operating *generating units* (in the absence of a disturbance) for all *connection point* voltages below 85% (or otherwise, below the under-voltage range agreed in accordance with subparagraph (g)(1)),

except that the *Network Operator* and *Power System Controller* may agree limits on active current injection where required to maintain power system security and/or the quality of supply to other *Network Users*.

General requirement

All generating systems

(j) The performance standard must include any operational arrangements to ensure the generating system including all operating generating units will meet its agreed performance levels under abnormal network or generating system conditions.

(k) When assessing multiple disturbances, a fault that is re-established following operation of automatic reclose equipment shall be counted as a separate disturbance.

(l) The performance standard must specify the cumulative time thresholds for which the generating system can remain in continuous operation for a sequence of disturbances consistent with 3.3.5.5(c) and (d). The standard must record the cumulative time with voltage at the connection point lower than 80% of *normal voltage* and the cumulative time with voltage at the connection point lower than 90% of *normal voltage*.

Asynchronous generating systems

(m) For the purpose of paragraph (f):

(1) the reactive current contribution may be limited to the maximum continuous current of a *generating system*, including its operating asynchronous *generating units*;

(2) the reactive current contribution and *voltage* deviation described may be measured at a location other than the *connection point* (including within the relevant *generating system*) where agreed with the *Network Operator* and *Power System Controller*, in which case the level of injection and absorption will be assessed at that agreed location;

(3) the reactive current contribution required may be calculated using phase to phase, phase to ground or sequence components of *voltages*. The ratio of the negative sequence to positive sequence components of the reactive current contribution must be agreed with the *Network Operator* and *Power System Controller* for the types of disturbances listed in this clause 3.3.5.5; and

(4) the performance standards must record all conditions (which may include temperature) considered relevant by the *Network Operator* and *Power System Controller* under which the reactive current response is required.

Synchronous generating systems and units

(n) For a generating system comprised solely of synchronous generating units, the reactive current contribution may be limited to 250% of the maximum continuous current of the generating system.

(o) For a synchronous generating unit within a generating system (other than a generating system described in paragraph (m)), the reactive current contribution may be limited to 250% of the maximum continuous current of that synchronous generating unit.

The following definitions are to be added to the glossary of terms in Attachment 1 of the NTC:

continuous uninterrupted operation

In respect of a generating system or generating unit operating immediately prior to a power system disturbance:

(a) not disconnecting from the power system except under its performance standards established under clauses 3.3.5.8 and 3.3.5.9;

(b) during the disturbance contributing active and reactive current as required by its performance standards established under clause 3.3.5.5;

(c) after clearance of any electrical fault that caused the disturbance, only substantially varying its active power and reactive power as required or permitted by its performance standards established under clauses 3.3.5.5, 3.3.5.11, 3.3.5.13 and 3.3.5.14; and

(d) not exacerbating or prolonging the disturbance or causing a subsequent disturbance for other connected plant, except as required or permitted by its performance standards,

with all essential auxiliary and reactive plant remaining in service.

transmission system

A *transmission network*, together with the *connection assets* associated with the *transmission network*, which is *connected* to another *transmission* or *distribution system*.

NTC Clause 3.3.5.6 – Quality of Electricity Generated and Continuous Uninterrupted Operation

Discussion and Final Decision

In this clause, the proposed revisions to the NTC introduce an automatic access standard that is equivalent to the minimum standard in the NT NER, noting this NT NER provision is not currently in effect. The NT NER expects the minimum standard is achieved in all cases, limiting scope for negotiation.

The drafting in the NTC suggests the opportunity to negotiate a lower level of performance might exist. While the potential exists for generators to seek to negotiate access levels lower than the automatic, the commission understands that it is unlikely that generators will find it difficult or expensive to comply with this automatic access standard and are therefore unlikely to try to negotiate a lower access standard.

The commission agrees with GHD, that the access standard proposed by PWC provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

No concerns were raised in submissions to the commission in relation to this clause.

The commission does not require any changes to the wording proposed by PWC.

NTC Clause 3.3.5.7 – Partial Load Rejection

Discussion and Final Decision

In this clause the proposed revisions to the NTC introduce an automatic access standard that is more onerous than that specified in the NT NER in terms of the size of load rejection (50% versus 30%) and the duration over which the load rejection occurs (0.5 seconds versus 10 seconds), noting this NT NER provision is not currently in effect.

PWC's proposed drafting is consistent with the higher RoCoF ride through limit of 4Hz per second and the more aggressive droop response specified in NTC 3.3.5.11.

GHD's advice to the commission is that the wording proposed by PWC is appropriate given the Territory power systems lack interconnection to stronger networks and are expecting to experience connection of significant levels of asynchronous generation offering little inertia.

Further, GHD advise that it is satisfied that the access standard proposed by PWC provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered. Accordingly, the commission supports that proposed by PWC in this clause, noting no concerns were raised in submissions to the commission in relation to this clause in the Draft Decision.

While no wording changes are required, some formatting changes are needed to correctly italicise terms as set out below.

Final Decision NTC wording

Clause 3.3.5.7

> The *automatic access standard* is a *generating system* shall be capable of *continuous uninterrupted operation,* during and following a load reduction which occurs in less than 0.5 seconds, from a fully or partially loaded condition provided that the load reduction is less than 50% of the generating system's *nameplate rating* and the load remains above minimum load or as otherwise agreed between the Network Operator and the relevant User and stated in the *connection agreement* between them.

NTC Clause 3.3.5.8 – Protection of Generating Units from Power System Disturbances

Discussion and Final Decision

The wording proposed by PWC introduces an automatic access standard, which is set at the same level as the minimum access standard in the NT NER, noting this is currently not in effect. The lack of a minimum standard in the proposed revisions to the NTC, suggests lower than automatic may be acceptable, potentially creating ambiguity as discussed for 3.3.5.6. However, as with 3.3.5.6, the commission is satisfied, based on GHD advice, that generators can normally achieve the level of access specified for the automatic access standard and are therefore unlikely to pursue a lower standard. Accordingly, no change to the wording proposed by PWC was required in the Draft Decision, except for those noted below.

The NT NER requires all generators >30MW to rapidly reduce output by at least half if required to control over-frequency events, noting this obligation is not currently in effect. This is missing from the wording proposed by PWC for this clause.

GHD advises that the over-frequency control of generators would be of high value for Territory power systems and that adding this requirement to the GPS would not add significant additional costs to generator development. Accordingly, the provision is to be added into the NTC. Further, given the much smaller size of the Territory power systems, the commission agrees with GHD, that the 30 MW threshold should be removed, which will mean that the requirement applies to all generators that are large enough to have a GPS.

The reference to emergency control schemes under NTC clause 2.6 is incorrect as clause 2.6 deals with stability. NTC clause 3.2.1.5 allows for the Network Operator to require the installation of emergency controls and would be a more appropriate reference.

The commission is satisfied, based on GHD's advice that the access standard proposed by PWC with the recommended revision is appropriate, as it provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

No concerns were raised in submissions to the commission in relation to this clause.

Final Decision NTC wording

Clause 3.3.5.8

(1) Protection of Generating Units from Power System Disturbances

(a) The automatic access standard is:

(1) subject to paragraph (d), for a *generating system* or any of its *generating units* that is required by a *Generator* or *Network Operator* to be automatically disconnected from the power system in response to abnormal conditions arising from the power system, the relevant protection system or control system must not disconnect the *generating system* for:

(i) conditions for which it must remain in continuous uninterrupted operation; or

(ii) conditions it must withstand under this Code.

(2) a *generating system*, connected to a *network* must have facilities to automatically and rapidly reduce its generation:

(i) by at least half, if the frequency at the *connection point* exceeds a level nominated by the *Network Operator* (not less than the upper limit of the *operational frequency tolerance band*) and the duration above this *frequency* exceeds a value nominated by the *Network Operator* where the reduction may be achieved:

(A) by reducing the output of the *generating system* within 3 seconds, and holding the output at the reduced level until the *frequency* returns to within the *normal operating frequency band*; or

(B) by disconnecting the *generating system* from the *power system* within 1 second; or

(ii) in proportion to the difference between the *frequency* at the *connection point* and a level nominated by the *Network Operator* (not less than the upper limit of the *operational frequency tolerance band*), such that the generation is reduced by at least half, within 3 seconds of the *frequency* reaching the upper limit of the *operational frequency tolerance band*.

(b) The Network Operator or Power System Controller may require that an access standard include a requirement for the generating system to be automatically disconnected by a local or remote control scheme whenever the part of the network to

which it is connected has been disconnected, forming an island that supplies a customer.

(c) The access standard must include specification of conditions for which the generating unit or generating system must trip and must not trip.

(d) Notwithstanding clauses 3.3.5.3, 3.3.5.4, 3.3.5.5, 3.3.5.6 and 3.3.5.7, a generating system may be automatically disconnected from the power system under any of the following conditions:

(3) in accordance with an ancillary services agreement between the Generator and the Network Operator or Power System Controller;

(4) where a load that is not part of the generating system has the same connection point as the generating system and the Network Operator and Power System Controller agree that the disconnection would in effect be under-frequency load shedding;

(5) where the generating system is automatically disconnected under paragraph (a), clause 3.3.5.9 or by an emergency frequency control scheme;

(6) where the generating system is automatically disconnected under clause 3.3.5.10; or

(7) in accordance with an agreement between the Generator and the Network Operator (including an agreement in relation to an emergency control scheme under clause 3.2.1.5 to provide a service that is necessary to maintain or restore power system security in the event of a specified contingency event.)

(e) The Network Operator or Power System Controller is not liable for any loss or damage incurred by the Generator or any other person as a consequence of a fault on either the power system, or within the Generator's facility.

The following definitions need to be added to the glossary of terms in Attachment 1 of the NTC:

generating system

a system comprising one or more *generating units* and includes auxiliary or *reactive plant* that is located on the *Generator's* side of the *connection point* and is necessary for the *generating system* to meet its performance obligations.

operational frequency tolerance band

The range of *frequency* within which the power system is to be operated under abnormal operating conditions as specified in clause 2.2.2 (b).

NTC Clause 3.3.5.9 – Protection Systems that Impact on Power System Security

Discussion and Final Decision

The wording proposed by PWC is consistent with the automatic access standard in the NT NER with the exception of the specified fault clearing times, noting this aspect of the NT NER currently has no effect in the Territory. GHD considers that the proposed fault clearing times are appropriate as they align with the Territory system standards specified in sections 2.9.4 and 2.9.5 of the NTC.

GHD advise that the access standard proposed by PWC is reasonable as it reflects the level of access typically achieved by new generators connecting to the NEM, with clearing times adjusted to reflect those appropriate for Territory power systems. Further, GHD advise that generators connecting to the Territory power systems should be able to meet the proposed access standard. If this is not feasible, the provision of clause 3.3.5 can be applied to negotiate a lower performance standard.

The commission is satisfied, based on GHD's advice that the access standard proposed by PWC is appropriate as it provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

The commission does not require any changes to this clause, noting no concerns were raised in submissions to the commission in relation to this clause.

NTC Clause 3.3.5.10 – Protection to Trip Plant for Unstable Operation

Discussion and Final Decision

The revisions proposed by PWC introduce a requirement for generator protection schemes to trip units that become unstable, with the assessment of stability informed by power system stability guidelines established under clause 16. Clause 16 does not mention the establishment of any guidelines. Clause 16 is titled "Stability criteria". The reference to guidelines should be replaced with criteria.

The NT NER states that power system stability guidelines are established in accordance with clause 4.3.4(h). However, this provision is not currently in effect, and clause 4.3.4(h) does not exist in the NT NER. In the NEM, AEMO is allocated the responsibility for producing power system stability guidelines via NER 4.3.4(h).

NER clause 4.3.4(h) states that AEMO must develop, and may amend, guidelines for power system stability but only in consultation with Registered Participants in accordance with the Rules consultation procedures, and must publish the guidelines for power system stability.

In all other respects the wording proposed by PWC reflects the automatic access standard in the NT NER. The commission agrees with GHD, that the access standard proposed by PWC is reasonable, as it reflects the level of access typically achieved by new generators connecting to the NEM and can readily be met by generators and assists in maintaining stable operation of the power system.

The commission agrees with GHD, that the access standard proposed by PWC with the revision below is appropriate as it provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

No concerns were raised in submissions to the commission in relation to this clause.

Final Decision NTC wording

(a) The automatic access standard is a generating system must have:

(1) for its synchronous generating units, a protection system to disconnect it promptly when a condition that would lead to pole slipping is detected, to prevent pole slipping or other conditions where a generating unit causes active power, reactive power or voltage at the connection point to become unstable as assessed in accordance with the power system stability criteria established under clause 16; and

(2) for its asynchronous generating units, a protection system to disconnect it promptly for conditions where the active power, reactive power or voltage at the connection point becomes unstable as assessed in accordance with the guidelines for power system stability established under clause 16.

NTC Clause 3.3.5.11 – Frequency Control

Discussion and Final Decision

For this clause, the proposed revisions to the NTC introduce frequency control requirements defined with reference to the maximum and minimum operating level of a generating unit or generating system. These terms are defined in the NT NER but those definitions appear to be missing from the proposed change to the NTC. The definitions in the NT NER should be included in the NTC.

There are two performance standards proposed by PWC in its September 2019 submission that require generators to provide a capability to respond to a disturbance in system frequency. NTC clause 3.3.5.11 requires provision of frequency response similar to the capability typically provided by governing systems on thermal generators. NTC clause 3.3.5.15 requires a much quicker response, mirroring the inertia response and provided by synchronous generators to limit RoCoF and arrest the frequency change following load or generation contingencies. The control systems and settings installed by generators that respond to frequency deviations need to be designed to meet the requirements of both clauses.

The proposed wording for NTC clause 3.3.5.11 included in the Draft Decision reflects requirements similar to the automatic access standard specified in the NT NER for frequency control. The proposed frequency control performance standard requires the provision of a frequency response capability defined by a droop response and dead band, as outlined below:

- the dead band must be settable with the range 0 to 1 Hz which although consistent with the NT NER is very wide for isolated power systems such as those in the NT. The requirement in the West Australian SWIS is a maximum dead band of +/- 0.025 Hz.
- the droop must be settable in the range 1% to 6%. While a 1% droop is quite aggressive for thermal generation it could be achieved by inverter connected systems.

PWC has advised that while the dead band and droop range is quite wide, to meet the performance standards specified in NTC clause 3.3.5.15, generators will need to select a narrow dead band a low droop setting. The commission accepted this view in the Draft Decision, based on GHD advice, and therefore did not require revision to the wording specifying the droop setting and dead band.

The NTC GPS provisions do not require the actual provision of any frequency response, but rather just demonstration of a capability to provide a response consistent with the performance standard. While this is consistent with the current provisions in the NT NER, it does not align with the approach in other jurisdictions. It is inconsistent with AEMO's

expressed desire to re-introduce mandatory frequency response in the NEM[13]. The SWIS generator performance guidelines published by Western Power and AEMO propose 4% droop and +/-0.025Hz dead band be met at all times subject to energy source limitations. GHD advice is that isolated power systems such as those in the Territory would benefit from the adoption of the approach proposed in the SWIS Generator Performance Guidelines by enhancing frequency control for no additional investment in generating plant.

GHD has advised that requiring frequency control capability to be available at all times, subject to energy source limitations is unlikely to add any significant cost to generation developments. Adopting this change would require frequency controls to be commissioned and left in service so that all generators provide frequency response (subject to energy source limitations) following contingencies. Contingencies are rare events hence there is minimal lost revenue from the actual provision of frequency response.

PWC has advised that it would expect all generators to keep their frequency control systems active at all times. PWC noted that provisions in the SCTC achieve this by requiring generators to maintain a normal mode of operation with active droop control (clause 4.2(b)) while the dispatch requirements in the NTC (clause 9.1.1(e)) specify that a generator must not change its frequency response mode without first gaining permission from the Network Operator. The commission agrees that these provisions allow PWC to ensure that generators maintain an active frequency response capability at all times and therefore revisions to the proposed drafting of the GPS for frequency control are not required to achieve this.

The recommended GPS framework and the referenced provisions in the NTC and SCTC mean that all generators (that are required to have a GPS) must provide capability to deliver frequency response consistent with the GPS specified in NTC clauses 3.3.5.11 and 3.3.5.15. Furthermore, all generators must ensure that a frequency response in accordance with their GPS is available at all times, subject to energy source availability. These requirements apply to all generators not just TGen, which is the current provider of frequency control ancillary services.

PWC's proposed drafting of sub-clause (b) may be interpreted as requiring the generator to be able to increase output in response to a reduction in frequency. Renewable generators will not be able to achieve this capability under most conditions as their output is dependent on energy source availability. Accordingly, the Draft Decision proposed that this requirement be clarified as being subject to energy source availability.

PWC has proposed amending SCTC clause 4.3(a) by adding sub-clause (7) to clarify that scheduling any ancillary services from generators other than TGen should not result in a reduced dispatch level. It would be inconsistent with this clause for PWC to constrain off renewable generators to increase the frequency response capability they deliver.

[13] Details of the AEMO request can be found on the AEMC website, https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response

Further PWC proposed revisions and issues raised in submissions

In response to the commission's Draft Decision, PWC raised the following concerns with the inclusion of the phrase "subject to energy source availability" in sub-clause 3.3.5.11(b)(1) and (b)(2):

- the inclusion of the phrase in sub-clause (b)(1) is unnecessary as the clause only requires that a generator does not respond in a manner that works against the restoration of power system frequency (e.g. raising output in response to a rise in frequency). Further, it is inconsistent with the equivalent clause in NT NER S5.2.5.11
- the inclusion of the phrase in sub-clause (b)(2) may create confusion (and the unintended introduction of semi-scheduled generation).

In contrast, Jacana Energy welcomes the revisions proposed by the commission to make the provision of frequency response subject to energy source availability. Jacana Energy believes that without this revision and in the absence of an ancillary service market, the frequency control requirements place a significant impost would be placed on new entrant generators.

Eni's submission endorses the commission's approach to making the frequency response requirement subject to energy source availability. Eni expects that PWC's interpretation of this clause will result in no pre-contingent curtailment on solar farms in the DKIS, whether under an automatic or negotiated access standard. Eni believes that any imposition of such a requirement for FCAS or C-FCAS raise capability should be compensated through a mutually acceptable payment for these services. Eni states that it would be a positive step to include some commentary within the clause to that effect.

Eni does not support the adoption of the approach proposed by PWC in its latest submission, to replace "subject to energy source availability" with "subject to energy source availability as determined in capacity forecasts under 3.3.5.17".

NTSF has considered the further revisions suggested by PWC. NTSF assert that the removal of "energy source availability" from sub-clause 3.3.5.11(b)(1) is reasonable but unnecessary. NTSF do not support modifying the wording of sub-clause 3.3.5.11(b)(2) to replace "subject to energy source availability" with "subject to energy source availability as determined in capacity forecasts under 3.3.5.17", as this revision may prevent a generator that can deliver a frequency response from doing so due to its capacity forecast differing from its actual capability. NTSF believe that all generators should try to contribute what they can to maintain the system regardless of their capacity forecast.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

Clause 3.3.5.11(b)(1)

The commission, with GHD, has again reviewed the drafting of clause 3.3.5.11(b)(1), to consider the impact of omitting the phrase "subject to energy source availability". It is noted that with this phrase omitted, the clause specifies the generating system's power transfer to the power system must not change "in response to" a rise or fall in frequency in a manner that would work against arresting any frequency change. The phrase "in response to" and its interpretation is important in assessing whether it is necessary to include the phrase "subject to energy source availability".

GHD's attached report to the commission discusses the implications of a narrow interpretation versus a broader interpretation of the meaning "in response to" and notes that clarity over which interpretation holds is likely to be very important for a generation investor. The narrow interpretation may not require the generator to make any particular investment to meet the performance standard. The second, broader interpretation may require a significant investment in energy storage to avoid any reduction in output coincident with a reduction in frequency.

The commission acknowledges that PWC correctly notes that the phrase, "subject to energy source availability" is not included in clause S5.2.5.11 in the NT NER or the equivalent clause in the NER. However, the frequency control framework applying in the Territory power systems is different to that in the NER, and revisions to the NER to re-introduce mandatory primary frequency response obligations may result in revisions to the frequency control provisions in the NER. Accordingly, GHD's view is that it is reasonable for the drafting in the provision in the NTC to differ from the drafting in the relevant clause in the NT NER.

To provide clarity to ensure that generators will not be required to make investments to comply with a broader interpretation of this clause, GHD does not recommend deleting the phrase "subject to energy source availability" from clause 3.3.5.11(b)(1) as requested by PWC. The commission agrees.

Clause 3.3.5.11(b)(2)

PWC have suggested a revision that replaces the phrase, "subject to energy source availability" with the phrase "subject to energy source availability as determined in capacity forecasts under clause 3.3.5.17". GHD's review found that this proposed addition does not provide any improved clarity. Further, GHD states that it is unclear why including the original revision proposed in the commission's Draft Decision creates confusion or introduces semi-scheduled generation.

Clause 3.3.5.17 specifies the performance standard for capacity forecasting. Clause 3.3.5.11 on the other hand specifies the performance standard for frequency control.

Clause 3.3.5.17 places requirements on a generator to forecast its future capacity accurately meeting the forecast accuracy requirements in Clause 3.3.5.17. Accurately forecasting future capacity will require the generator to attempt to forecast energy source availability. However, the commission notes that any forecast of energy source availability developed to meet the accuracy requirements in 3.3.5.17 will be imperfect.

The inclusion of the phrase "subject to energy source availability" in clause 3.3.5.11(b)(2) means that a generator is not required to deliver the frequency control action specified in the remainder of this sub-clause if there is insufficient energy source availability to do so. The revision proposed by PWC changes the caveat, by qualifying the energy source availability to be that as determined in the capacity forecasts developed to meet the performance standard defined in 3.3.5.17.

The commission agrees with the arguments presented by NTSF, that it is not appropriate to limit the frequency response to be subject to the energy source availability as determined in capacity forecasts under 3.3.5.17. This is on the basis of GHD's advice, that doing so may lead to an unnecessarily complex design of control systems providing frequency response capability and the situation where an imperfect capacity forecast may unnecessarily restrict the frequency response to less than that which could be achieved if the available energy source was fully utilised. Accordingly, the commission does not approve the revision to clause 3.3.5.11(b)(2) proposed by PWC.

Based on that discussed above, the commission requires revised wording consistent with the Draft Decision as set out below to reflect a performance standard that should be able to be achieved without imposing significant additional cost on generators. The commission agrees with GHD, that delivering the performance consistent with the standard will assist in maintaining control of frequency and therefore represents an appropriate balance between generation costs and power system security.

Final Decision NTC wording

Clause 3.3.5.11

3.3.5.11 Frequency Control

(a) For the purpose of this clause 3.3.5.11:

Droop means, in relation to frequency response mode, the percentage change in power system frequency as measured at the connection point, divided by the percentage change in power transfer of the generating system expressed as a percentage of the maximum operating level of the generating system. Droop must be measured at frequencies that are outside the deadband and within the limits of power transfer.

maximum operating level means in relation to:

(1) a *generating unit*, the maximum sent out *generation* consistent with its *nameplate rating* to which it may be dispatched*;* and
(2) a *generating system*, the combined maximum sent out *generation* to which its in-service *generating units* may be dispatched.

minimum operating level means in relation to:

(1) a *generating unit*, its minimum sent out *generation* for continuous stable operation;
(2) a *generating system*, the combined minimum sent out *generation* of its in-service *generating units*.

(b) The automatic access standard is:

(1) subject to energy source availability a *generating system's* power transfer to the power system must not:

(i) increase in response to a rise in the frequency of the power system as measured at the connection point; or
(ii) decrease in response to a fall in the frequency of the power system as measured at the connection point; and

(2) subject to energy source availability a *generating system* must be capable of operating in frequency response mode such that it automatically provides a proportional:

(i) decrease in power transfer to the power system in response to a rise in the frequency of the power system as measured at the connection point; and

(ii) increase in power transfer to the power system in response to a fall in the frequency of the power system as measured at the connection point,

sufficiently rapidly and sustained for a sufficient period for the *Generator* to be in a position to offer measurable amounts of all ancillary services for the provision of power system frequency control.

(c) Each control system used to satisfy this clause 3.3.5.11 must be adequately damped.

(d) The amount of a relevant market ancillary service for which the plant may be registered must not exceed the amount that would be consistent with the performance standard registered in respect of this requirement.

(e) For the purposes of subparagraph (b)(2):

(1) the change in power transfer to the power system must occur with no delay beyond that required for stable operation, or inherent in the plant controls, once the frequency of the power system as measured at the connection point leaves a deadband around 50 Hz;

(2) a generating system must be capable of setting the deadband and droop within the following ranges:

(i) the deadband referred to in subparagraph (1) must be set within the range of 0 to ± 1.0 Hz. Different deadband settings may be applied for a rise or fall in the frequency of the power system as measured at the connection point; and
(ii) the droop must be settable within the range of 1% to 6%, or such other settings as agreed with the *Network Operator* and *Power System Controller*;

(3) nothing in subparagraph (b)(2) is taken to require a *generating system* to operate below its minimum operating level in response to a rise in the frequency of the power system as measured at the connection point, or above its maximum operating level in response to a fall in the frequency of the power system as measured at the connection point; and

(4) the performance standards must record:

(i) agreed values for maximum operating level and minimum operating level, and where relevant the method of determining the values, and the values for a generating system must take into account its in-service generating units; and
(ii) for the purpose of subparagraph (b)(2), the market ancillary services, including the performance parameters and requirements that apply to each such market ancillary service.

NTC Clause 3.3.5.12 – Impact on Network Capability

Discussion and Final Decision

The proposed automatic standard aligns with the automatic access standards in the NT NER, noting the relevant provisions are not currently in effect.

The NT NER drafting includes guidance on specific matters to consider when negotiating a standard lower than automatic. This information is not included in the proposed wording for

the NTC clause. Parties wishing to negotiate a standard lower than the automatic may benefit from referring to this guidance available in the NT NER.

The minimum standard in the NT NER allows for a generation connection to proceed even if it reduces transfer limits as long as the reduced limit does not impede the ability to supply customer load. There may be circumstances where such a relaxation of the automatic access standard is appropriate in the Territory power systems.

The NT NER requires that the performance standard include details of any control systems installed to achieve the access standard. This provision should be added to the NTC drafting:

> "A negotiated access standard under this clause S5.2.5.12 must detail the plant capabilities, control systems and operational arrangements that will be maintained by the Generator, notwithstanding that change to the power system, but not changes to the generating system, may reduce the efficacy of the plant capabilities, control systems and operational arrangements over time."

The NT NER also provides for the NSP to negotiate commercial terms for the generator to install controls that would enhance transfer limits. There is no similar provision in the NTC drafting, however NTC clauses 13.8 and 13.9 require non-network options be considered as alternatives to network investments, which is arguably sufficient. For this reason GHD has not recommended any wording changes to address this matter. This was reflected in the commission's Draft Decision.

Issues raised in submissions

Eni's submission expresses concern regarding the ability of generators to negotiate access standards with PWC that are lower than the automatic access standard. Eni considers that a generator should be able to negotiate a standard even if it reduces transfer limits, as long as the reduced limit does not impede the ability to supply customer load. Eni states that no justification has been provided for removing this standard from the NT NER. It states that if new loads, at a later date eventuate, that require modification to generator control systems to release the transfer capacity that they have utilised, then the Network Provider should be required to negotiate suitable control system solutions with generators to do so, rather than the other way around.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

It is accepted that PWC will have greater knowledge of the capability of the Territory's power systems than connecting generators and this knowledge asymmetry may impede the ability of generators to negotiate performance standards set at levels which are less onerous than the automatic access standard. To address issue, in the Draft Decision, the commission extended clause 3.3.5 imposing specific requirements on PWC to provide detailed reasons for rejecting any proposed performance standard. This commission agrees with GHD, that including these additional requirements in the Final Decision should be sufficient to address the concern raised by Eni.

GHD advises that in most instances achieving the level of performance specified in the wording proposed by PWC should not add significant cost to generators. The commission is satisfied, based on GHD's advice that the access standard proposed by PWC with the revision below is reasonable, as it provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

Final Decision NTC wording

Clause 3.3.5.12

(a) The automatic access standard is a *generating system* must have plant capabilities and control systems that are sufficient so that when connected it does not reduce any intra-regional power transfer capability below the level that would apply if the *generating system* were not connected.

A *negotiated access standard* under this clause 3.3.5.12 must detail the *plant* capabilities, *control systems* and operational arrangements that will be maintained by the *Generator*, notwithstanding that change to the *power system*, but not changes to the *generating system*, may reduce the efficacy of the *plant* capabilities, *control systems* and operational arrangements over time.

NTC Clause 3.3.5.13 – Voltage and Reactive Power Control

Discussion and Final Decision

No specific guidance is provided for negotiation of standards below automatic. Such guidance is offered in the NT NER, noting it is not currently in effect. Parties wishing to negotiate a standard lower than the automatic may benefit from referring to this indicative guidance available in the NT NER.

The commission notes that various terms are either poorly defined or misused in the proposed drafting, creating potential ambiguity, such as:

- “rotating rectifier” is used but not defined;
- the definition for “static excitation system” in the glossary is not consistent with the definition in the NT NER as it does not differentiate between static systems and rotating rectifiers.

Clause 3.3.5.13(a)(2) refers to excitation control systems as a collective term applicable to all forms of generation. This is not appropriate as inverter connected generating systems have no excitation system.

The NT NER S5.2.5.13(b)(1) requires that all generating systems provide plant capabilities and control systems sufficient to ensure stable operation from the perspective of oscillatory stability, noting this is not currently in effect. NTC clause 3.3.5.13(a)(1)(iii) attempts to impose similar but not identical provisions on synchronous generators. There are no provisions in the proposed GPS revisions to the NTC that impose these obligations on non-synchronous generation. The proposed clause 3.3.5.13(a)(1)(iii) should be deleted and the wording from the NT NER included to address this issue. The commission notes that oscillatory behaviour at solar farms in Western Victoria is currently creating system security concerns in the NEM. This underlines the importance of having all large generators designed to avoid introducing oscillatory stability issues.

The NT NER S5.2.5.13(b)(2) requires that all control systems incorporate adequate disturbance monitoring and testing facilities, noting this is not currently in effect. GHD advises that continuous high speed monitoring is the most cost effective means of assessing ongoing generator compliance with performance standards and the technology is not an expensive addition to new generating system. The commission therefore considers that a similar requirement should be included in the NTC.

The NT NER S5.2.5.13(b)(2A) requires all generating systems have the capability to control voltage, reactive power or power factor and the ability to switch between control modes,

noting this is not currently in effect. This requirement is missing from the proposed revisions to the NTC. The proposed revisions require a single control mode agreed with the Network Operator. Experience elsewhere suggests this approach is likely to be sufficient and no change from the proposed drafting is considered necessary.

Much of the wording of this clause is significantly different to the NT NER, however many of the technical requirements expressed are similar and consistent with current Territory regulations and therefore no change is considered necessary as they reflect current practice for connection of generators to Territory power systems.

The required range for the voltage and reactive power set point values are not well defined. There are some technical requirements that differ and revisions to the proposed drafting is necessary to address these:

- NT NER voltage set point range – 95% to 105% for all generating systems, whereas NTC revisions only specify an upper limit for synchronous generating systems and no limits for non-synchronous systems;
- NT NER specifies performance requirements for limiters in S5.2.5.13(h). Those requirements are missing from the NTC and should be included.

Further PWC proposed revisions and issues raised in submissions

In response to the commission's Draft Decision, PWC proposed further revisions to this clause to replace the term "registered participants" with the term Users on the basis that registered participants are not defined in the Territory power systems.

Eni's submission has raised concerns that the requirement for continuous monitoring is an arduous requirement and should be removed.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

GHD reviewed the revisions proposed by PWC and has recommended that the revisions be adopted, as they will improve clarity. The commission agrees with these revisions:

- replacing the term *registered participants* with the term *Users* in sub-clause 3.3.5.13(b)(1)(iii)
- deleting the word synchronous from the first line of sub-clause 3.3.5.13(b)(2).

Further, it is noted that the first sentence of sub-clause 3.3.5.13(b)(2) states, "The excitation control system of a synchronous *generating unit* shall be capable of:" with the dot points that follow specifying various requirements to be met by synchronous and non-synchronous generator control systems. Inverter connected non-synchronous generators such as solar farms do not have excitation control systems and to reduce the risk of confusion, the commission agrees with GHD, that the word excitation be deleted from the first sentence in sub-clause 3.3.5.13(b)(2).

In relation to Eni's concerns, that the requirement for continuous monitoring is an arduous requirement and should be removed, the commission notes that this requirement reflects the provisions in the automatic access standard for the relevant requirement specified in the NER. This requirement encourages the installation of monitoring equipment which would be useful in confirming the ongoing compliance of the generator with its performance standards and would therefore help address the compliance obligation specified in clause 5.4 (d) of the NTC. GHD has advised that the concerns raised by Eni could be resolved by agreeing the

configuration settings for the recorder with PWC. This would also help to satisfy the obligation expressed in NTC clause 5.4(d). On this basis, no further revision is considered necessary.

The Final Decision wording below is consistent with GHD's recommendation, including advice that achieving the level of performance specified in the revised wording should not add significant cost to generators compared to that faced historically to connect to the Territory power systems.

The commission is satisfied, based on GHD advice, that the access standard recommended is appropriate as it provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

Final Decision NTC wording

Clause 3.3.5.13

(a) For the purpose of this clause 3.3.5.13:

> **static excitation system** means in relation to a *synchronous generating unit*, an *excitation control system* that does not use rotating machinery to produce the field current.

(b) The voltage and reactive power control automatic access standard is:

(1) The *excitation control system* of a *synchronous generating unit* shall be capable of:

(i) limiting *generating unit* operation at all *load* levels to within *generating unit* capabilities for continuous operation;

(ii) controlling the *generating unit* output to maintain the short-time average *generating unit* output voltage at highest rated level (which shall be from a maximum of 5% below the nominal output voltage to at least 5% above the nominal output voltage and is usually 10% above the nominal output voltage);

(iii) ensuring that plant capabilities and control systems are sufficient such that:

a. power system oscillations, for the frequencies of oscillation of the generating unit against any other generating unit, are adequately damped;

b. operation of the generating system does not degrade the damping of any critical mode of oscillation of the power system; and

c. operation of the generating system does not cause instability (including hunting of tap-changing transformer control systems) that would adversely impact other *Users*.

(iv) in the case of a rotating synchronous generator, the five second ceiling excitation voltage shall be at least twice the excitation voltage required to achieve maximum continuous rating at nominal voltage; and

(v) providing reactive current compensation settable for boost or droop unless otherwise agreed by the *Network Operator*.

(2) The ~~excitation~~ control system of a *generating unit* shall be capable of:

(i) New synchronous *generating units* shall be fitted with fast acting excitation control systems. AC exciter, rotating rectifier or static excitation systems shall be provided for any new *generating units* with a rating greater than 10 MW or for new smaller *generating units* within a power station totalling in excess of 10 MW. Excitation control systems shall provide voltage regulation to within 0.5% of the selected set point value.

(ii) New non-synchronous *generating units* must be fitted with fast acting voltage and / or reactive power control systems, which must utilise modern technology and be approved by the *Network Operator*. Control systems must provide regulation to within 0.5% of the selected set point value.

(iii) Unless agreed by the *Network Operator*, new synchronous *generating units* shall incorporate power system stabiliser circuits that modulate *generating unit* field voltage in response to changes in power output and/or shaft speed and/or any other equivalent input signal approved by the *Network Operator*. The stabilising circuits shall be responsive and adjustable over a frequency range that shall include frequencies from 0.1 Hz to 2.5 Hz.

(iv) The *Network Operator* may require power system stabiliser circuits on synchronous *generating units* with ratings less than or equal to 10 MW or smaller synchronous *generating units* within a power station with a total active power output capability less than or equal to 10 MW (if power system simulations indicate a need for such a requirement). Before commissioning of any power system stabiliser, the *Generator* must propose preliminary settings for the power system stabiliser, which must be approved by the *Network Operator*.

(v) Power system stabilisers may also be required for non-synchronous *generating units*. The performance characteristics of these *generating units* with respect to power system stability must be similar to those required for synchronous *generating units*. The requirement for a power system stabiliser and its structure and settings will be determined by the *Network Operator* from power system simulations.

(vi) Before commissioning of any power system stabiliser, its preliminary settings shall be agreed by the *Network Operator*. The User shall propose these preliminary settings that should be derived from system simulation studies and the study results reviewed by the *Network Operator*.

(vii) The performance characteristics set out in Figure 7 are required for AC exciter, rotating rectifier and static excitation systems.

Figure 7 – *Synchronous Generator* excitation system performance requirements

Performance Item	Units	Static Excitation	A.C. Exciter or Rotating Rectifier	Notes
***Sensitivity*:** A sustained 0.5% error between the *voltage* reference and the sensed *voltage* will produce an excitation *change* of not less than 1.0 per unit.	Open loop gain (ratio)	200 minimum	200 minimum	1
Field *voltage* rise *time*: *Time* for field *voltage* to rise from rated *voltage* to excitation ceiling *voltage* following the application of a short duration impulse to the *voltage* reference.	second	0.05 maximum	0.5 maximum	2
Settling *time* with the *Generator synchronised* following a disturbance equivalent to a 5% step *change* in the sensed *Generator* terminal *voltage*.	second	2.5 maximum	5 maximum	3
Settling *time* with the *Generator unsynchronised* following a disturbance equivalent to a 5% step *change* in the sensed *Generator* terminal *voltage*. Shall be met at all operating points within the *Generator* capability.	second	1.5 maximum	2.5 maximum	3
Settling *time* following any disturbance that causes an excitation limiter to operate.	second	5 maximum	5 maximum	3

Notes:

1. One per unit is that field *voltage* required to produce nominal *voltage* on the air gap line of the *Generator* open circuit characteristic (Refer IEEE Standard 115-1983 – Test Procedures for Synchronous Machines).
2. Rated field *voltage* is that *voltage* required to give nominal *Generator* terminal *voltage* when the *Generator* is operating at its maximum continuous rating. Rise *time* is defined as the *time* taken for the field voltage to rise from 10% to 90% of the increment value.
3. Settling time is defined as the time taken for the Generator terminal voltage to settle and stay within an error band of ±10% of its increment value.

(viii) The performance characteristics required for the voltage or reactive power control systems of all non-synchronous *generating units* are specified in Figure 8.

Figure 8 – *Non-synchronous Generator voltage* or *reactive power* control *system* performance requirements

Performance Item	Units	Limiting Value	Notes
***Sensitivity*:** A sustained 0.5% error between the reference *voltage* and the sensed *voltage* must produce an output change of not less than 100% of the *reactive power generation* capability of the generating unit, measured at the point of control.	Open loop gain (ratio)	200 minimum	1
Rise time: Time for the controlled parameter (*voltage* or *reactive power* output) to rise from the initial value to 90% of the change between the initial value and the final value following the application of a 5% step change to the *control system* reference.	second	1.5 maximum	2
Small disturbance settling time Settling time of the controlled parameter with the *generating unit* connected to the *transmission or distribution network* following a step change in the *control system* reference that is not large enough to cause saturation of the controlled output parameter. Must be met at all operating points within the *generating unit's* capability.	second	2.5 maximum	3
Large disturbance settling time Settling time of the controlled parameter following a large disturbance, including a *transmission or distribution network* fault, which would cause the maximum value of the controlled output parameter to be just exceeded.	second	5 maximum	3
Notes: 1. A control system with both proportional and integral actions must be capable of achieving a minimum equivalent gain of 200. 2. The controlled parameter and the point where the parameter is to be measured must be agreed and included in the relevant *connection agreement*.			

3. Settling time is defined as the time taken for the controlled parameter to settle and stay within an error band of ±10% of its increment value.

(ix) The *Network Operator* shall approve the structure and parameter settings of all components of the excitation control system, including the voltage regulator, power system stabiliser, power amplifiers and all excitation limiters.

(x) The structure and settings of the excitation control system shall not be changed, corrected or adjusted in any manner without prior written notification to the *Network Operator*. The *Network Operator* may require *generating unit* tests to demonstrate compliance with the requirements of Figure 7 or Figure 8. The *Network Operator* may witness such tests.

(xi) Settings may require alteration from time to time as advised by the *Network Operator or Power System Controller*. The cost of altering the settings and verifying subsequent performance shall be borne by the User, provided alterations are not made more than once in each 18 months for each *generating unit*. If more frequent changes are requested the person making that request shall pay all costs on that occasion.

(xii) Excitation limiters shall be provided for under excitation and over excitation and may be provided for voltage to frequency ratio. The *generating unit* shall be capable of stable operation for indefinite periods while under the control of any excitation limiter. Excitation limiters shall not detract from the performance of any power system stabiliser or power oscillation damping capability and shall have settings applied which are co-ordinated with all protection systems.

(3) a control system must have:

(i) for the purposes of disturbance monitoring and testing, permanently installed and operational, monitoring and recording facilities for key variables including each input and output; and

(ii) facilities for testing the control system sufficient to establish its dynamic operational characteristics.

The following definition needs to be added to the glossary of terms in Attachment 1 to the NTC:

rotating rectifier

A type of brushless excitation system for a *synchronous generating unit*.

NTC Clause 3.3.5.14 – Active Power Control

Discussion and Final Decision

No specific guidance is provided for negotiation of standards below automatic. However, guidance for negotiation is offered in NT NER, noting it is not currently in effect. Parties wishing to negotiate a standard lower than the automatic may benefit from referring to this indicative guidance available in the NT NER.

The wording for the NTC clause proposed by PWC specifies a minimum ramping rate (at least 5% of nameplate per minute). The NT NER only requires that ramping be done linearly from one dispatch target to another. The proposed wording for the NTC clause is acceptable, noting the linear ramping requirement in the NT NER (which is not in effect) reflects characteristics of the NEM dispatch system and need not be replicated in Territory power systems.

NT NER specifies differing requirements for scheduled, semi-scheduled and non-scheduled generators and the automatic standard in the NT NER specifies that requirements are subject to energy source availability for generating units that are not scheduled. The lack of recognition of energy source availability in the NTC creates ambiguity regarding whether the required capability is to be delivered under all conditions.

Accordingly, the Draft Decision was that the requirements should be qualified to be subject to energy source availability.

Further PWC proposed revisions and issues raised in submissions

While accepting the need for greater clarity, PWC has proposed further revisions to this clause to clarify this matter and the relationship between the capacity forecasting requirement specified in 3.3.5.17 and the active power control requirement specified in this clause.

PWC is seeking, through the changes proposed, to ensure that the proposed introductory reference to energy source availability does not undermine the requirement to maintain a scheduled generator outcome for the NT.

Eni's submission supports the inclusion of "subject to energy source availability" in this clause as proposed in the commission's Draft Decision. Eni does not support the revisions proposed by PWC as they would link the active power requirement to the capacity forecasting requirement specified in NTC clause 3.3.5.17.

NTSF also does not support one of the revisions proposed by PWC, namely the recommendation that the words "subject to energy source availability" in clause 3.3.5.14(a) be replaced with the words "subject to energy source availability as determined in capacity forecast under clause 3.3.5.17". NTSF is concerned that such a change would remove the flexibility for System Control. Specifically, that the revision would prevent system control from issuing a generator with a dispatch instruction which exceeds its capacity forecast even in the situation where the actual energy source availability would allow dispatch to a higher output.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

GHD has considered the revisions proposed by PWC and, based on its recommendation, the commission accepts those revisions except for the change to Draft Decision clause 3.3.5.14(a) that would replace the caveat "subject to energy source availability" with the

caveat “subject to energy source availability as determined in capacity forecast under clause 3.3.5.17”. Consistent with NTSF’s argument, this change is not considered prudent, as it may prevent System Control from being able to issue a dispatch instruction which would fully utilise the capacity available from a generator.

GHD recommends that clause (f) proposed by PWC be adopted and modified slightly to ensure clause (e) is considered, which the commission supports.

The commission has accepted the remainder of the revisions proposed by PWC as they provide greater clarity regarding the performance requirements for capacity forecasts and active power control. As advised by GHD, they seek to relocate some of the performance criteria that more directly apply to active power control capability from 3.3.5.17, and do not materially change the costs to connecting parties.

Final Decision NTC wording

(a) Subject to energy source availability, the active power control automatic access standard is a *generating system* must have an active power control system capable of:

(i) Maintaining and changing its active power output in accordance with its dispatch instructions to the accuracy specified in paragraph (f); and

(ii) Receiving and automatically responding to AGC signals as updated (nominal update rate of once per four seconds)

(b) Each control system used to satisfy the requirements of paragraph (a) must be adequately damped.

(c) Settings may require alteration from time to time as advised by the *Network Operator or Power System Controller*. The cost of altering the settings and verifying subsequent performance shall be borne by the User, provided alterations are not made more than once in each 18 months for each *generating unit*. If more frequent changes are requested the person making that request shall pay all costs on that occasion.

(d) A *generating system* must be capable of ramping its active power output linearly at a rate not slower than 5% of nameplate rating per minute

(e) ~~Forecasts may differ from the firm offer, and actual capacity may differ from the dispatch capacity~~ *Active power* output of the generating system may differ from *dispatch* instructions as a result of actions to correct system *frequency* in accordance with other provisions of this *Code*.

(f) The *active power* output of the *generating system* must be within +/-0.5% of the *dispatch* instructions subject to clause 3.3.5.14(e), the firm offer in clause 3.3.5.17 and plant ramp rates.

NTC Clause 3.3.5.15 – Inertia and Contingency FCAS

Discussion and Final Decision

The proposed changes to the NTC introduce a requirement for generators to be capable of providing a combination of inertia and contingency frequency control ancillary services (C- FCAS) capability. Neither term is defined sufficiently in the NTC for generators to be able to assess their ability to meet the automatic access standard.

PWC's proposed drafting requires the specifications and evaluation framework in the SSG to be used by the Power System Controller to provide accreditation of a generating system's C-FCAS and inertia capability. While the commission does not have a role in reviewing or approving the SSG, the content of the guidelines will dictate whether this performance standard as drafted is acceptable.

The version of SSG provided by PWC lacks sufficient detail to allow a generation developer to assess the level of C-FCAS their plant would be assessed as providing. This gap should be addressed by PWC in subsequent drafts of the SSG.

The lack of detail in the SSG will impede a generator's ability to understand the investment required to achieve a C-FCAS performance level. GHD's report recommends that the SSG specify precisely how the C-FCAS capability provided by a generator will be assessed. The commission agrees and for clarity considers that worked examples illustrating the calculation for a solar farm providing no inertia and a synchronous generator providing inertia should be provided.

The PWC submission suggests that generators must be capable of providing C-FCAS in the raise and lower direction subject to energy supply limitations, however the proposed drafting does not provide certainty regarding the requirement. Accordingly, the Draft Decision proposed that sub-clause (a)(1) be altered to:

> "A generating system must have an adequate inertia and contingency FCAS capability as defined by the characteristic below. Subject to energy source availability, the generating system must be able operate at a real power output that will deliver inertia and contingency FCAS capability within the adequate zone as shown. The required capability can be achieved by any combination of partially loaded generating unit(s), and/or additional plant (e.g. synchronous condensers, energy storage system, etc.)."

The amendment provides clarity for generators that there is no expectation that they provide contingency FCAS capability if there is insufficient energy source availability (i.e. insufficient sunlight to achieve an increase in output). However they do not provide any clarity for the generators regarding the conditions under which PWC may choose to constrain their output to provide increase raise contingency FCAS capability.

As noted earlier in this paper, this matter has been raised with PWC who confirmed that there is no intention to constrain renewable generation if sufficient contingency raise FCAS is available from other generation sources. Revisions proposed to the SCTC clause 4.3(a) clarify this position. PWC expects that under most conditions contingency raise capability will be provided by head room available on thermal generators. During periods of high solar generation thermal generators will be operating at reduced output, which should provide sufficient raise capability.

PWC expects that the Power System Controller and Network Operator will not constrain the real power output of a generating system to increase the available contingency FCAS response unless there is an ancillary service agreement in place with the generator that provides for such action.

GHD's review of the relevant provisions of the SCTC and the NTC defining dispatch requirements, the revisions proposed to clause 4.3(a) of the SCTC and recommended revisions to the NTC to introduce GPS, has confirmed that the proposed regulations as a whole supports the advice provided by PWC and it is therefore unlikely that a renewable generator will be constrained off to provide additional contingency frequency response capability.

Renewable generators will be expected to provide contingency lower FCAS under most conditions. This should not impose a significant cost on generators, as in the absence of any contingency there is no constraint on the output of the generator. Contingencies are rare events hence there is minimal lost revenue from the actual provision of frequency response following a load contingency.

The revised wording in the commission's Draft Decision sought to provide greater clarity regarding the C-FCAS requirement which should be able to be met by generators without significant additional capital cost and without significant levels of constrained operation, based on GHD's advice.

Further PWC proposed revisions and issues raised in submissions

In response to the Draft Decision, PWC has suggested a similar revision to 3.3.5.15 to that proposed for 3.3.5.11(b)(2).

Eni's submission requests that the wording of this clause be reviewed to give clear effect to the intent expressed in the explanatory note that no pre-contingency curtailment of solar farms to supply C-FCAS raise services will occur in the absence of an ancillary services agreement that the generator has freely consented to.

Further, Eni does not support the revision proposed by PWC to replace the words "subject to energy source availability, with "subject to energy source availability as determined in capacity forecasts under clause 3.3.5.17".

NTSF's submission does not support the revision proposed by PWC to replace the words "subject to energy source availability, with "subject to energy source availability as determined in capacity forecasts under clause 3.3.5.17". NTSF believes that adopting this revision would unnecessarily limit the generators ability to provide C-FCAS response to its capacity forecast even if the actual energy source availability would allow a greater response.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission agrees with NTSF's concerns that adopting PWC's proposed revision may unnecessarily limit the generators ability to provide C-FCAS response to its capacity forecast even if the actual energy source availability would allow a greater response.

In relation to the additional concern raised by Eni, the commission considers this was adequately considered in making the Draft Decision and does not consider any additional revision is needed.

The commission is satisfied, based on GHD's advice, that the access standard proposed by PWC in September 2019 with the revision below, which is consistent with the Draft Decision without further revision, is appropriate as it provides an appropriate balance between costs imposed on generators in meeting the standards and the system security benefit delivered.

The commission recommends that revisions to the SSG are made to better clarify how the C-FCAS capability will be assessed, as this will assist generators in designing the control systems they implement to respond to changes in system frequency.

The continual provision of lower contingency FCAS capability by renewable generators means that it is important that adjustments are made to the capacity forecasting GPS to make sure that departing from a forecast dispatch target to correct frequency is not

penalised. Wording changes for this issue are covered under clause 3.3.5.17, which is discussed later in this report.

Final Decision NTC wording

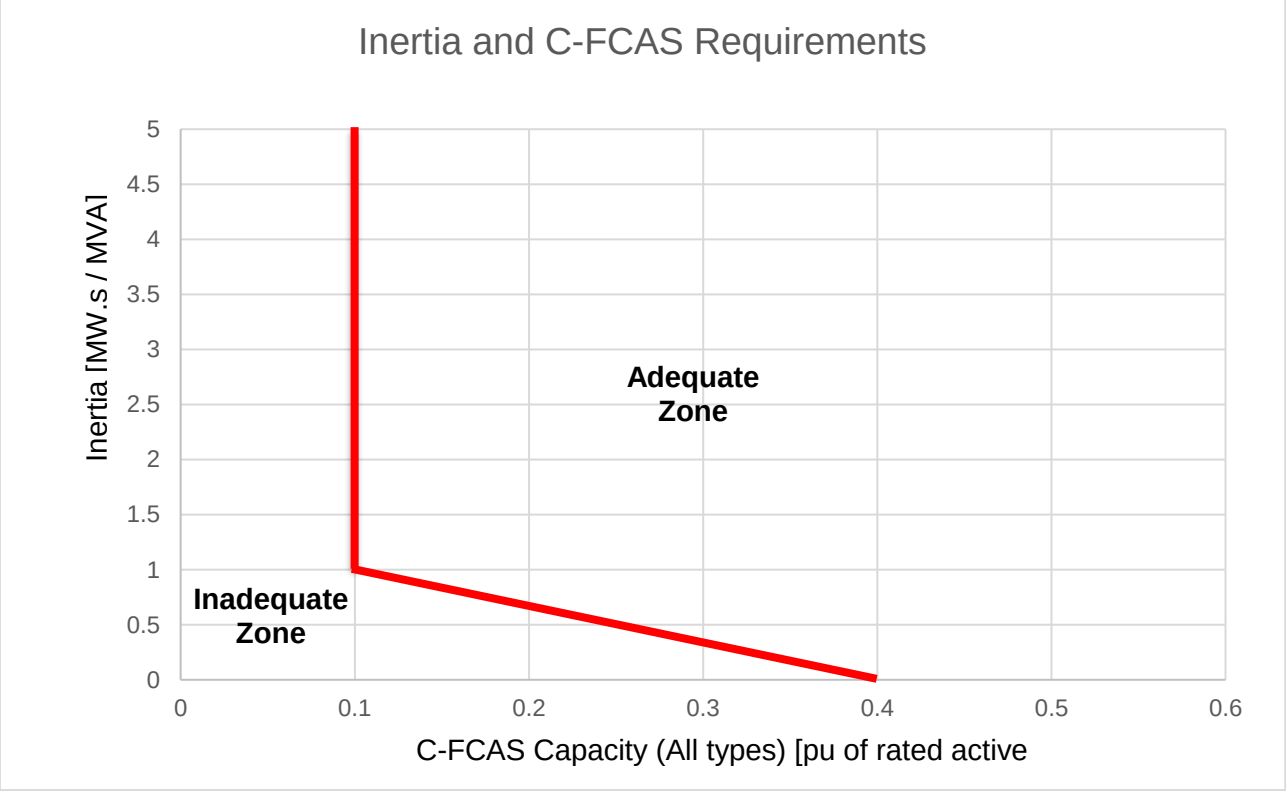
(a) The *inertia* and *contingency FCAS* automatic access standard is:

(1) A *generating system* must have an adequate *inertia* and *contingency FCAS* capability as defined by the characteristic below. Subject to energy source availability, the *generating system* must be able to operate at a real power output that will deliver *inertia* and *contingency FCAS* capability within the adequate zone as shown. The required capability can be achieved by any combination of partially loaded *generating unit(s)*, and/or additional plant (e.g. *synchronous condensers*, energy storage system, etc.), to achieve the required capability.

(2) *Inertia* offered or provided from non-synchronous (emulated) sources needs to be assessed and accepted by the *Power System Controller* and *Network Operator*.

(3) The *inertia* and *FCAS* capabilities will be accredited by the *Power System Controller* using the specifications and evaluation framework outlined in the System Secure Guidelines.

Figure 9 – Inertia vs C-FCAS Trade Off Requirements for New Generators



NTC Clause 3.3.5.16 – System Strength

Discussion and Final Decision

There is no specific performance standard specified in the NT NER or NER addressing system strength.

The NTC drafting relies on the System Strength Impact Assessment Guidelines that AEMO is required to develop under clause 4.6.6 of the NER. This clause has not been adopted in the NT NER and it is unreasonable to assume that the AEMO guideline has been developed for use in the NT. The commission notes that a similar concern arose when developing system strength provisions for the SWIS. The approach adopted in that instance was for a requirement to be placed on the Network Operator (Western Power) to develop a system strength impact assessment guideline for the SWIS. This approach requires Western Power to review the AEMO guideline and adopt those aspects that are applicable in the SWIS.

The commission considers that the NTC should include a provision for PWC to develop and maintain a System Strength Impact Assessment Guideline appropriate for the Territory power systems. This requirement could be met by PWC reviewing and leveraging the AEMO guideline as appropriate for Territory power systems. The requirement ensures that specific consideration is given to the technical characteristics of the Territory power systems and if necessary, refinements to the AEMO guideline are implemented in developing an appropriate guideline for application in the Territory power systems.

The AEMO assessment guidelines require a two stage assessment. While the preliminary assessment can be made with power system models used for power flow and fault calculations, the detailed assessment requires access to an EMT model of the power system and connected generators. Revisions were included in the Draft Decision to the model provision requirements in clause 3.3.4 of the NTC to include provision of an EMT model for connecting generators. The inclusion of this requirement aligns with advice provided by PWC that they currently request generators to provide such models. The provision of EMT models by generators should allow PWC to develop and maintain EMT models for the Territory power systems allowing the application of the detailed assessment procedure described in the AEMO System Strength Impact Assessment Guidelines.

The wording proposed by PWC refers to various terms that are not defined in the glossary. The Draft Decision advised the definitions in the NT NER are to be adopted for the following terms:

- system strength connection works
- adverse system strength impact
- system strength remediation scheme.

<u>Further PWC proposed revisions and issues raised in submissions</u>

In response to the Draft Decision, PWC has proposed further revisions on the basis that changes made to the NEM guidelines may not be applicable in the Territory given the very different characteristics of the NEM and the Territory power systems. These are to:

- remove a specific requirement for PWC to review the system strength impact assessment guidelines for the Territory power systems whenever AEMO amends the equivalent guidelines for the NEM
- introduce a specific requirement allowing relevant sections of the NEM system strength impact assessment guidelines to be adopted in the NT until the Territory guidelines have been developed.

While Eni supports the preparation of system strength impact assessment guidelines for the Territory power systems, it is concerned that PWC may not be the correct party to develop those guidelines and states that the commission should have oversight over the guidelines and the best way to achieve this would be for the guidelines to be included in the NTC. Further, Eni does not understand the concern expressed by PWC regarding the need to review the guidelines for the Territory power system should the equivalent NEM guidelines by amended and is concerned regarding the transparency of any application of the assessment guidelines if the EMT models are restricted only to PWC.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission agrees that there are significant differences between the NEM and the Territory power systems and that not all revisions to the NEM guidelines are likely to require revisions to the NT guidelines. However, consistent with GHD's advice, the commission does not agree that the requirement on PWC to assess whether the NT guidelines need to be altered when changes are made to the NEM guidelines should be completely removed. Accordingly, the commission has revised its drafting of sub-clause 3.3.5.16(a) to require PWC to assess the need to amend the guidelines when any changes are made to the AEMO guidelines to make clear that a complete review is not necessary each time.

Consequently, the commission has accepted PWC's other revision as it simply allows for the use of the AEMO guidelines until NT specific guidelines are developed.

Regarding the other concerns raised by Eni, it is noted that access to the EMT model has been discussed elsewhere in this report, in relation to clause 3.3.4 (provision of information). The commission considers that adoption of the recommendation proposed for clause 3.3.4 should address the concerns raised by Eni.

The commission agrees with GHD, that the revised wording below represents an appropriate balance between imposing costs through the generator connection process and maintaining system security.

Final Decision NTC wording

Clause 3.3.5.16

(a) The *Network Operator* must prepare system strength impact assessment guidelines. In preparing the first version of the guidelines, the *Network Operator* must review the AEMO System Strength Impact Assessment Guidelines v1.0 July 2018 and adopt those aspects of that document that are appropriate to apply in the Northern Territory together with any other provisions the *Network Operator* considers appropriate. The *Network Operator* may amend the guidelines at any time, and must assess the need to amend the guidelines when any changes are made to the AEMO guidelines. The *Network Operator* must consult with *Users* before issuing or amending the guidelines.

(a1) Until the *Network Operator* has developed and published the first version of its *system strength impact assessment guidelines*, it may undertake assessments based on the relevant provisions of AEMO's System Strength Impact Assessment Guidelines v1.0 July 2018.

(b) The system strength *automatic access standard* is a *generating system* must not cause an adverse impact on system strength as defined in the system strength impact assessment guidelines and following an assessment by the *Network Operator*.

Subject to paragraph (a),

(1) a *Network Operator* must undertake system strength connection works at the cost of the connection applicant if the full assessment undertaken in accordance with the system strength impact assessment guidelines indicates that the connection applicant's proposed new connection of a generating facility or the *Generator*'s proposed alteration to a generating system will have an adverse system strength impact, or

(2) to the extent that the adverse system strength impact referred to in paragraph (a) is or will be avoided or remedied by a system strength remediation scheme agreed or determined under this clause and implemented by the connection applicant in accordance with its *connection agreement*.

(i) A connection applicant proposing to install plant as part of a system strength remediation scheme must include a description of the plant, the ratings of the proposed plant (in MVA) and other information (including models) reasonably required by the *Network Operator* and *Power System Controller* to assess the system strength remediation scheme.

The following definitions need to be added to the glossary of terms in attachment 1 to the NTC:

system strength connection works

Investment in a *transmission or distribution system* in order to remedy or avoid an *adverse system strength impact* arising from establishing a *connection* for a *generating system* or from any alteration to a *generating system*.

adverse system strength impact

An adverse impact, assessed in accordance with the *system strength impact assessment guidelines*, on the ability under different operating conditions of:

(a) the power system to maintain system stability; or

(b) a generating system forming part of the power system to maintain stable operation including following any credible contingency event,

so as to maintain the power system in a *secure operating state*.

system strength remediation scheme

A scheme required to be implemented as a condition of a *connection agreement* to remedy or avoid an *adverse system strength impact*.

system strength impact assessment

Power system studies to assess the impact of the *connection* of a new *generating system* or of any proposed alteration to a *generating system* on the ability under different operating conditions of:

(a) the power system to maintain system stability; and

(b) generating systems forming part of the power system to maintain stable operation including following any credible contingency event,

so as to maintain the *power system* in a *secure operating state*.

system strength impact assessment guidelines

The guidelines for conducting *system strength impact assessments* developed by the Network Operator under clause 3.3.5.16.

NTC Clause 3.3.5.17 – Capacity Forecasting

Discussion and Final Decision

Clarity of requirements and response to non-compliance

Several stakeholders raised concerns in their submissions to PWC and the commission regarding the introduction of the capacity forecasting accuracy requirements as part of the GPS to Territory power systems. As mentioned in the summary of considerations and reasons chapter of this Final Decision, the submissions cite a number of concerns including:

- the cost of complying with the automatic access standard proposed threatens the commercial viability of new solar generation projects
- the forecast accuracy requirement prevents the adoption of other more efficient measures such as central batteries shared by a number of generators
- the forecast accuracy requirement is difficult to meet for generators developed behind the meter and operating with a zero-export connection agreement.

The commission agrees that the capacity forecasting requirements are unique in the Australian context and that the capacity forecast accuracy requirements and the surrounding compliance process needs further clarification to enable generator developers to assess how best to invest to meet these requirements. Further clarity is required regarding the proposed accuracy requirement, the manner in which PWC will assess whether accuracy requirements are being met and the approach PWC will take in response to any failure to meet the forecast accuracy requirements.

Accordingly, the Draft Decision was that PWC must develop and publish the procedure that will be followed by the Network Operator, if a breach of the performance standard is detected. The published procedure should clarify the process the Network Operator will use and how the Network Operator will consider the difference between the actual performance and the performance requirement specified in the GPS when deciding on the appropriate action to take following detection of a non-compliance.

Providing sufficient information on the accuracy requirements and the compliance process should allow generators to develop the most efficient solution for their projects that appropriately balances the cost of meeting the accuracy requirements and the risk to their

operation of a breach of those performance requirements. This information is also crucial to allow a generator to assess whether there is merit in submitting a proposal for a negotiated performance standard and to develop the information necessary to support the adoption of a negotiated performance standard.

GHD's review on behalf of the commission identified a number of discrepancies between information provided in the submission prepared by PWC and the proposed wording for clause 3.3.5.17 of the NTC. Through discussion with PWC the following points were clarified:

- there are three accuracy requirements that need to be met
- the first measures the alignment between the actual capacity and the dispatch capacity. Those two quantities must differ by less than +/- 0.5% of the dispatch capacity for every dispatch interval
- the next two assess the alignment between the firm offer and the six forecasts updated each five minutes for the 30 minutes prior to the firm offer being submitted, specifically:
    - the six forecasts are compared with the firm offer and any non-zero forecast which is lower than the firm offer is counted. The process is repeated for all firm offers across a rolling 24 hour window. To meet the accuracy requirement at least 90% of the non-zero forecasts must be must be less than their respective firm offer
    - the last accuracy requirement is that any of the forecasts that are higher than the firm offer, must not exceed the firm offer by:
        - 5% of the generating unit's nameplate rating; or
        - 1MW, whichever is the lesser.

The Draft Decision advised that wording for sub-clause (3) needs to be revised to correctly reflect the above accuracy requirements.

The commission notes that the accuracy requirements encourage generators to under bid their capacity in the five to 30 minute ahead forecast to reduce the risk that the forecasts ever exceed the firm offer and reduce the risk that the 90% accuracy requirement is breached. The risk with this approach is that additional capacity offered in the firm offer that was not offered in the 30 minute ahead forecast may not be dispatched by system control. This could arise as a result of the scheduling of thermal generators being set based on the 30 minute out forecast and not being able to accommodate increased output from the renewable generator. This is probably a low risk as maximising the dispatch of renewable generation should in most instances lead to a more efficient dispatch result and therefore a better result from the dispatch objective.

Sub-clause (e) allows the Power System Controller to adjust subsequent forecasts and firm offers if a generator is found to be non-compliant with forecasting accuracy requirements. The drafting lacks sufficient precision for a generator to quantify the risk to their revenue of a forecasting breach. PWC has advised that they are preparing an outage management procedure that will provide information on a range of topics including the process PWC will take following the detection of a non-compliance with the forecast accuracy requirement. Providing sufficient information in that document is important to allow generators the ability to understand the curtailment risk they might face. This will help generation proponents to

optimise the investment they make in forecasting systems and energy storage systems to adequately manage the curtailment risk.

The accuracy requirement proposed by PWC could be achieved by generators adopting conservative forecasts of their solar generation capacity. A conservative forecast could be developed by considering the probability of a forecast error given expected weather conditions and applying a discount to the forecast capacity to provide sufficient confidence that the forecast capacity would be achieved at the time of dispatch. While this approach may avoid or reduce the risk of any non-compliance it could result in periods where the generation dispatched from the solar farm is significantly lower than the generation available if the irradiance levels at the time of dispatch was fully utilised. The outcome could arise if:

- the solar capacity forecast available when generation commitment decisions are made by the Network Operator (30 minutes ahead of dispatch)[14] is lower than the firm offer made five minutes ahead of dispatch. Increasing the solar dispatch to the firm offer may not be possible if that would require thermal generators to be dispatched below technical minimums. In this scenario actual solar dispatch is less than that reflected in the firm offer indicating underutilised solar generation capacity
- the firm offer under-estimates the actual solar generation that could have been achieved during the dispatch interval.

Of these, the first scenario may be unlikely as the dispatch principles defined in clause 4.3 of the SCTC require the Network Operator to implement economic dispatch. Economic dispatch principles should allow solar generation to be dispatched in preference to thermal generators which have higher variable costs.

Adopting a conservative forecast approach utilising state of the art forecasting systems may be seen by an investor as a prudent strategy as it could delay investment in more expensive battery storage.

Meeting the accuracy requirements while avoiding the risk of under-utilised solar capacity will probably require some level of additional investment in a BESS. The cost of this investment will depend on the use case assumed for BESS sizing. Developing the appropriate BESS use case requires a detailed understanding of the expected performance of the installed solar forecasting system, the forecast accuracy requirement and the actions PWC will take in response to any non-compliance with the forecast accuracy requirement.

A risk adverse investor may want to avoid any curtailment risk. That could require a BESS which is sufficient to mitigate a worst case cloud event and have no change between the 35 minute ahead forecast and actual dispatch. That would require a BESS with a maximum discharge capacity of approximately 80% of the solar farm capacity and an energy storage capacity sufficient to store 80% of the maximum energy output from a solar farm for at least

[14] PWC have indicated that forecasts available in the pre-dispatch time frame (30 minutes ahead of dispatch) are used to decide on the commitment of thermal generation – see page 31 of the PWC submission to the Utilities Commission

30 minutes. The commission notes that for a 25 MW solar farm this requires a BESS rated at 20MW/10MWh, which could cost up to $10 million.

The commission notes that BESS costs are predicted to fall over the coming years, so there is significant economic benefit in delaying investment until the need is proven.

GHD recommended a number of revisions to the drafting proposed by PWC, which the commission accepted in its Draft Decision, to clarify the forecast accuracy requirements. Further, the Draft Decision required PWC to produce a procedure that details the process the Network Operator will use to detect any non-compliance with the capacity forecasting performance standard and the process that will be used to determine the action taken in response to any non-compliance with that performance standard.

Some submissions, including in response to the Draft Decision, proposed that a preferable alternative to the capacity forecasting requirements (and the inertia and contingency FCAS requirements in clause 3.3.5.15) would be to use a central battery shared by several generators to provide equivalent services rather than each generator being required to install its own equipment to meet these requirements. The commission notes that the NTC does not prevent alternative arrangements such as the use of a central battery and that the capacity forecasting requirements set out in clause 3.3.5.17 are only the automatic access standard at which PWC must connect any generator. The NTC also allows a generator to propose alternative arrangements as part of a negotiated access standard.

The commission's required changes to the process for negotiated access standards under clause 3.3.5 will provide greater certainty for generation proponents who wish to propose alternatives to the automatic access standards. Under that clause:

- a connection applicant may propose a negotiated access standard having regard to a range of specific factors including the commercial and technical feasibility of complying with the automatic access standard
- PWC may reject the proposed negotiated access standard where it reasonably considers that it will adversely affect power system security or the quality of supply to other users
- if PWC rejects the proposed negotiated access standard, it must provide detailed reasons in writing for the rejection.

Balance of system risk verses generation project cost

The proposed accuracy requirements have the potential to impose significant cost on renewable generators. It is therefore necessary to consider whether the accuracy requirements are overstated or represent a level of performance which is appropriate to manage the impact of the variability of renewable generation on other network users. The submissions and consultation documents published by PWC present some analysis to justify the setting selected for capacity forecasting accuracy requirement.

PWC's analysis appears to have considered 12 months of actual dispatch data for the DKIS on top of which they have overlaid the potential operation of 120 MW of solar generation. PWC applied a forecast accuracy model that varied the percentage of periods for which the forecast capacity was greater than the actual capacity and the maximum amount by which the forecast capacity exceeded the actual capacity. The analysis was used to assess how often the SSG were breached.

The results shown in Table 2.1 (extracted from the PWC submission) show the percentage of daylight periods which would have breached the SSGs. The columns and rows in the table

differentiate between different aspects of the assumed accuracy of the solar forecast with the columns varying the percentage of periods for which the forecast exceeded the actual capacity and the rows showing the maximum amount by which the forecast capacity exceeded the actual capacity.

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%

Figure 6.5: Forecasting accuracy, worst error

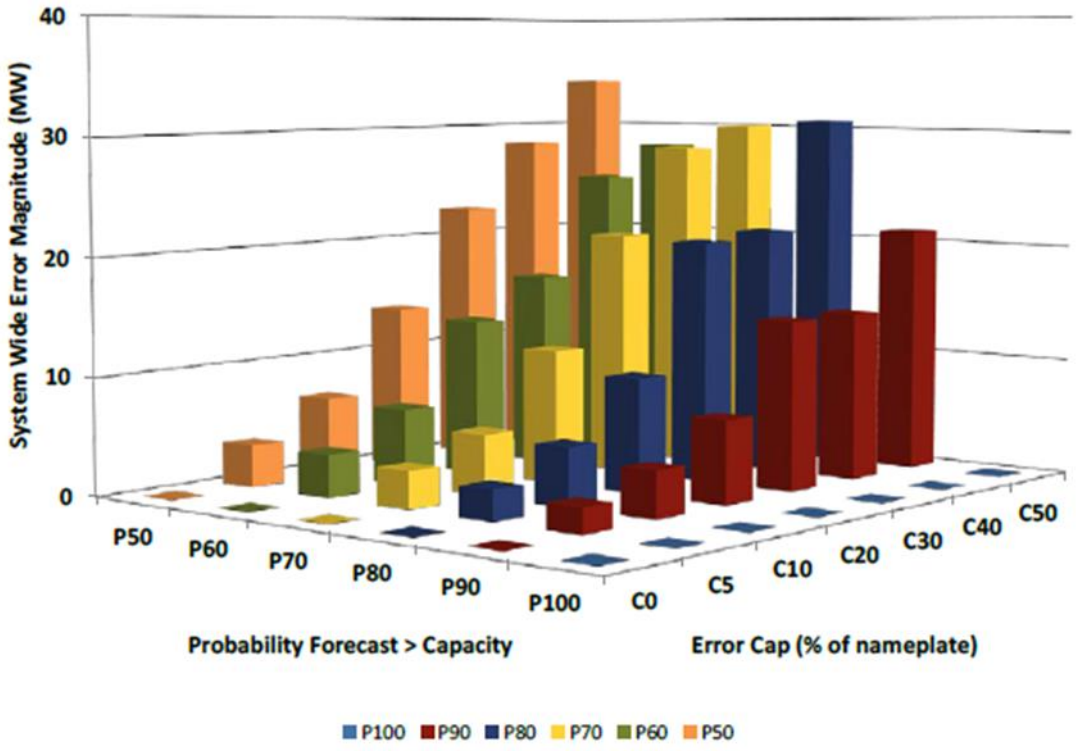


Figure 6.5 shows the system wide error that was simulated for different levels of solar forecast accuracy.

The proposed accuracy standard would deliver 90% of periods where forecast capacity is less than the actual capacity and a maximum error of 5% between the forecast and actual solar capacity. Table 2.1 indicates that forecast accuracy is estimated to breach the SSG about 1.5% of the time that solar generators are producing power. Figure 6.5 suggests the specified forecast accuracy will result in a system wide impact of a few MW.

Figure 4 below was extracted from the supplementary consultation paper developed by PWC in March 2019, titled “Framework for the Future”. The figure presents an analysis of the size of imbalance between load and generation that could breach the frequency operating standard assuming no governor response. It shows that an imbalance of less than 3.75 MW in DKIS, with no governor response available should not give rise to load shedding. This means that a cloud cover event that causes a net generation reduction of less than 3.75 MW and occurs concurrently with a generator contingency should not give rise to load shedding. 3.75 MW aligns with the level of system wide error shown in Figure 6.5 for a solar forecast accuracy requirement achieving 90% of forecasts below the actual capacity and a maximum forecast error of 5%. This suggests that these accuracy requirements may be appropriate if cloud cover events are likely to align with generator contingencies in the Territory power systems.

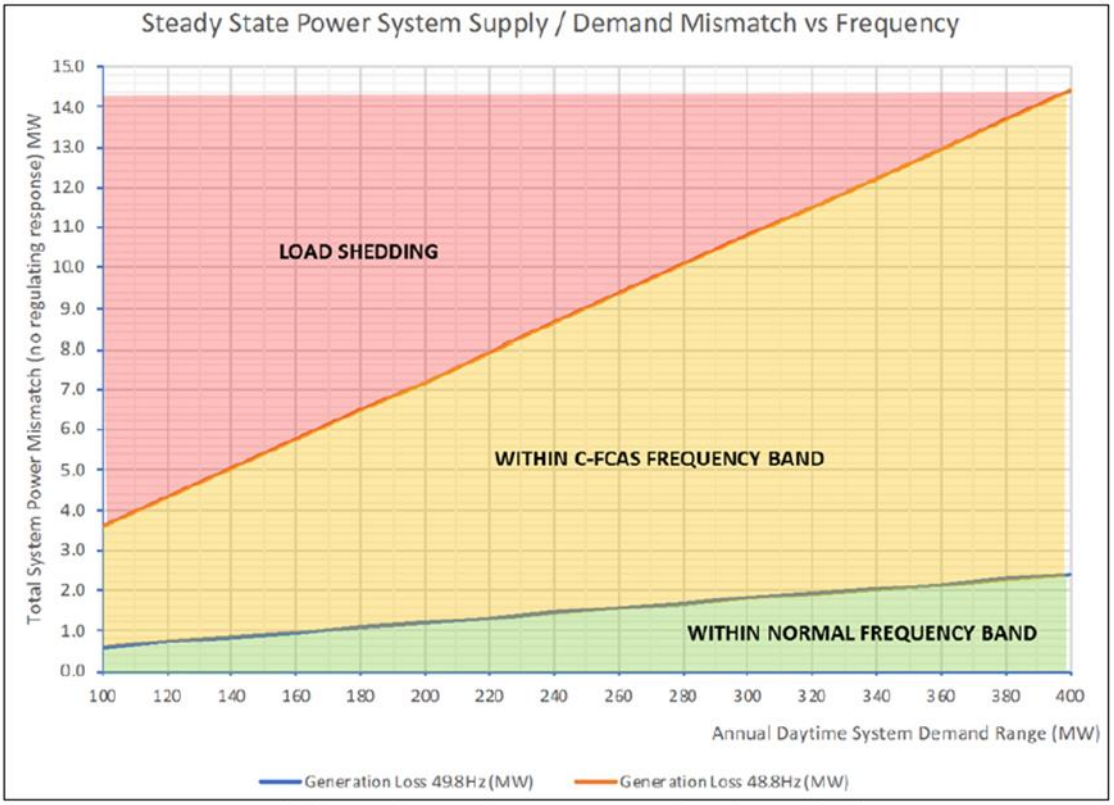


Figure 4 - Power Supply / Demand Mismatch vs System Demand and Unregulated Frequency Impacts

The thermal generation fleet supplying the DKIS currently experience a high number of forced outages (98 occurred over a 12 month period in 2017-18). On that basis PWC have asserted that it is reasonable to assume cloud events and generator outage may occur at the same time. PWC appear to have assumed that the available governor response would be called upon to address the generator contingency and it is therefore necessary to limit the size of the forecast error due to a cloud cover event such that load shedding is not triggered assuming no governor response. This approach appears to be reasonable, as confirmed by

GHD, as it seeks to establish a forecast accuracy requirement that maintains the current risk of load shedding for customers.

Further PWC proposed revisions and issues raised in submissions

The commission's Draft Decision included revisions to clause 3.3.5.17 to provide greater clarity regarding the capacity forecasting requirement. PWC has accepted the intent of the revisions proposed in the Draft Decision and suggested further revisions to improve the clarity of the capacity forecasting requirement. The revisions include:

- moving some sub-clauses that place caveats on when actual active power output may differ from dispatch instructions to clause 3.3.5.14
- deleting definitions of terms dispatch capacity and actual capacity as these terms are no longer used
- altering the responsibility to publish a process that specifies the process for detecting non-compliance from the Network Operator to the System Controller.

Jacana Energy's submission does not support the introduction of minimum accuracy requirements for new entrant generators proposed in clause 3.3.5.17 of the NTC. Jacana Energy believes that this places an unfair burden on new entrants compared to incumbent generators to address stability and reliability matters in the network.

Eni is concerned with the high cost of implementation of a BESS on top of its existing investment in order to meet the capacity forecasting requirements of the GPS in clause 3.3.5.17. Eni believes that the same level of investment in a BESS system in the Darwin area would provide larger benefits to the reliability of the power system. Eni did acknowledge that there was nothing in the GPS that prevented it contracting with an external centralised provider of a BESS to ensure compliance with capacity forecasting requirements of the GPS, but it would not be in their best interests to do so.

Eni states in its submission that it recognises the benefits of forecasting capacity from solar plants but that the important factor is the accuracy of the aggregate forecast and that equivalent inaccuracies from forecasted production from conventional plant is managed through C-FCAS/spinning reserve. It also identified than an accurate forecast of the combined output of rooftop solar is also necessary for the System Controller to be able to operate the system in a reliable manner. Eni also state that it has no confidence in the modelling provided by PWC to support their changes to NTC Clause 3.3.5.17.

NTSF's submission agrees with the wording changes to 3.3.5.17 except the removal of clause (f). It believes that (f) is a sensible inclusion that you can vary from your capacity forecast as a result of actions to correct system frequency in accordance with other provisions of the code and that it should be retained. NTSF states that it is in their commercial interests the keep the system secure and operational during contingencies and once everything is stable again, the forecast rules can apply.

Assure Energy's submission presents very detailed analysis that it has commissioned of the capacity forecasting clauses in 3.3.5.17 in the proposed NTC. From that analysis Assure Energy concluded that they believe they can provide the capacity forecasts contemplated and it is only the accuracy requirements within clause 3.3.5.17 that presents an issue. The analysis showed that compliance with the accuracy requirements would not be possible with their present plant design (which includes BESS) without either significant additional investment (estimated at $10 million) or agreeing to an acceptable negotiated performance standard for the capacity forecasting components of the NTC.

Assure Energy states that it believes that system security issues are best dealt with at an aggregate level so that individual solar generators are not charging and discharging batteries simultaneously to meet their individual forecast accuracy requirements. It also notes that under clause 3.3.5.17(g) of the NTC a process for detecting non-compliance with capacity forecasts and the action that will be taken in response to any non-compliance is to be developed and published by PWC by 30 March 2020. They understand that this is a key piece of information and that it is difficult to make a fulsome submission around the forecasting requirements with that piece of information missing.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

The commission acknowledges the feedback from generators that the capacity forecasting requirements in the GPS will significantly increase solar generators' costs and thus deter investment, and that it does not explicitly provide for arguably more efficient solutions to address system security and reliability concerns, such as the provision of a central battery.

Further, the commission acknowledges that there may be more efficient solutions than that required under the automatic standards in the GPS. It is for this reason that the new framework includes a process for negotiated access standards where generators are able to negotiate alternatives if they can demonstrate that adopting those standards does not adversely affect power system security or the quality of supply to Territory electricity consumers, such as a central battery if it makes commercial sense to do so.

As there is no central battery (or other alternative solutions) currently in the Darwin-Katherine system, the commission cannot rely on this for the automatic standard in this Final Decision, nor can the commission compel a party to build a central battery or compel other proposed alternatives such as upgrades to existing generation plant. Given the lead times to construct, connect and test a battery, even a commitment to build a central battery by a public or private party as soon as possible would not address the immediate issues for at least the next two years.

The commission agrees that the capacity forecast accuracy requirements and the surrounding compliance process needs further clarification to enable generator developers to properly assess how best to invest to meet these requirements. Additional clarity is required regarding the proposed accuracy requirement, the manner in which the System Controller will assess whether accuracy requirements are being met and the approach the System Controller will take in response to any failure to meet the forecast accuracy requirements.

In its Draft Decision, the commission included a requirement for PWC to develop and publish the procedure that will be followed by the System Controller, if a breach of the performance standard is detected. The published procedure should clarify the process the System Controller will use to detect any non-compliance with the forecasting performance standard and the process that will be used to determine the action taken in response to any non- compliance with that performance standard. Providing sufficient information on the accuracy requirements and the compliance process should allow generators to develop the most efficient solution for their projects that appropriately balances the cost of meeting the accuracy requirements and the risk to their operation of a breach of those performance requirements. This information is also crucial to allow a generator to assess whether there is merit in submitting a proposal for a negotiated performance standard and to develop the information necessary to support the adoption of a negotiated performance standard.

Given the importance of this issue to present and future generation proponents and given the submissions made on the draft GPS, the commission has amended the NTC wording to require the System Controller to seek feedback from interested parties and the commission prior to developing this procedure, with the draft procedure to be published by 30 March 2020.

In relation to the changes most recently proposed by PWC, GHD advised the commission that it does not believe that they materially alter the performance standard from that appearing in the Draft Decision. The changes do provide greater clarity regarding the interaction of the capacity forecasting requirement and the active power control requirement and are therefore supported. It should be noted that clause 3.3.5.17 (f) from the Draft Decision has now been incorporated into wording changes made to clause 3.3.5.14, which allows the active power output to differ from dispatch instructions as a result of actions to correct system frequency.

Subject to the wording changes below, the commission is satisfied, based on GHD advice, that the proposed generator performance standard with the changes published were appropriate, as it seeks to impose an accuracy requirement sufficient to maintain existing levels of reliability of supply for customers connected to Territory power systems.

Final Decision NTC wording

(a) In this clause 3.3.5.17, the following terms apply:

(1) 't' is time.

(2) 't=0' refers to the moment when a forecast is updated.

(3) 't=[numeral]' refers to the number of minutes elapsed since t=0.

(4) 'capacity' means the minimum capability of a *generating system* to deliver an active power output at a continuous steady level over the relevant 5 minute interval.

(5) 'firm offer' means the capacity forecast provided at t=0 for the interval commencing t=0 for 5 minutes

~~(6)~~ ~~'dispatch capacity' means the capacity instructed to the Generator to be injected into the grid.~~

(7) ~~'actual capacity' means the minimum instantaneous power injected into the grid for the interval commencing t=0 for 5 minutes.~~

(b) The capacity forecasting automatic access standard is:

(1) Subject to paragraph (f), a *Generator* must supply to the *Power System Controller* a forward forecast of the capacity of its *generating system*.

(2) The forecast in 3.3.5.17(b)(1) must:

(i) include a 24 hour ahead forecast for capacity for every 5 minute interval, updated at 5 minute intervals; and

(ii) have an accuracy such that in any rolling 24 hour period, at least 90% of the non-zero forecasts for the intervals commencing from t=5 to t=30 do not exceed the firm offer for the time for which the forecast was made.

(3) For every forecast assessed in paragraph (2)(ii) above, that exceed the firm offer, the forecast must not exceed the firm offer by a margin greater than:

(i) 5% of the *generating unit's* nameplate rating; or

(ii) 1 MW,

whichever is the lesser.

(4) ~~The actual capacity must be within +/- 0.5% of the dispatch capacity.~~ The firm offer must be the capacity of the generating system for the interval and therefore the generating system must follow a dispatch instruction up to the firm offer in accordance with the requirements in clause 3.3.5.14.

Note: When issuing dispatch instructions, the System Controller will respect plant limits such as firm offers and ramp rates of plant.

(c) A *Generator* must provide forecasts to the *Power System Controller* in a format specified by the *Power System Controller*.

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

(e) In the event of non-compliance with the automatic access standard by a *Generator*, the *Power System Controller* may adjust that *Generator's* subsequent forecasts and firm offers accordingly.

~~(f) Forecasts may differ from the firm offer, and actual capacity may differ from the dispatch capacity, as a result of actions to correct system frequency in accordance with other provisions of this *Code*.~~

(f) The *System Controller* must publish a procedure that specifies the process the *System Controller* will use to detect any non-compliance with the capacity forecasting performance standard and the process that will be used to determine the action taken in response to any non-compliance with that performance standard. In formulating this process the System Controller shall publish a proposed draft process and then consult with, and consider the input from interested parties, including the Utilities Commission and *Users*. The draft procedure must be published by 30 March 2020. Following the required consultation the final procedure must be published by 8 May 2020.

NTC Clause 3.3.6 – Monitoring and Control

Discussion and Final Decision

There is no automatic standard defined in the proposed wording for clause 3.3.6 of the NTC, rather a single set of technical requirements is provided stating the generator parameters that need to be monitored and/or controlled by the Network Operator and Power System Controller and the required communications systems. The NT NER specifies automatic and minimum access standards, noting these are not currently in effect. The requirements specified by PWC are consistent with the indicative automatic access standard in the NT NER.

The NTC requires remote monitoring and control to continue to operate for eight hours after total loss of supply, compared to three hours in the NT NER. The basis for longer time frame

has been clarified with PWC as being justified by the typical restoration times following outages for Territory power systems. The commission is therefore satisfied, based on GHD advice, that no change to the wording proposed by PWC is required and that wording provides an appropriate balance between the cost imposed on generators and the system security benefit achieved, noting no concerns were raised in submissions to the commission in relation to this clause.

NTC Clause 3.3.7 – Power Station Auxiliary Supplies

Discussion and Final Decision

The proposed wording for this clause is consistent with the indicative NT NER clause S5.2.7 and is considered reasonable.

The commission does not require any changes to this clause, noting no concerns were raised in submissions to the commission in relation to this clause.

NTC Clause 3.3.8 – Fault Current

Discussion and Final Decision

The wording proposed by PWC for this clause is consistent with the automatic access standard of the NT NER (S5.2.8, noting it is not currently in effect). Although no minimum access standard or negotiating guidance is specified in the NTC, the commission understands those indicative provisions in the NT NER would be difficult to apply.

The commission does not require any changes to this clause, noting no concerns were raised in submissions to the commission in relation to this clause.

NTC Clause 12 – Transitional Arrangements and Derogations

Discussion and Final Decision

These clauses accommodate existing generators as follows:

- generators connected before 1st April 2019 – may use version 3 of the code and must assess their ability to meet clause 3 of version 4 of the NTC via testing where necessary. There is no requirement to meet clause 3 automatic standards if this requires modification, alteration or enhancement to existing plant and equipment. This process does not actually result in a GPS being defined for existing plant
- generators connected post 1st April 2019 – are allowed a grace period of between 30 days and 13 months to comply with the requirements of version 4 of the NTC. A process to achieve compliance within the grace period is specified, which allows for negotiation of agreed GPS during the grace period specified in schedule S4. The commission considers the proposed grace periods are reasonable as longer periods are allowed for those performance standards that differ significantly from the technical requirements in version 3.1 of the NTC.

In the Draft Decision, the commission advised that it considered the proposed approach acceptable, other than PWC's proposed amendments to require a generator to pay PWC's costs of negotiating and documenting the associated matters unreasonable. Accordingly, PWC's proposed amendments were removed in the Draft Decision, with a further change made to correct a typographical error in NTC clause 12.3(e).

Further PWC proposed revisions and issues raised in submissions

PWC have proposed that the specific provisions requiring generators to fund their reasonable costs be reinstated claiming that:

- the recovery of these costs from generators is consistent with other provisions in chapter 5 of NT NER related to the process for establishing or modifying a connection
- the recovery of costs for generators is appropriate as this avoids those costs being allocated to network customers
- the recovery of costs from generators will assist in minimising the number of iterations undertaken in negotiating performance standards by providing a greater incentive for generators to achieve an efficient negotiation process
- the removal of the cost recovery is not consistent with the approach proposed in various stakeholder engagements undertaken as part of developing the revisions to the NTC to introduce generator performance standards.

In relation to the funding of costs, NTSF states in its submission that the proposed transitional arrangements in clause 12 do not affect them, but it believes it is unfair that if (there is) a generator who has a connection agreement but has not connected by 1 April 2019, and there is something unreasonable in the new code, then the generator has to pay PWC's "reasonable" costs associated with negotiating an access standard. The same applies to negotiating other matters to be agreed under the Code, and also for any resultant testing. NTSF believe that there is no incentive for PWC to conclude negotiations and behave reasonably and that this exposes generators to unknown and uncontrollable costs.

TGen's submission supports the commission's provisions in the Draft Decision that would not require TGen to recompense PWC their expenses for the compliance testing.

In relation to the grandfathering provisions, Eni's submission expresses concern around the choice of the cut-off date for application of version 3 of the code as being 1 April 2019. Eni states that it is exposed to the risk of having to transition to version 4 of the NTC more than any other stakeholder in the Territory power system as they own over 80% of the capacity currently committed and under construction. Eni are particularly concerned about the cost of compliance with the capacity forecasting clauses of the Draft Decision. Eni states that its main concern is that already sanctioned and committed projects are not being grandfathered. Eni believe that this precedent would create a degree of regulatory risk which will significantly raise the cost of capital for new renewable energy investment in the Territory, a form of energy generation that relies on a low cost of capital, thereby creating an additional unnecessary barrier to market entry.

Jacana Energy's submission requests that the commission ensure that transition timeframes are clearly stipulated and enforced within the GPS framework. Jacana Energy does not support open ended timeframes for PWC to become fully compliant with the revised GPS as it considers that this may delay the connection of new generation to the NT grid. Similarly, TGen suggests that indicative timelines should be explicit and implementation of action items are monitored by the commission.

In its submission, TGen requests that the commission modify clause 12 to ensure that plant connected to the network at 1 September 2012 will continue to be subject to grandfathering provisions. TGen propose that the following to be added to the proposed clause 12.2(b)(i): "For avoidance of doubt, clause 12.2 of version 3 of the NTC will continue to apply to plant

and equipment in the Network and all facilities connected to the Network existing at 1 September 2012".

TGen are concerned that the requirement of clause 12.2(c), to document compliance or non- compliance of all generating units against the proposed new requirements if required by the Network Operator will be problematic. TGen states that this is because there are neither testing guidelines nor template test plans provided by the Network Operator as to what tests and what test programs are to be undertaken to demonstrate compliance. Currently test plans are developed on a case by case and ad hoc basis.

TGen expressed concerns with proposed clause 12.2(f), which would require them to meet full compliance with the NTC if existing plant is modified. TGen has a number of "non- compliances" that are grandfathered. In particular, compliance with the proposed Reactive Power Capability (see clause 3.3.5.1 of the proposed NTC), would likely require replacement of plant and not an upgrade. If TGen were to make a modification to one part of a generating unit that has grandfathering provisions, say the control system, then the current draft would require upgrading of the entire generating unit to full compliance. TGen believe that this is a disincentive to making any upgrade to a generating unit or power station and will lead to suboptimal outcomes.

TGen has requested that the modification provisions in proposed clause 12.2(f) be updated to address it concern as follows: "If a Generator User materially modifies, alters or enhances existing Connection Plant, then it must do so, if required by the Network Operator, in accordance with any applicable provisions of the NT NER and this Code (including, where required by this Code, complying with the automatic access standards or such negotiated access standards as maybe agreed)."

TGen also suggests that a general grandfathering provision should be included in the SCTC to cover all changes to the SCTC that affect existing generators.

TGen noted that, in the proposed NTC Clause 12, the grace period for new generators connecting to the system would be between 30 days to 13 months to comply with the GPS. As the current supplier of ancillary services, TGen noted that there would be increased pressure on TGen to provide additional ancillary services. It stated that they would like a mechanism to be implemented to provide adequate compensation to recover the costs of providing these services.

In its submission, Assure Energy states that if the commission continues with the proposed GPS, it believes that an additional element of grandfathering is appropriate. Under the proposed GPS there are grandfathering arrangements for projects with an existing connection agreement and Assure Energy believe that a grandfathering regime should also apply in respect of the capacity forecasting accuracy requirements to projects that have an executed power purchase agreement.

Assure Energy states that these are projects that have committed to investment in the Northern Territory (and are currently delivering that investment) and that the projects were struck before the rules came to light and so the economics do not take into account the proposed GPS. Assure Energy states that the accuracy requirements of the capacity forecasts in the proposed GPS will have a major impact on the financial viability of its project and future investment decisions.

The commission's consideration of this most recent feedback is discussed below.

Final discussion

Allocation of costs

The commission agrees that there are many examples in chapter 5 of the NT NER where the connection applicant funds the Network Operator's reasonable costs for the assessment of connection related matters. These provisions include allocation of costs to generators associated with processing enquiries and applications for new connections and applications to modify existing generators. While these provisions have some relevance, a key difference between those provisions and the application of clause 12.3 of the NTC is that clause 12.3 is applying obligations on generators that have already negotiated a connection agreement.

It is reasonable that the processes in chapter 5 of the NT NER recover from connection applicants the costs incurred by the Network Operator in assessing those applications. This consistent allocation of costs provides a level playing field for all generator connection applicants. Allocating the Network Operator's reasonable costs to the connection applicant ensues that the party generating the work pays for that work and avoids any unwarranted allocation of those costs to other network users.

GHD's report to the commission on this matter considered the impact on customers, the need to encourage an efficient negotiation process, whether PWC's proposed allocation of costs is consistent with previous stakeholder consultation and stakeholder feedback. GHD concluded that on balance it would not be reasonable that generators fund the costs incurred by the Network Operator in supporting the development of negotiated access standards for generators covered by clause 12.3.

If each party bears their own costs, they would both be incentivised to achieve an efficient outcome when negotiating performance standards, making revisions to connection agreements and performing tests on equipment to establish whether a generator meets proposed performance standards. Accordingly, the commission does not accept PWC's proposed revisions to clause 12.3.

Grandfathering

The commission acknowledges feedback from stakeholders regarding the lack of grandfathering for their respective projects and associated impact that this will have on their respective projects. However, the commission notes that the new GPS follows two years notice (including the publication of proposed draft standards) to the industry that new standards were to be introduced for the Territory's regulated power systems, over 12 months formal consultation by PWC and consultation by the Commission on its Draft Decision.

This notice is in addition to advice to new licensees that they should take into consideration the changing framework when designing connection infrastructure and clear associated licence conditions that require compliance with regulatory instruments, including any new requirements that come into force when instruments are amended from time to time. PWC's submissions to generation licence applications over the last two years have also included draft GPS so that new entrants were aware of the potential new obligations. Given the significant notice provided, the commission considers that a prudent investor would have factored this risk into their associated contracts, noting some of the standards in this Final Decision are less onerous than originally proposed in 2018.

Accordingly, the commission does not require any further changes to clauses 12.2 12.2(a) and (b) or 12.3(a) and (b). Further, the commission does not consider it necessary to add additional wording to 12.2(b) to explicitly cover facilities connected to the network existing at 1 September 2012, as these are clearly covered by the pre 1 April 2019 timeframe.

Modification of existing plant

The commission has considered TGen's request to modify provisions in proposed clause 12.2(f) to address its concern of having to achieve full compliance with the NTC if it makes modifications to existing plant, in consultation with GHD, and agrees.

The revised wording will allow PWC to determine if the changes proposed to existing plant do or do not actually warrant having to make it fully compliant with the GPS. For example requiring full compliance with the GPS may not be considered necessary when changing or upgrading components which may enhance reliability or have reached end of life but not otherwise materially change the performance characteristics of the generator.

Development of guidelines

Submissions from TGen and Jacana Energy were concerned with the time taken to transition to the new GPS and the need for required information and guidelines to be provided by PWC to allow generators to determine their ability to comply with the GPS. In particular, a generator that needs to comply with Clause 12.3 will require information and guidelines to be provided by PWC so that they can determine their level of compliance with the GPS, what they need to do to make their plant compliant with the GPS and, if necessary, implement changes to ensure compliance with the GPS prior to specified grace periods elapsing.

To address these concerns GHD has recommended, and the commission agrees, that an additional clause be included to provide that any grace periods referred to in clause 12.3 only commence from the date that the Network Operator provides the Generator User with information and guidelines required by the GPS in order for the Generator User to determine the ability of their plant to comply with the GPS.

It was also identified that the acronym GPS was used in the NTC to mean two different things, "global positioning system" and "generator performance standard". To avoid confusion, a wording change is included in Schedule S4.

Final Decision NTC wording

12.2(f) If a *Generator User* materially modifies, alters or enhances *Existing Connection Plant*, then it must do so, if required by the *Network Operator*, in accordance with any applicable provisions of the NT NER and this Code (including, where required by this *Code*, complying with the *automatic access standards* or such *negotiated access standards* as maybe agreed).

12.3 Post 1 April 2019 plant and equipment

(e) A *Generator User* to whom this clause applies may request the *Network Operator* to agree with it a *negotiated access standard* in substitution for an *automatic access standard* and, if so, the *Network Operator* will negotiate in good faith with the *Generator User* to agree such *negotiated access standard* in accordance with the criteria set out in clause 3.3.5. ~~The *Generator User* must, at such times reasonably determined by the *Network Operator*, reimburse the *Network Operator* its reasonable costs of undertaking any such negotiations.~~ Until such time as a *negotiated access standard* is agreed, any *connected plant* of the *Generator User* must, subject to clause 12.3(b), comply with the *automatic access standard*.

(f) Where this *Code* contemplates a matter being agreed between the *Network Operator* and the *Generator User* and such matter is not specified in the *connection agreement* then:

(i) the *Network Operator* may, as a condition to connecting the *plant* to the *electricity network* and permitting its commissioning, require that the *Network Operator* and the *Generator User* agree such matters and document them as an amendment to the connection agreement; or

(ii) if the *plant* is already *connected* and commissioned as at the time Version 4 of this *Code* comes into effect, the *Generating User* must, if required by the *Network Operator*, negotiate in good faith to agree and document such matters by an amendment to the *connection agreement* (and if such matters are not agreed within 4 months of the *Network Operator's* request then the matter may be referred for determination by the *Utilities Commission* under clause 1.6(b)).

~~(g) The *Generator User* must, at such times reasonably determined by the *Network Operator*, reimburse the *Network Operator* its reasonable costs of negotiating and documenting the matters referred to in clause 12.3(f).~~

(g) The *Generator User* must report the results of the tests conducted in accordance with a plan referred to in clause 12.3(b) to the *Network Operator* in such manner specified by the *Network Operator* acting reasonably. The *Generator User* must bear its own costs of undertaking such tests ~~and must reimburse the *Network Operator*, at such times reasonably determined by the *Network Operator*, the *Network Operator's* reasonable costs of conducting and overseeing such tests~~.

(h) Any grace periods referred to in this clause 12.3 shall only commence from the date that the *Network Operator* provides the *Generator User* with information and guidelines specified in clauses 3.3.4 and 3.3.5 to enable the *Generator User* to determine the ability of their plant to comply with the technical requirements in 3.3.5.

Schedule S4 Grace periods for purposes of clause 12.3

Clause	Clause Title	Transition to Compliance Grace Period
3.3.5.1	Reactive power capability	13 months
3.3.5.2	Quality of electricity generated	30 days
3.3.5.3	Generation unit response to frequency disturbance	30 days
3.3.5.4	Generating System Response to Voltage Disturbances	13 months
3.3.5.5	Generating System Response to Disturbances Following Contingency Events	6 months
3.3.5.6	Quality of Electricity Generated and Continuous Uninterrupted Operation	30 days
3.3.5.7	Partial Load Rejection	30 days
3.3.5.8	Protection of Generation Units from Power System Disturbances	30 days
3.3.5.9	Protection Systems that Impact on Power System Security	30 days

Clause	Clause Title	Transition to Compliance Grace Period
3.3.5.10	Protection to Trip Plant for Unstable Operation	30 days
3.3.5.11	Frequency Control	30 days
3.3.5.12	Impact on Network Capability	30 days
3.3.5.13	Voltage and Reactive Power Control	30 days
3.3.5.14	Active Power Control	30 days
3.3.5.15	Inertia and Contingency FCAS	30 days
3.3.5.16	System Strength	30 days
3.3.5.17	Capacity Forecasting	13 months
3.3.6.1	Remote Monitoring and Control	30 days
3.3.6.2	Communications Equipment	30 days

Explanatory notes:

1. The transition to compliance timeframes includes the 30 days for the generator to provide a compliance plan and confirm the generator performance standard.
2. The transition to compliance grace periods include all aspects including design, modelling, procurement, programming, installation and testing as appropriate.
3. Clauses with 30 day timeframe to compliance reflect that the requirements are either:
   a. The same or equivalent outcome as those under the existing NTC V3.1; or
   b. Not expected to result in a compliance gap.
4. For the clause with a 6 month timeframe, a compliance gap is considered at least possible, with any gap most likely related to a programming / setting change and testing to demonstrate compliance.
5. For the clauses with a 13 month timeframe, a potential compliance gap is considered possible, with that gap most likely related to requiring additional plant or equipment and testing to demonstrate compliance.
6. A generator may seek an extended derogation under NTC clause 12.1, but only where it can be justified, and the generator demonstrates its best endeavours to achieve timely compliance.

Changes to italicised terms and definitions proposed by PWC

Discussion and Final Decision

PWC have proposed some revisions to the definitions appearing in the commission's Draft Decision. PWC has suggested that the following classes of revisions be made:

- General corrections – these revisions are proposed to correct the formatting and text to use consistent italicised terms throughout the NTC[15], and correct minor errors in referencing. PWC recommends omitted headings or deleted sections be identified with placeholders stating “Deleted”
- Use of NT NER definitions – PWC have identified that NTC Attachment 1 paragraph (c) states that “an italicised word or phrase defined in the NT NER has the meaning given in the NT NER unless redefined in the table below”
- Terms that need not be defined – PWC assert that the commission has proposed that the terms “plant standard” and “dispatch instruction” be defined. PWC note these terms are defined in the NT NER but refer to provisions of the NT NER that do not currently apply in the NT. PWC suggest that the plain English definition is appropriate and therefore a specific definition is not required.

Other submissions have not proposed additional changes to definitions and have not raised specific concerns with the revisions proposed by PWC.

In terms of the proposed general corrections, the commission notes that the proposed changes were not provided to the commission with sufficient time for consideration[16]. Regardless, the commission does not consider that changes to correct formatting and referencing require the commission’s approval.

Use of NT NER definitions
The commission agrees that there is no need to copy definitions from the NT NER to NTC glossary of terms (i.e. Attachment 1) where the NT NER definition is also applicable in the Territory power systems. The commission’s Draft Decision recommended definitions for the following terms be added to the glossary:

- confidential information
- normal voltage
- continuous uninterrupted operation
- transmission system
- generating system
- operational frequency tolerance band
- rotating rectifier
- system strength connection works
- adverse system strength impact

[15] PWC refer to the term Code in their submission. GHD has assumed this is a reference to the NTC.

[16] PWC submitted marked up codes with comments to, among other things, show and explain further/alternative changes on 18 February 2020.

- system strength remediation scheme
- system strength impact assessment
- system strength impact assessment guidelines

In addition the following definitions were embedded in specified clauses of the NTC:

- static excitation system
- maximum operating level
- minimum operating level

GHD has reviewed the definition of the above terms in the NT NER and advised that the definition proposed in the Draft Decision is the same as the NT NER for the following term. It is therefore agreed that this term be italicised rather than adding the definition to the NTC:

- transmission system

However, the remaining definitions proposed in the Draft Decision are to be retained as they differ from those in the NT NER, having been customised to be applicable in the Territory power systems:

- confidential information
- normal voltage
- continuous uninterrupted operation
- generating system
- operational frequency tolerance band
- static excitation system (definition embedded in clause 3.3.5.13)
- rotating rectifier
- adverse system strength
- system strength connection works
- system strength remediation scheme
- system strength impact assessment
- system strength impact assessment guidelines
- maximum operating level (definition embedded in clause 3.3.5.11)
- minimum operating level (definition embedded in clause 3.3.5.11).

In completing this review of definitions, GHD identified that the following definitions included in the Draft Decision should be amended to remove terms that are not applicable in the Territory power system. The changed text is highlighted in yellow with deleted text struck through.

system strength connection works

Investment in a *transmission or distribution system* in order to remedy or avoid an *adverse system strength impact* arising from establishing a *connection* for a *generating system* ~~or *market network service facility*~~ or from any alteration to a *generating system*.

adverse system strength impact

An adverse impact, assessed in accordance with the system strength impact assessment guidelines, on the ability under different operating conditions of:

(a) the power system to maintain system stability; or

(b) a generating system ~~or market network service facility~~ forming part of the power system to maintain stable operation including following any credible contingency event ~~or protected event~~,

so as to maintain the power system in a secure operating state.

system strength impact assessment

Power system studies to assess the impact of the connection of a new generating system or of any proposed alteration to a generating system on the ability under different operating conditions of:

(a) the power system to maintain system stability; and

(b) generating systems ~~and market network service facilities~~ forming part of the power system to maintain stable operation including following any credible contingency event ~~or protected event,~~

The commission's Draft Decision did not specifically state that the terms "plant standard" and "dispatch instruction" are to be defined in the glossary to the NTC.

The Draft Decision highlighted in yellow revisions to clause 3.3.5.2 to show terms that should be italicised as they were italicised in the equivalent standard in the NT NER or were terms defined in Attachment 1 to the NTC. It is acknowledged this resulted in the term plant standard being italicised.

The commission accepts that the definition in the NT NER is not directly applicable for the Territory power systems as it refers to sections of the NT NER which are yet to be adopted in the NT. It is agreed that the term should not be italicised in clause 3.3.5.2. This will rely on a plain English definition which unlikely to create any confusion.

The original drafting for clause 3.3.5.17 proposed by PWC included a note in sub-clause (b)(4). All of the text in the note was italicised in the original drafting. The commission agrees that the formatting of that note should be amended with only defined terms italicised.

It is also noted that "dispatch instruction" is defined in the SCTC. It is therefore likely that parties will assume that definition is also applicable for the term in the NTC.

The SCTC definition is:

Dispatch instruction:

An instruction given to a *Generator* pursuant to clause 4.7 to *synchronise*, desynchronise, *supply ancillary services* including *spinning reserve* or *supply energy*.

It is agreed that there is no need for the term "dispatch instruction" to be italicised in the NTC.

Further amendments to the NTC proposed by PWC

Discussion and Final Decision

PWC has advised that in reformatting and reviewing the NTC, they have identified a number of additional revisions to various sections of the NTC to make minor corrections. They also propose making the following changes to improve consistency and clarity:

- changes consequential on commencement of NT NER Chapter 7A - Clause 3.2.1.8 - clause 10 and Attachment 4 and associated definitions in the Glossary have now been deleted, and clauses referring to these have been amended accordingly
- clause 3.2.1.8 - Deleted the reference to clause 3.3.2.11, which has been deleted
- note on Australian Standards - At the beginning of section 1.2, add:

  note - Australian Standards are defined in Attachment 1 as the most recent edition of a standard publication by Standards Australia. Historical standards referred to in this Code should be interpreted accordingly
- changes to clause 2.2.2 that mirror those in 3.3.5.3(a), for consistency and clarity.

Of these proposed revisions, only the proposed drafting for clause 2.2.2 was provided to the commission with sufficient time for consideration[17]. The proposed revision to this clause inserts a definition of stabilisation time which is consistent with that included in clause 3.3.5.3(a). As the proposed revision is entirely consistent with the drafting of clause 3.3.5.3(a), the commission has approved this revision to clause 2.2.2.

Final Decision NTC wording

2.2.2 Frequency range under abnormal operating conditions

(a) To cover for the loss of a generating unit from the power system two measures will be applied to arrest the fall in frequency following the loss of generation and to return the frequency to within normal operating levels as specified in clause 2.2.1:

(1) utilisation of available spinning reserve or C-FCAS as applicable in each regulated power system, under the direction of the Power System Controller; and

(2) disconnection of system load manually or by means of automatic protection.

(b) Under abnormal operating conditions, the network frequency may vary between 47 Hz and 52 Hz.

(b1) In the case of operations between 47 Hz and 52 Hz, the stabilisation time is 10 minutes, where stabilisation time means:

[17] PWC submitted marked up codes with comments to, among other things, show and explain further/alternative changes on 18 February 2020.

the longest time allowable for the frequency of the power system to remain outside the normal operating frequency band, for any condition (including an “island” condition) in the frequency operating standards that apply to each region.

Alignment with SCTC

Discussion and Final Decision

SCTC 3.11.1 Forecasts – 3.11.1 in SCTC required generators to submit half hourly 30 day ahead generation capability forecast. During the interview with PWC it was confirmed that as there is no accuracy requirement associated with this forecast. Accordingly, the commission considers it is appropriate for the provision to remain in the SCTC rather than be combined with the forecast accuracy performance standard specified in clause 3.3.5.17 of the NTC.

APPENDICES

Appendix A: GHD report – Review of GPS proposed by PWC and associated changes to NT technical regulations

Appendix B: GHD report – Review of issues raised in submissions - GPS regulatory changes