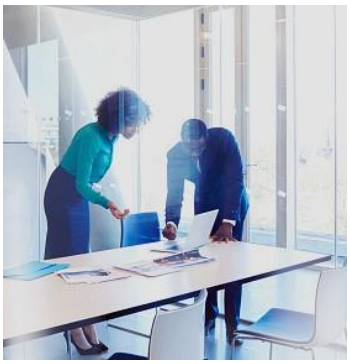
GHD Advisory



Review of issues raised in submissions - GPS regulatory changes

Utilities Commission of the Northern Territory

28 February 2020

GHD

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Executive summary

GHD has been engaged to assist the Utilities Commission of the Northern Territory (the Commission) with its review and consideration of revisions to the Network Technical Code (NTC), the System Control Technical Code (SCTC) and the Secure System Guidelines (SSG) proposed by Power and Water Corporation (PWC). We have considered the revisions proposed by PWC and other stakeholders in their submissions following the release of the draft decision by the Commission to implement proposed generator performance standards (GPS) for the following Northern Territory (NT) power systems:

- Darwin Katherine Interconnected System (DKIS);
- Alice Springs power system, and
- Tennant Creek power system.

In November 2019 we provided a report presenting outcomes from our review of the September 2019 submission provided by PWC.

On 4 December 2019 the Commission published a draft decision in relation to the proposed amendments to codes to implement generator performance standards and invited feedback from stakeholders with submission due by 29 January 2020. The following parties made submissions on the draft decision:

- PWC;
- Assure Energy Asset Pty Ltd (as trustee for the Assure Energy Asset Trust) (Assure Energy);
- Eni Australia Limited (EAL);
- NT Solar Futures (NT Solar);
- Territory Generation; and
- Jacana Energy.

GHD has reviewed the submissions and considered the revisions to the NTC proposed by all stakeholders that made submissions. GHD has identified areas of concern with a number of suggested revisions. Those areas of concern are discussed in the body of this report. After consideration of the opinions expressed in all submissions GHD has drafted revised clauses that appropriately balance:

- the desire for system security;
- the costs imposed on generators needing to conform to the GPS; and
- the allocation of risk and cost among connecting generators, PWC and System Control.

All resulting revisions have been detailed in Table 2 in the Conclusions and Recommendations of this report.

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1. Introduction & Purpose

GHD has been engaged to assist the Commission with its review and consideration of revisions to the NTC, the SCTC and the SSG proposed by PWC. We have specifically considered the revisions proposed by all stakeholders that made submission in response to the Commission's draft decision to implement proposed GPS for the following NT power systems:

- Darwin Katherine Interconnected System (DKIS);
- Alice Springs power system, and
- Tennant Creek power system.

In November 2019 we provided a report presenting outcomes from our review of the September 2019 submission provided by PWC. Our review considered whether the proposed GPS appropriately balances:

- the desire for system security;
- the costs imposed on generators needing to conform to the GPS; and
- the allocation of risk and cost among connecting generators, PWC and System Control.

On 4 December 2019 the Commission published a draft decision in relation to the proposed amendments to codes to implement generator performance standards and invited feedback from stakeholders with submissions due by 29 January 2020. The following parties have provided submissions to the Commission considering both the draft decision and the subsequent submission from PWC:

- PWC;
- Assure Energy Asset Pty Ltd (as trustee for the Assure Energy Asset Trust) (Assure Energy);
- Eni Australia Limited (EAL);
- NT Solar Futures;
- Territory Generation; and
- Jacana Energy.

This report considers the matters raised in the submissions and considers whether the material presented justifies a revision to the recommendations made in our November 2019 report. This report has been prepared for the Commission recognising that the Commission may choose to publish the report to help inform stakeholders of information considered in making a final decision.

2. Consideration of issues raised in submissions

Many of the submissions have supported significant portions of the Commission's draft decision. Some submissions have requested further amendment of a clauses. In the following sections we consider each of those clauses in turn and consider the merit of the arguments put forward in submissions. Our focus in considering the revisions is whether the proposed revisions result in the GPS appropriately balancing:

- the desire for system security;
- the costs imposed on generators needing to conform to the GPS; and
- the allocation of risk and cost among connecting generators, PWC and System Control.

Our review has identified the need for revised drafting for some sections of the NER NT. We have used the following colour coding to identify the recommended revisions:

- green highlighting has been used to identify new sections or clauses;
- yellow highlighting has been used to identify revisions to existing sections or clauses.

A number of submissions have raised concerns and issues that extend beyond the implementation of appropriate regulatory changes to implement generator performance standards. Section 3 of this report considers those broader issues.

2.1 Changes to italicised terms and definitions

2.1.1 Further revisions suggested by PWC

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[1], 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 identified** – 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 raise specific concerns with the revisions proposed by PWC.

As GHD has not been provided with a revised version of the NTC we are not able to comment on the specific changes proposed, we have instead provided an "in principle" review.

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

2.1.2 Consideration of suggested revision

In principal GHD has no objection to implementing the proposed general corrections although we would recommend careful review of such changes to reduce the risk of errors being introduced inadvertently.

2.1.3 Use of NT NER definitions

The argument presented by PWC has merit. GHD presumes that PWC is recommending 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 NT 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
- 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

We have reviewed the definition of these terms in the NT NER and agree that the definitions proposed in the draft decision are the same as the NT NER for the following terms. We therefore recommend that those terms be italicised rather than adding the definition to the NTC:

- transmission system

The remaining definitions proposed in the draft decision should be retained as they differ from those in the NT NER, having been customised to be applicable in the NT 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 we have identified that the following definitions included in the draft decision should be amended to remove terms that are not applicable in the NT 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,~~

2.1.4 Terms that need not be defined

We could not find a direct statement in the Commission's draft decision that requested the terms "plant standard" and "dispatch instruction" be defined in the glossary to the NTC.

Our November report 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. We acknowledge this resulted in the term plant standard being italicised. We accept that the definition in the NT NER is not directly applicable for the NT power systems as it refers to sections of the NT NER which are yet to be adopted in the NT. We agree 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. We agree that the formatting of that note should be amended with only defined terms italicised. We also note 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*.

We agree that there is no need for the term "dispatch instruction" to be italicised in the NTC.

2.2 Clause 3.3.4 - provision of information

The Commission's draft decision includes revisions to clause 3.3.4 to improve certainty for connecting parties regarding their ability to access the system modelling information required to undertake connection studies and negotiate generator performance standards. Those revisions implemented changes to align with the processes in the NER for the access to modelling information.

2.2.1 Further revisions suggested by PWC

PWC support the adoption of the revisions proposed by the Commission and has suggested additional revisions to provide greater clarity regarding the information and model provision obligations.

In addition to the Commission's amendments to paragraph (b), Power and Water 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[2].

2.2.2 Issues raised in submissions

EAL supports the provisions in the draft decision relating to information provision. In their submission they identified 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 EAL and the absence of a proper system model has been a major impediment to work around for our investments in the NT".

[2] 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

NT Solar Futures has 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).

2.2.3 GHD consideration and recommendations

Unencrypted models

The requirement for provision of unencrypted models to the Network Operator included in PWC's proposed amendment to clause 3.3.4 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 requirement for provision of encrypted models is specified in NER clause S5.2.4(6). This clause includes a qualification that the model source code is provided "in circumstances required by the Power System Model Guidelines". Those guidelines provide important details regarding the extent of black-boxing or partial encryption that may be adopted to protect IP.

The present practice in the NEM is:

a) The NER provides AEMO with access to the following modelling information for its own use (mainly for the purposes of any deep-dive / forensic analysis of the performance of models and to have good confidence that the model actually represents all the critical parts of the generating plant):

   (a.1) PSSE source code (RMS model with no black boxing, or encryption) and functional block diagrams

   (a.2) PSCAD models (EMT models) – with some black-boxing to mask any commercially sensitive IP). In some situations if AEMO considered the black-boxing masks important details, AEMO has requested more detailed PSCAD models, which manufacturers normally do not release to other parties.

b) AEMO will require the following for issuing to registered participants:

   (b.1) Encrypted PSSE model and Releasable User Guide (RUG). AEMO integrates this model into the NEM power system model stored in the OPDMS. The model is made available to participants as OPDMS with snapshots or study files.

   (b.2) PSCAD models (with most parts black-boxed) and RUGs sufficient to guide parties in the use of the PSCAD model. These models are provided to Network Service Providers to assess system strength issues by conducting Full Impact Assessment (FIA) studies. In this version of the PSCAD model most parts visible in above (a.2) could be black-boxed. Although AEMO is not presently issuing PSCAD models to registered participants, they are aware that they will have to provide the PSCAD models to the registered participants to review the FIA results, if the results produced by NSPs are challenged.

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. GHD understands that to provide comfort to the OEMs around the protection of IP, AEMO has instituted strict controls over the access to model source codes with access restricted to a few individuals.

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 NT Power System. Additional specialist personnel will be required by the Network Operator to manage the evaluation and acceptance of unencrypted models and systems will be required to securely store such models. This expense 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 RUG based on that accepted for use in the NEM.

There remains the potential that some equipment proposed for the NT power system may not yet have had a model accepted by AEMO for use in the NEM. To manage this situation it is appropriate to retain the requirement to provide unencrypted models however, we recommend revising the drafting proposed by PWC, to require model provision **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 encrypted 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. An approach that may be more effective for the NT Power system given its size is to only require un-encrypted models, as and when required.

When developing the guidelines PWC should consult with the Utilities 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. This alignment of model and information provision processes delivers consistency between the model and information provision process applicable in the NEM and the NT power systems. GHD therefore recommends that the proposed revisions be adopted.

We note 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. We recommend an appropriate definition be added to the Attachment 1 of the NTC. The following definition has been developed from that in the NT NER with amendments to reflect arrangements governing the NT power systems:

The following specific revisions to the amendments proposed by PWC are recommended.

(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.

(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.

***releasable user guide*:**

A document associated with a 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.

2.3 Clause 3.3.5 - technical requirements

2.3.1 Further revisions suggested by PWC

In its draft determination the Commission included a revision to clause 3.3.5 (d) to set a 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. PWC has requested that the wording specifying the timeframe be modified setting the timeframe 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 4 months for a connection offer to be made for an application to connect a generator to the distribution network.

2.3.2 Issues raised in submissions

Two submissions supported the inclusion of a firm deadline in the NTC for PWC to respond to proposed performance standards:

- EAL state: “EAL 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 EAL does not understand PWC’s request in their subsequent submission to remove this timeframe, as they have the final say over negotiated access standards. EAL also endorses GHD’s proposed wording”
- NT Solar Futures 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.

2.3.3 GHD consideration and recommendations

GHD considers that the revisions suggested by PWC provides greater flexibility regarding the timeframe within which the Network Operator must complete its assessment of a negotiated access standard. While not specifying a precise time limit, the proposed drafting requires that proposed negotiated access standards are assessed in a timeframe that allows the Network Operator to meet the timelines for issuing the connection offer. While the enhanced flexibility may assist PWC while it establishes systems and capability to efficiently assess access standards, as noted by EAL and NT Solar Futures the flexibility also creates additional uncertainty for generator developers regarding the time for assessing any proposed negotiating access standard.

In practice GHD expects that PWC will need to respond to a proposed negotiated access standard well within the time periods specified in NT NER clause 5.3.6, if PWC is to meet its obligations to provide a connection offer within the time frames specified in that clause.

When setting the time limit for the assessment of generator performance standards 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. GHD considers that the revisions proposed by PWC will create greater uncertainty regarding timing for the assessment of proposed negotiating access standards which is likely to impose a cost on generation developers. We therefore recommend the change requested by PWC be rejected. Experience in the NEM suggests that with appropriate processes and resources in place PWC should be able to meet the specified 30 day timeframe particular given:

- the obligations on generators to substantiate any request for a performance standard set at a level below the automatic access standard (NTC clause 3.3.5 (c)) and
- the 30 day time limit does not commence until the generator has provided all of the information required (NTC clause 3.3.5(d)).

Furthermore, given the need for performance standards to be agreed before a connection offer is made, it is likely that PWC would need to respond within 30 business days to meet the required timelines for developing the connection offer specified in NT NER 5.3.6.

GHD recommends that the changes to the draft decision proposed by PWC be rejected and the 30 business day period be retained. GHD does not recommend any changes be made to the draft decision made by the Commission.

2.4 Clause 3.3.5.1 - reactive power capability

2.4.1 Further revisions suggested by PWC

The Commission's draft decision recommended expanding clause 3.3.5.1 by adding subclauses (d) and (e) that allow a connection applicant greater flexibility in how it may meet reactive power requirements. The more flexible options specified reflect those allowed in the NEM and specified in NT NER clause S5.2.5.1 (d) and (e).

PWC has 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 operators 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.

2.4.2 Issues raised in submissions

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

- Assure Energy have suggested 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.
- EAL have suggested 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.

2.4.3 GHD consideration and recommendations

While the existing drafting of 3.3.5 allows connecting parties to propose negotiated standards, they provide little specific guidance for generators regarding the sort of changes to automatic access standards that may be accepted. GHD believes that there is value in retaining within the NTC explicit provisions similar to sub-clauses (d) and (e). We understand that similar provisions in the NER have been useful in negotiating more efficient arrangements for meeting reactive power requirements than providing capability matching the automatic access standard by expanding the capability of the generating systems and are therefore likely to provide valuable guidance for parties wishing to negotiate connection arrangements in the NT.

GHD agrees that the revisions proposed by PWC to sub-clauses (d) and (e) provide greater clarity while not reducing the guidance provided to connection applicants and we therefore recommend adopting the proposed revisions.

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. As such we believe that there is little risk that the positioning of sub-clauses (d) and (e) in clause 3.3.5.1 will result in a lack of clarity regarding the automatic access standard. we therefore see no benefit in moving this sub-clause to clause 3.3.5.

With respect to the change proposed by Assure Energy, we note that clause 3.3.5.1(a) as reflected in the Commission's draft decision specifies an automatic access standard that requires a generator to provide a level of reactive power equal to the product of 0.395 and the rated active power. This means that a generator rated to provide 100 MW of active power would satisfy the automatic access standard if it had the capability to produce +/- 39.5 MVAr of reactive power for the range of voltage conditions specified in clause 3.3.5.1(a)(2). It is therefore difficult to envisage how the automatic access standard could be interpreted as requiring an additional amount of reactive power capability to be provided.

If the 100 MW generator used in the previous example, was to operate beyond its rated output then the automatic access standard as proposed in the Commission's draft decision would require the generator to continue to provide +/- 39.5MVAr of reactive power even when operating beyond its rated active power capability. GHD agrees that it is unreasonable to expect that the generator should continue to deliver this level of reactive power if operating beyond its rated active power.

GHD recommends changing the drafting of clause 3.3.5.1(a)(1) to specify that the performance is to be delivered at any level of active power output not exceeding the rated active power of the generating system. We believe this is a simpler revision than that proposed by Assure Energy but addresses the issue raised. Adopting this recommendation would require clause 3.3.5.1 (a) to be revised to read as follows:

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

The revisions suggested by EAL seek to prevent PWC requiring the generator to provide more reactive power range than that required to accommodate the generator connection. GHD considers that the proposed revision is unnecessary as NTC clause 3.3.5 as specified in the Commission's draft decision already allows a connection applicant to propose a negotiated access standard which is lower than the automatic access standard provided the requirements of clause 3.3.5(a) are satisfied. These provisions would allow a generator to seek an access standard which specifies a lower reactive power range if they can demonstrate that accepting that lower range would not adversely affect power system security or the quality of supply for other Network Users.

2.5 Clause 3.3.5.3 – generating unit response to frequency disturbance

2.5.1 Issues raised in submissions

Territory Generation notes that compliance with the automatic access standard requires that generators remain connected provided the frequency remains within the envelope specified in clause 3.3.5.3. Conversely generators would not be in breach of the automatic access standard if they tripped immediately once the frequency moves outside the boundary specified in the automatic access standard. Territory Generation is concerned that the automatic standard as specified does not provide sufficient opportunity for

PWC and generators to agree on frequency trip settings that provide sufficient grading and prevents multiple generator tripping at once.

To address the issue Territory Generation recommends amending the NTC by adopting revisions described in section 2.3.1.6 of their submission to PWC dated 29 March 2019. 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 2 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 figure to show a box from 52 Hz to 53.5 Hz, for 2 seconds of continuous uninterrupted operation.

EAL has suggested 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 NT power system than in the NEM.

2.5.2 GHD consideration and recommendations

PWC considered the revisions suggested by Territory Generation but decided not to implement the suggested revision to the NTC. In their published response to the submission PWC state, "At this stage we propose to leave the status quo accepting that there is no connection requirement for uninterrupted operation above 52 Hz. However this is a technical matter to be coordinated under NTC clause 3.3.3, which would require for power system security that the over frequency protection on generators throughout each power system are graded to ensure that generator over-frequency trip events do not all occur concurrently. We are in the process of developing our system dynamic models which will assist in the coordination of technical matters such as this."

GHD has considered the concern raised by Territory Generation. We agree 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. We do not believe that the revisions proposed by Territory Generation would offer any greater certainty of achieving this than the drafting of clause 3.3.5.3 proposed in the Commission's draft decision. The wording proposed by Territory Generation simply moves the problem from 52 Hz to 53.5 Hz.

The risk can be addressed if over frequency trip settings are appropriately coordinated and we agree that 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. We therefore do not expect that the automatic access standard as proposed in the Commission's draft decision will impede appropriate coordination of generator over-frequency protection settings.

GHD has 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. 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. We believe therefore that 10 minutes is a reasonable timeframe for the NT power systems.

As such we do not recommend any further revision to NTC clause 3.3.5.3.

2.6 Clause 3.3.5.4 – definition of normal and nominal voltage

2.6.1 Further revisions suggested by PWC

In addition to accepting the revisions to clause 3.3.5.4 proposed by the Commission in the draft decision, 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*.

2.6.2 Issues raised in submissions

EAL has raised 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. EAL is concerned that the high and low voltage requirements may therefore exceed the capability of common inverters.

2.6.3 GHD considerations and recommendations

GHD had considered the concern raised by EAL, 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.

2.6.3.1 Is the use of the term normal voltage appropriate in NTC clause 3.3.5.4?

The drafting of clause 3.3.5.4 and in particular the use of the term normal voltage to define the high and low voltage ride through requirements reflects the specification of those requirements in the NER NT clause S5.2.5.4 which reflects the same clause in the NER. In the NER NT normal voltage is defined as follows:

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 *AEMO*, for that *connection point* at the request of the *Network Service Provider* who provides *connection* to the *power system*.

GHD understands that the definition of normal voltage is intended to allow the network service provider and AEMO to agree to design and operate portions of the power system at voltages that differ from the nominal voltage. In choosing the normal voltage a consideration would be the ratings and capability of already connected plant and equipment.

The normal voltage should be specified at the time a connection is being negotiated so that a connecting generator can take that into account when specifying plant and equipment. If a normal voltage was not defined during the connection negotiation process and the generator has taken the normal voltage to be the nominal voltage in designing and specifying equipment, then this should be taken into account when assessing the appropriate performance standard for that generator. This could be achieved by the Network Operator specifying that the normal voltage for this connection point is the nominal voltage. Alternately if the Network Operator believes the normal voltage should be set to a level other than nominal the process specified in NTC clause 3.3.5 should allow a negotiated standard reflecting the generator's capability to be agreed.

In the NER and NER NT the system standards require voltages to remain within 110% and 90% of the normal voltage except as a consequence of a single credible contingency. The NTC defines the system voltage standard somewhat differently. While NTC clauses 2.3.2 and 17.1.1 specify the voltage rise following a credible contingency with reference to a percentage change in the normal voltage, NTC clause 2.3.1 and 15.2 specify the steady state voltage variation for areas of the network operating at greater than 11 kV, must be within 110% and 90% of nominal voltage. The adoption of the term nominal voltage in clause 15.2 gives rise to the potential for the continuous ride through requirements in specified in NTC clause 3.3.5.4 to exceed the system standard specified in NTC clause 15.2, this will occur where the normal voltage exceeds the nominal voltage.

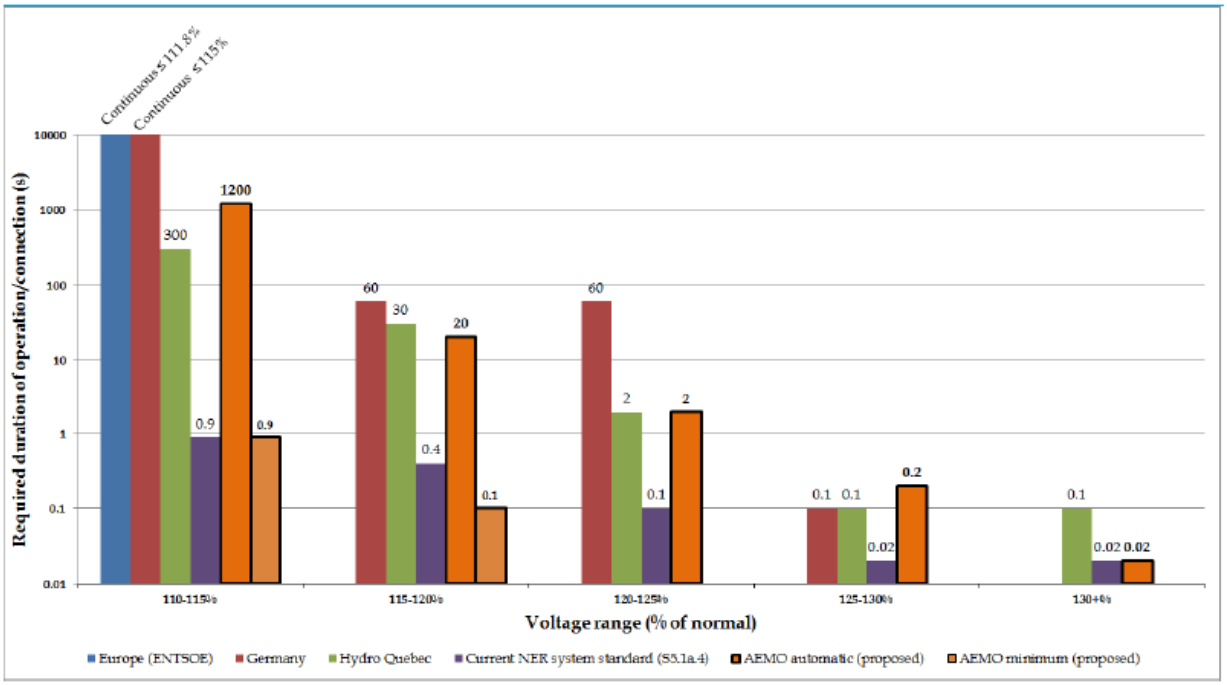
The intent of the voltage ride through requirement specified in NTC clause 3.3.5.4 is to specify an automatic access standard that exceeds the voltage fluctuations permitted by the system standard. In this way the Network Operator has a high degree of confidence that generators will ride through voltage disturbances that meet the system standard. It is consistent with this for the automatic access standard specified in NTC clause 3.3.5.4 to be specified with reference to the normal voltage.

2.6.3.2 Is the voltage ride through requirement in NTC clause 3.3.5.4 appropriate?

EAL has raised a concern that the voltage ride through requirements specified by the automatic access standard specified in NTC clause 3.3.5.4 may not be able to be met by commonly available inverters.

The AEMC consider this question as part of its 2018 review of generator technical performance standards. The AEMC compared the proposed automatic and minimum over-voltage performance standards with those adopted in a number of jurisdictions around the world with the results plotted in Figure 1.

Figure 1 Comparison of NER over-voltage ride through requirements with international practice[3]



[3] Figure 10.3 from AEMC final determination regarding the 2018 generator technical performance standards rule change: https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

The AEMC concluded that from its analysis including the results shown in Figure 1 that, “the over-voltage requirements in the proposed automatic access standard were comparable, and in many cases less arduous, than standards in other jurisdictions.”[4]

As part of its review the AEMC sought information from equipment suppliers regarding their ability to meet the proposed performance standards. The AEMC identified that while some equipment suppliers may not be able to meet the automatic access standard, “there are still several manufacturers available from all of the technology types surveyed that can guarantee their equipment can meet over-voltage and under-voltage requirements for AEMO’s updated proposed automatic access standards for S5.2.5.4 of the NER, and most equipment manufacturers can guarantee their equipment can meet the requirements of the proposed minimum access standard.”[5]

As the performance standard in NTC Clause 3.3.5.4 aligns with the updated automatic access standard proposed by AEMO, GHD believes it is reasonable to expect that some equipment suppliers for all technology types considered by the AEMC will be able to meet the voltage ride through requirement proposed in the draft decision published by the Commission. Generators who are unable to meet the automatic requirement can use the processes in NTC clause 3.3.5 to agree a negotiated performance standard. GHD therefore believes the voltage ride through performance levels specified in clause 3.3.5.4 are appropriate. We do not recommend any revision to the draft decision to address the concerns raised by EAL regarding the NTC clause 3.3.5.4.

GHD has reviewed the definition of nominal voltage proposed by PWC and recommends this definition be added to Attachment 1 as it will improve clarity for users of the NTC.

2.7 Clause 3.3.5.5 – generating system response to disturbances following contingency events

The Commission’s draft decision included revisions to clause 3.3.5.5 to introduce two cumulative thresholds that sought to impose restrictions on the requirement to ride through multiple contingency events which were consistent with those in the relevant clauses in the NT NER. Those revisions were considered necessary given ambiguity in the interpretation of other sub-clauses, which might otherwise expose a connecting applicant to excessive ride through requirements that may be difficult and expensive to satisfy.

2.7.1 Further revisions suggested by PWC

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.

2.7.2 Issues raised in submissions

EAL has raised 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.

[4] AEMC final determination regarding the 2018 generator technical performance standards rule change: https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

[5] AEMC draft determination on the 2018 generator technical performance standards rule change: https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

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

2.7.3 GHD considerations and recommendations

GHD has considered 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. Our assessment was enhanced by the opportunity to meet with PWC representatives on 8th January 2020 to clarify various aspects of their proposed revisions. Our key findings are:

1. The revised clause proposed by PWC presents provisions which describe a sequence of faults that generators may be exposed to when connected to NT power systems.
2. 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))
3. 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 ms is consistent with a fault sequence which would be permitted by the existing planning criteria in the NTC:
   a) with the 15 faults being of the type nominated in clause (d) (i.e. 6 faults resulting in a deep voltage reduction consistent with sub clause (d)(1), one fault cleared by breaker fail protection, and the remaining faults spread between the different connection voltages specified in NTC clause 2.9.4 (c);
   b) all faults resulting in deep voltage reduction and the single fault cleared by breaker fail protection are assumed to produce a transient voltage dip consistent with NTC clause 16.2.6.

   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 it typical for faults actually experienced with the NT power systems.
4. While the accumulated time threshold for voltage <90% proposed by PWC is significantly longer than that adopted in the NER, PWC has provided evidence showing that the proposed time of 60,000 ms is consistent with a maximum series of six events over a 5 minute window in which each event causes a fluctuation described by NTC 3.3.5.4 (a)(7), which requires continuous uninterrupted operation for a disturbance of 10 seconds between 80-90% of normal voltage. Such a fault sequence would be permitted by the existing planning criteria for short duration voltage disturbances in the NTC clause 17.1(a).

   Similar to the case above there is no fault recording data available to determine if the accumulated time threshold would be typical for faults actually experienced with the NT power system.
5. The accumulated time thresholds are significantly greater than those adopted in the NEM. 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. This information is presented in section 2.7.3.1. It is uncertain whether generators will be able to meet the accumulated time thresholds proposed in the revised automatic access standard nominated by PWC. While we note that should a generator identify particular difficulties in meeting the accumulated time threshold in the automatic access standard they could seek to negotiate a lower threshold utilising the process defined in NTC clause 3.3.5, the lack of actual fault information available is likely to impede that negotiation process particularly for generators captured by the transition process described in NTC Clause 12. We recommend PWC commence recording fault information for NT power systems so that

they are able to assess the likelihood of the cumulative time across any 5 minute period with the voltage at a connection point falling below the thresholds specified in the proposed automatic access standard. PWC confirmed during the meeting on 8th January that this information is not currently recorded.

6. We recommend that the cumulative time threshold specified in the automatic access standard be reviewed once a sufficient set of actual fault records for NT power systems have been analysed, until then we recommend 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.
7. The ability of generators to be able to remain in continuous uninterrupted operation in the NT power system is an important characteristic for PWC to understand. For this reason GHD recommends that the Commission includes 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. The Network Operator will collect this information and compare with recorded fault data to determine the actual risk faced during typical disturbances on the NT networks.

2.7.3.1 Accumulated Time Threshold - Considerations from NEM Rule Change Process

GHD has reviewed the 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. Table 1 lists the cumulative thresholds specified in the NER.

Table 1 - Cumulative thresholds specified in the NER

Measure	Automatic Standard	Minimum Standard
accumulated time across 5 minutes with connection point voltage < 90% of the normal voltage	1800 ms	1000 ms
time integral of the difference between 90% of the normal voltage and the connection point voltage across any 5 minutes considering only times when connection point voltage < 90% of the normal voltage	1.0 pu seconds	0.5 pu seconds

The original rule change proposed by AEMO only specified the first accumulated time threshold. In developing the rule change proposal AEMO surveyed a number of generator technology manufacturers to assess the ability of their technology to ride through multiple contingencies.

AEMO reported that: “In the wind turbines typically installed today, total fault duration is the most critical factor because it determines the amount of heat dissipated across the dynamic braking chopper or dump resistor connected to the power electronic converter's DC-link. Similar concepts apply to the inverters that interface solar photovoltaic (PV) or storage systems with the network. Older forms of wind turbine technology tend to have more limitations on multiple disturbances, citing concerns regarding residual charge of auxiliary power supplies and potential mechanical stress in wind turbine components.”[6]

In the same document AEMO provided the following table summarising the ride through information provided by manufacturers of asynchronous generators (such as inverter connected wind farms and solar farms). The maximum accumulated time advised by most manufacturers fell well below the 10,000 ms proposed by PWC. This does not mean that all manufacturers are unable to meet the fault duration time proposed by

[6] AEMO rule change submission: https://www.aemc.gov.au/sites/default/files/content/1e3e9d43-a82d-4d12-ac84-45e30d6eea72/Rule-change-request.pdf

PWC as the ride through capability will depend on the sequence of faults not just the total fault duration, however it does suggest that some manufacturers may not be able to meet the proposed automatic access standard.

Table 4 Capability of various types of wind and solar plant to withstand multiple faults

Manufacturer	Total fault duration withstand capability (ms)	LVRT activation threshold (% of nominal voltage)	Pre-set limit allowing maximum number of successful ride-through events	Compliant or able to modify operation to comply with the proposed requirements
Manufacturer 1	1,800–2,400	80	N/A	Yes
Manufacturer 2	Unknown	80	N/A	Unclear
Manufacturer 3	1,800–2,000	90	15	Yes
Manufacturer 4	>2,400	90	20	Yes
Manufacturer 5	2,000	60–80	N/A	Yes
Manufacturer 6	2,000	85	10	Yes

The second criteria (time integral) was introduced by AEMO following further system studies and stakeholder feedback[7]. Importantly, those studies considered the impact of increasing the accumulated voltage and time integral threshold by simulating a more onerous sequence of faults than that defined by the NER automatic access standard. The simulations identified issues with generators being able to ride through sequences with accumulated time thresholds >1800 ms.

It therefore appears likely that some generators wishing to connect to NT power systems may have difficulty in meeting the accumulated time thresholds proposed by PWC which are significantly longer than those specified in the NER.

GHD 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. 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.

The recommendations by GHD to the Commission will result in Paragraph 3.3.5.5(d) now reading as follows:

(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*;

[7] AEMO supplementary report: https://www.aemc.gov.au/sites/default/files/2018-03/AEMO%20report%20updated%20proposed%20multiple%20fault%20withstand%20obligation.pdf

~~(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;~~

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

(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.

~~(7) 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~~

(8) ~~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~~.

Further we recommend that PWC commence collecting fault data and develop fault statistics for NT power systems that will assist in processing any requests and assessing the risks associated with any proposed negotiated connection standards and that the following new sub-clause 3.3.5.5(l) be adopted with subsequent sub-clauses renumbered:

(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*.

2.8 Clause 3.3.5.11 – frequency control

Clause 3.3.5.11 was amended in the draft decision by making the requirement for renewable generators to provide frequency response subject to energy source availability. Those changes were intended to clarify that a renewable generator need only meet the stated frequency control capability if there is sufficient energy available from the renewable energy source to do so (i.e. sufficient sunlight in the case of a solar farm).

2.8.1 Further revisions suggested by PWC

PWC has 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 NER NT S5.2.5.11, and
- the inclusion of the phrase in sub-clause (b)(2) may create confusion (and the unintended introduction of semi-scheduled generation)

2.8.2 Issues raised in submissions

Jacana Energy welcomed 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 a significant impost would be placed on new entrant generators.

NT Solar Futures has considered the further revisions suggested by PWC. They assert that the removal of "energy source availability" from sub-clause 3.3.5.11(b)(1) is reasonable but unnecessary. NT Solar Futures 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. NT Solar Futures believe that all generators should try to contribute what they can to maintain the system regardless of their capacity forecast.

EAL endorsed the approach proposed in the Commission's draft decision making the frequency response requirement subject to energy source availability. EAL expects that PWC's interpretation of this clause to result in no pre-contingent curtailment on solar farms in the DKIS, whether under an automatic or negotiated access standard. EAL 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. EAL states that it would be a positive step to include some commentary within the clause to that effect.

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

2.8.3 GHD considerations and recommendations

2.8.3.1 Consideration of 3.3.5.11 (b)(1)

GHD has reviewed again the drafting of clause 3.3.5.11(b)(1) to consider the impact of omitting the phrase "subject to energy source availability". 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".

A narrow interpretation of the meaning of "in response to" may mean that a renewable generator that suffered a change in output due to a reduction in the available energy source would not be in breach of the requirement specified in clause 3.3.5.11(b)(1) as the change in output was not directly in response to a frequency change. Applying this narrow interpretation would mean that a scenario where a cloud cover event reduced the output of a solar farm (i.e. reduced the available energy source) and that event coincided with a reduction in system frequency would not be considered a breach of the performance standard. A breach would only occur if the solar farm had active frequency controls that responded directly to an under-frequency event by reducing the solar farm output.

A broader interpretation of "in response to" may capture a change in generator output that occurs at the same time as the under-frequency event. Applying this interpretation to the example of the cloud event occurring at the same time as an under-frequency event may lead to the generator being assessed as not meeting the performance standard as its output reduced at the time the power system frequency was falling.

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.

While PWC correctly note 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, the frequency control framework applying in the NT power systems is different to that in the NER. In the NER, clause S5.2.5.11 defines a capability which is to be demonstrated during commissioning, but need not be available during actual system events unless the generator is providing a frequency control ancillary service. Revisions to the NER to re-introduce mandatory primary frequency response obligations may result in revisions to the frequency control provisions in the NER. GHD therefore believes 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.

In order 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). We recommend therefore that the Commission reject the revision to clause 3.3.5.11(b)(1) proposed by PWC.

2.8.3.2 Consideration of 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 does not believe that this addition creates any improved clarity. It is also unclear why including the original revision proposed in the Commission’s draft determination 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 had 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 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. GHD agrees with the arguments presented by NT Solar Futures 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, in our opinion 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.

We recommend therefore that the Commission reject the revision to clause 3.3.5.11(b)(2) proposed by PWC.

GHD believes that it would be inconsistent with the proposed wording of NTC clause 3.3.5.11 and the proposed amendment of SCTC clause 4.3(a)[8] for PWC to constrain off or curtail renewable generators

[8] This amendment adds sub-clause (7) to clarify that scheduling any ancillary services from generators other than Territory Generation should not result in a reduced dispatch level

during normal operation, where the generators are complying with their GPS, to increase their frequency response capability. We therefore do not believe that additional wording is warranted to address the concerns raised by EAL.

2.9 Clause 3.3.5.12 – impact on network capability

2.9.1 Issues raise in submissions

EAL has expressed concerns regarding the ability of generators to negotiate access standards with PWC that are lower than the automatic access standard. EAL 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. EAL believes that no justification has been provided for removing this standard from the NER NT. It is EAL's view that network transfer capacity is there to be used and should first be used by loads and secondly by generators, in that order. 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 NSPs should be required to negotiate suitable control system solutions with generators to do so, rather than the other way around.

2.9.2 GHD consideration and recommendation

GHD accepts that PWC will have greater knowledge of the capability of the NT 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. GHD believes these additional requirements should be sufficient to address the concern raised by EAL.

We do not recommend any additional revision to clause 3.3.5.12.

2.10 Clause 3.3.5.13 - voltage and reactive power control

2.10.1 Further revisions suggested by PWC

PWC has proposed a 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 NT power systems.

2.10.2 Issues raised in submissions

In its draft decision the Commission amended clause 3.3.5.13 adopting GHD's recommendation to require each control system to have permanently installed and operational disturbance monitoring and recording facilities for key variables including each input and output. EAL has raised concerns that the requirement for continuous monitoring is an arduous requirement and should be removed.

2.10.3 GHD considerations and recommendations

GHD has reviewed the revisions proposed by PWC. We recommend those revisions be adopted as they will improve clarity by addressing issues introduced by the revisions included in the draft determination. The recommended revisions are:

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

In addition we note 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 we recommend deleting the word excitation from the first sentence in sub-clause 3.3.5.13(b)(2). With this revision and that proposed by PWC the sentence will now read, “The ~~excitation~~ control system of a ~~synchronous~~ *generating unit* shall be capable of:”.

With respect to the issue raised by EAL, GHD does not agree that the requirement to provide monitoring is overly onerous. We note 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. We believe that the concerns raised by EAL 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).

GHD does not recommend any further revision to clause 3.3.5.13 to address the concern raised by EAL.

2.11 Clause 3.3.5.14 - active power control

In its draft decision the Commission introduced a revision to clause 3.3.5.14 to make meeting the level of performance specified in the automatic access standard subject to energy source availability. This revision was considered necessary to clarify how energy source availability should be considered in assessing the ability to meet the automatic access standard for active power control.

2.11.1 Further revisions suggested by PWC

While accepting the need for greater clarity regarding how energy source availability is to be considered in assessing the ability to meet the active power control requirements, PWC has proposed further revisions to this clause to further 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.

The changes proposed by PWC seek 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.

PWC feels that the following points should be clear in regard to the interaction between this clause and NTC 3.3.5.17. The sequence intended is as follows:

- Generator provides a capacity forecast in accordance with 3.3.5.17.
- NTESMO incorporates the capacity forecast into its dispatch algorithm (SCTC).
- NTESMO issue dispatch target to generator (SCTC).
- Generator accurately follows the dispatch target (this clause 3.3.5.14)

The final outcome is that all generators are capable of being classified as scheduled and the issue of energy source availability is managed through the capacity forecasting requirement.

2.11.2 Issues raised in submissions

EAL supported the inclusion of subject to energy source availability in this clause as proposed in the Commission’s draft decision. EAL 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.

NT Solar Futures 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”. NT Solar Futures is concerned that such a change would remove the flexibility for system control. 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.

2.11.3 GHD considerations and recommendations

GHD has considered the revisions proposed by PWC and we recommend the Commission accept those revisions except for the change to 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”. We agree with the argument put by NT Solar Futures that this change would not be 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. The updated clause should be:

“(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.”

The remainder of the revisions proposed by PWC provide greater clarity regarding the performance requirements for capacity forecasts and active power control. They seek to relocate some of the performance criteria that more directly apply to active power control capability from 3.3.5.17. Those revisions do not materially change the costs to connecting parties and we recommend they be accepted by the Commission.

2.12 Clause 3.3.5.15 - inertia and contingency FCAS

2.12.1 Further revisions suggested by PWC

PWC has suggested a similar revision to 3.3.5.15 to that proposed for 3.3.5.11(b)(2).

2.12.2 Issues raised in submissions

EAL requested that the wording of this clause be reviewed to give clear effect to the intent expressed in the explanatory noted 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.

EAL also did 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”.

NT Solar Futures also did 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”. NT Solar Futures 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.

2.12.3 GHD considerations and recommendations

GHD agrees with the concern raised by NT Solar Futures and recommends the revision proposed by PWC be rejected by the Commission.

GHD believes the additional concern raised by EAL was adequately considered in the draft decisions and we do not believe any additional revision to this clause is warranted.

2.13 Clause 3.3.5.16 – system strength

2.13.1 Further revisions suggested by PWC

PWC has proposed revisions to this clause that:

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

PWC suggests that the requirement to review the NT system strength guidelines when any change is made to the AEMO guidelines should be removed as revision made to the NEM guidelines may not be applicable in the NT given the very different characteristics of the NEM and the NT power systems.

2.13.2 Issues raised in submissions

While EAL supports the preparation of system strength impact assessment guidelines for the NT power systems, EAL is concerned that PWC may not be the correct party to develop those guidelines and 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.

EAL does not understand the concern expressed by PWC regarding the need to review the guidelines for the NT power system should the equivalent NEM guidelines by amended.

EAL is concerned regarding the transparency of any application of the assessment guidelines if the EMT models are restricted only to PWC.

2.13.3 GHD considerations and recommendations

GHD agrees that there are significant differences between the NEM and the NT power systems and that not all revisions to the NEM guidelines are likely to require revisions to the NT guidelines. However we do not agree that it is wise to completely remove the requirement on PWC to assess whether the NT guidelines need to be altered when changes are made to the NEM guidelines.

We accept that a complete review of the NT guidelines may not be necessary whenever the NEM guidelines are revised and acknowledge that the drafting included in the draft decision may be interpreted as requiring this. We therefore propose changing the sub-clause 3.3.5.16 (a) to read as follows (revised text is highlighted in yellow):

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 ~~review~~ 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.

GHD recommends that the other revision proposed by PWC be accepted as it simply allows for the use of the AEMO guidelines until NT specific guidelines are developed.

Regarding the other concerns raised by EAL, GHD notes that access to the EMT model has been discussed in section 2.2.3 of this report. We believe that adoption of the recommendation proposed in this section should address the concerns raised by EAL.

2.14 Clause 3.3.5.17 – capacity forecasting

2.14.1 Submission on draft decision by PWC

The 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.*

2.14.2 Issues raised in other submissions

In their submission Jacana Energy did not support the introduction of minimum accuracy requirements for new entrant generators proposed in clause 3.3.5.17 of the NTC. They believed that this placed an unfair burden on new entrants compared to incumbent generators to address stability and reliability matters in the network.

EAL were concerned with the high cost of implementation of a battery energy storage system on top of their existing investment in order to meet the capacity forecasting requirements of the GPS in clause 3.3.5.17. They believe 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 because such a system could provide additional ancillary services that would not be possible when installed at a single solar generation site with limited capacity available at the connection point. EAL did acknowledge that there was nothing in the GPS that prevented them 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.

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

In their submission NT Solar Futures agreed with the wording changes to 3.3.5.17 except the removal of clause (f). They believed that (f) was 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. NT Solar Futures stated 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.

In their submission Assure Energy presented very detailed analysis that they had commissioned of the capacity forecasting clauses in 3.3.5.17 in the proposed NTC. From that analysis they 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 $10m) or agreeing to an acceptable negotiated performance standard for the capacity forecasting components of the NTC.

Assure Energy stated that they believe that system security issues are best deal with at an aggregate level so that individual solar generators are not charging and discharging batteries simultaneously to meet their individual forecast accuracy requirements. They also noted 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.

2.14.3 GHD consideration and recommendations

GHD has reviewed the changes proposed by PWC and 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. It should be noted that clause 3.3.5.17 (f) from the draft determination 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.

GHD acknowledges the submissions from generators relating to their concerns about their ability to achieve, and the cost of being able to comply with, the capacity forecasting requirements of clause 3.3.5.17. As detailed in our earlier report to the Commission, GHD agrees that the capacity forecasting requirements in the NTC 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 properly assess how best to invest to meet these requirements. Further 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.

To achieve this GHD recommended that PWC 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 GHD recommends that, as part of the process to be followed in publishing the procedure referred to in the now updated 3.3.5.17(f) that the System Controller should seek feedback from interested parties, including the Utilities Commission and network users, prior to developing this procedure. To ensure this occurs GHD recommends that the Commission make a modification to 3.3.5.17(f) so that it reads:

"(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."

2.15 Clause 12 - transitional arrangements and derogations from the code

In its draft decision the Commission introduced revisions to clause 12.3. This clause applies to generators who have negotiated a connection agreement prior to version 4 of the NTC coming into force and did not connect to the network prior to 1 April 2019. The clause places obligations on these generators to negotiate a set of generator performance standards consistent with version 4 of the NTC. The clause sets out a framework and timeline for negotiating the generator performance standards. The revisions introduced by the Commission removes obligations on generators to fund the Network Operators reasonable costs in assessing any negotiated performance standards. The revisions effectively mean that the Network Operator's costs incurred in assessing any negotiated access standards for generators captured by clause 12.3 will be paid by network users through regulated tariffs.

2.15.1 Submission on draft decision by PWC

PWC have proposed that the specific provisions requiring generators to fund their reasonable cost 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; and
- 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.

2.15.2 Issues raised in other submissions

In their submission EAL expressed concern around the choice of the cut-off date for application of version 3 of the code as being 1 April 2019. EAL stated that they are exposed to the risk of having to transition to

version 4 of the NTC more than any other stakeholder in the NT power system as they own over 80% of the capacity currently committed and under construction. EAL are especially concerned about the cost of compliance with the capacity forecasting clauses of the draft decision. EAL stated that their main concern is that already sanctioned and committed projects are not being grandfathered. EAL 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 NT, a form of energy generation that relies on a low cost of capital, thereby creating an additional unnecessary barrier to market entry.

Jacana Energy requested that the Commission ensures 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 they consider that this may delay the connection of new generation to the NT grid.

NT Solar Futures stated in their submission that the proposed transitional arrangements in Clause 12 do not affect them but believe it is unfair that if 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. NT Solar Futures believe that there is no incentive for PWC to conclude negotiations and behave reasonably and that this exposes generators to unknown and uncontrollable costs.

In their submission Territory Generation requested that the Commission modify Clause 12 to ensure that plant connected to the network at 1 September 2012 would continue to be subject to grandfathering provisions. Territory Generation proposed 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".

Territory Generation were 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 would be problematic. They stated 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.

Territory Generation supported the provisions in the draft decision that would not require Territory Generation to recompense PWC their expenses for the compliance testing.

Territory Generation expressed concerns with proposed clause 12.2(f) which would require them to meet full compliance with the NTC if existing plant is modified. Territory Generation 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 Territory Generation 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. They believe that this is a dis-incentive to making any upgrade to a generating unit or power station and will lead to suboptimal outcomes. To address this concern Territory Generation requested that the modification provisions in proposed clause 12.2(f) be updated 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)."

Territory Generation suggested that a general grandfathering provision should be included in the SCTC to cover all changes to the SCTC that affect existing generators.

Territory Generation were pleased to see that PWC was provided with a number of actions to be performed in response to Territory Generation's submissions. Territory Generation suggested that indicative timelines should be explicit and implementation of action items are monitored by the Commission.

Territory Generation noted that, in the proposed NTC Clause 12, the grace period for new generators connecting to the system would be between 1 to 13 months to comply with the GPS. As the current supplier of ancillary services, Territory Generation noted that there would be increased pressure on Territory Generation to provide additional ancillary services. They stated that they would like a mechanism to be implemented to provide adequate compensation recover the costs of providing these services.

In their submission Assure Energy stated that if the Commission continues with the proposed GPS, they believe that an additional element of grandfathering would be 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 stated that these are projects that have committed to investment in the Northern Territory (and are currently delivering that investment). The projects were struck before the rules came to light and so the economics do not take into account the proposed GPS. The accuracy requirements of the capacity forecasts in the proposed GPS will have a major impact on the financial viability of their Project and future investment decisions. If the proposed GPS is implemented for future projects then they can factor in the design, economics and broader implications into the negotiations and investment decision but already committed projects have not been able to make this consideration.

2.15.3 GHD consideration and recommendations

GHD understands that this matter is a policy issue, not a technical one and the wording in the draft decision was not covered in the original GHD report. As such GHD will present a summary of the submissions made following the draft decision for the Commission to consider when making their final decision.

Grandfathering issues

GHD believes that the provisions of Clause 12.2(a) and (b) and 12.3(a) and (b) are consistent with the consultation process that has taken place when developing the new GPS. The recommended outcome from PWC's proposed new GPS follows two years notice that new standards were to be introduced for the Territory's regulated power systems (including the publication of proposed draft standards), as well as over 12 months formal consultation by PWC followed by consultation by the Commission on its draft decision. New licensees were also advised that they should take into consideration the changing framework when designing connections to the network 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. Because of this GHD does not recommend any changes to clauses 12.2(a) and (b) or 12.3(a) and (b). Likewise, GHD sees no value in adding 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

Territory Generation in their submission raised the issue of having to achieve full compliance with the NTC if they make modifications to existing plant. They believe that this is a dis-incentive to making any upgrade to a generating unit or power station and will lead to suboptimal outcomes for example upgrading a control system on existing plant which would not be able to achieve compliance with the GPS unless it was completely replaced. To address this concern Territory Generation requested that the modification provisions in proposed clause 12.2(f) be updated 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)."

GHD agrees with this proposal as it will allow PWC to determine if the changes proposed to existing plant do or don't 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. GHD therefore recommends that the Commission adopts Territory Generation's proposed revisions to clause 12.3.

Allocation of costs to achieve GPS compliance in Clause 12.3

GHD 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.

A generator that negotiated a connection application after 1 April 2019 will have already funded the Network Operator's costs associated with processing the original connection application. Clause 12.3 as proposed by PWC would require the generator to fund additional costs on top of those already paid. The additional costs being those incurred by the Network Operator in assessing proposed performance standards, negotiating revisions to connection agreements and assisting with tests to establish whether a generator meets proposed performance standards. It is possible that these additional costs will be greater than the costs the generator may have faced if it was able to negotiate performance standards as part of its original connection application.

Impact on customers

Customers stand to benefit from the introduction of new performance standards as they should reduce power system security risk. It could be argued that customers through regulated charges have funded the development of the changes to the NTC to implement the generator performance standards and that it may not be appropriate that customers fund the additional costs incurred by the Network Operator in negotiating performance standards with generators captured by Clause 12.3.

Encouraging efficient negotiation process

If generators are only required to fund their own costs they may not face the same incentive to efficiently negotiate a set of performance standards as they would if they pay not only their costs but also the reasonable costs incurred by the Network Operator. Alternatively some submissions from generators were concerned that the Network Operator may not efficiently negotiate a set of performance standards if the generator is paying their costs and that "this exposes generators to unknown and uncontrollable costs".

Consistency with previous stakeholder consultation

PWC has asserted that the provisions in clause 12.3 are consistent with information provided to stakeholders during the one year consultation used to develop the proposed revisions to the NTC. GHD has reviewed the issues paper published by PWC in June 2019 and confirmed that document included the following statement.

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

While this statement provides evidence that impacted generators were made aware of the need to meet the proposed performance standards. It is unclear when they were first made aware of the requirement to fund the costs incurred by the Network Operator in assessing any proposed negotiated access standards. In the absence of any explicit information regarding the allocation of costs, GHD expects that it would have been reasonable for impacted generators to expect that similar funding arrangements to the connection application would apply (i.e. generators funding the costs).

After considering the various reasons provided by all parties making submissions on the draft decision GHD believes 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. We therefore recommend that the Commission does not adopt PWC's proposed revisions to clause 12.3.

Development of guidelines for GPS

Submissions from Territory Generation 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 recommends that the Commission adds an additional clause: 12.3(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 specified in 3.3.5.

Schedule S4 of the NTC as presented in the Commission's draft decision used the acronym GPS in note 1 to refer to generator performance standards. To avoid confusion with different uses of GPS in other clauses of the NTC, GHD recommends replacing the term GPS in note 1 of Schedule S4 with the words generator performance standard.

2.16 Further amendments to the NTC proposed by PWC

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 proposed 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, GHD has only been provided with proposed drafting for clause 2.2.2. 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) we recommend the Commission endorse the suggested revision to clause 2.2.2.

3. Additional matters raised in submissions

The submissions made during the consultation on the Commission's draft decision, including those from Jacana Energy, EAL, Assure Energy, NT Solar Futures and Territory Generation indicated that the implementation of the Northern Territory Electricity Market and in particular an ancillary services market would allow generators to be paid for provision of ancillary services and also make a centralised battery or a centrally controlled distributed battery solution more attractive to proponents. This may provide a more efficient way to achieve the level of forecasting accuracy required by the NTC across the entire generation fleet. While the NTC does not provide any barriers to generators negotiating with third parties or co-operating with each other to establish a centralised battery the full benefits of such a solution including voltage control, frequency control and black start services are unlikely to be achieved without a competitive electricity and ancillary services market. At this point in time such a market does not exist and as such the development of the NTC is unable to implement a mechanism to deliver these associated benefits.

GHD understands that the Northern Territory government has been contemplating further electricity market reforms and commenced consultation in early 2019 to determine the form of a reliability standard to ascertain whether the combination of generating units is sufficient to meet the desired standard for customers. The lack of a competitive ancillary services market whereby other parties can be paid for providing these services, means that the provision of a centralised battery solution may not eventuate. 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, also in early 2019. At this point in time there has been no further progress on this matter which may ultimately provide efficient alternatives to achieve GPS outcomes. The NTC has been developed in the absence of such reforms and as such has been designed to address the technical capabilities of network connected generation.

GHD has no recommendations to the Commission for changes that can be made to the NTC to address these matters.

4. Conclusions and Recommendations

GHD has reviewed the revisions proposed by PWC to the NTC as well as the submissions made by stakeholders as part of the consultation process.

Following consideration of all submissions GHD has made recommendations to the Commission on changes to drafting of clauses in the NTC. GHD recommends adopting those revisions as the resulting drafting appropriately balances:

- the desire for system security;
- the costs imposed on generators needing to conform to the GPS; and
- the allocation of risk and cost among connecting generators, PWC and System Control.

GHD has considered the inputs from all submissions and developed a recommended set of revisions to clauses in the NTC. An overall summary of the recommended changes to the drafting of the clauses is provided in Table 2.

Those clauses for which we are recommending revisions be made to the drafting that appeared in the Commission's draft decisions are shown in full in Table 2 with the revised text highlighted in yellow deleted text shown as ~~struck out~~ and new sections of sub-clauses highlighted in green.

Table 2 - Recommended revisions

NTC Clause or topic	Concerns and recommendations
General corrections	In principal GHD has no objection to implementing the general corrections proposed by PWC although we would recommend careful review of such changes to reduce the risk of errors being introduced inadvertently.
Use of NT NER definitions	The definitions for the following terms proposed in the Commission's draft decisions should be retained as the NER NT definitions are not immediately applicable to NT 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) Amendments to some of these definitions are recommended in section 2.1.3 We recommend that the term transmission system be italicised rather than defined in Attachment 1 as the definition in the NER NT is appropriate for NT power systems
3.3.4	The term releasable user guide should be defined in NTC Attachment 1
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;

NTC Clause or topic	Concerns and recommendations
	(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 ~~may~~ 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 of 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 (g), 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 (h) to provide a releasable user guide 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 (h) to provide a form of the model source code that the Network Operator received from a Generator or from any

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	other source, the Network Operator must provide that information: (i) only in the form of, at the Network Operator's discretion: ~~(A) complied information (such as,gor example compiled Fortran code in object code or dynamic link library (DLL form);~~ (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 (h) 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 advisers 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 advisers to whom it discloses the information keep it confidential and only use it for the purpose referred to in paragraph (j).
Clause 3.3.5	No changes are recommended.
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

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	negotiated access standard in accordance with clause 3.3.5(a) to (h), based on solutions including (without limitation)~~must~~: (1) ~~pay compensation to~~ 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 standar*d, operational arrangements by which the plant can achieve an agreed level of performance for those operating conditions.
Clause 3.3.5.2	The term plant standard should not be italicised
Clause 3.3.5.3	No changes are recommended.
Clause 3.3.5.4	GHD recommends the definition of nominal voltage proposed by PWC and recommends this definition be added to Attachment 1 as it will improve clarity for users of the NTC
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;

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

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	(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. ~~(7) 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~~ ~~(8) 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.~~ **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

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	(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)),

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	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 (n)), the reactive current contribution may be limited to 250% of the maximum continuous current of that synchronous generating unit.

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Clause 3.3.5.6	No changes are recommended.
Clause 3.3.5.7	No changes are recommended.
Clause 3.3.5.8	No changes are recommended.
Clause 3.3.5.9	No changes are recommended.
Clause 3.3.5.10	No changes are recommended.
Clause 3.3.5.11	No changes are recommended.
Clause 3.3.5.12	No changes are recommended.
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 ~~Registered Participants~~ *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*.

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(2) The ~~excitation~~ control system of a ~~synchronous~~ *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

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***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.

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(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*.

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	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.
Clause 3.3.5.14	(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.

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	(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.
Clause 3.3.5.15	No changes are recommended.
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 ~~review~~ 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 AEMO system strength impact assessment guidelines indicates that the *connection applicant's* proposed new *connection* of a *generating system* 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.
Clause 3.3.5.17	(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~~

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	~~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 that 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 ~~Network Operator~~ must publish a procedure that specifies the process the System Controller ~~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. 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.
Clause 12.2(f)	(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 may be agreed).
Clause 12.3	**12.3 Post 1 April 2019 plant and equipment** (a) This clause applies to a *Generator User* who has entered into a connection agreement with the *Network Operator* prior to Version 4 of this Code coming into effect but had not completed the *connection* of *plant and equipment* to the *electricity network* prior to 1 April 2019. (b) Subject to this clause 12.3, such *Generator User* must ensure all *plant and equipment connected* to the *electricity network* pursuant to that *connection agreement* complies with the requirements of this *Code* including (subject to paragraph (c) below) the *automatic access standards.* However

NTC Clause or topic	Concerns and recommendations
	where a grace period for a technical requirement is specified in Schedule S4 a *Generator User* will not be regarded as in breach of this *Code* if: (i) within 30 days of commencement of version [4] of this *Code* it submits to the *Network Operator* a written communication confirming each *automatic access standard* that is met, and for each individual *automatic access standard* that is not met, a plan setting out the procedures, consistent with *good electricity industry practice*, which will be followed by the *Generator User* to ensure it complies with that technical requirement from the end of the applicable grace period; and (ii) it complies with that plan; and (iii) it ensures it complies with that technical requirement as soon as reasonably practicable and in any event from the end of the relevant applicable grace period. (c) A plan submitted under clause 12.3(b): (i) may include a process for negotiating a *negotiated access standard*; and (ii) must include the testing and commissioning procedures which will be followed by the *Generator User* to establish it has achieved compliance with each relevant technical requirement. (d) A *Generator User* must make such changes to a plan submitted under clause 12.3(b) as reasonably required by the *Network Operator*. (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 standards* 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. 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 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. (i) 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 specified in 3.3.5.
Attachment 1	**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**

NTC Clause or topic	Concerns and recommendations
	An adverse impact, assessed in accordance with the system strength impact assessment guidelines, on the ability under different operating conditions of: (c) the power system to maintain system stability; or (d) 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,~~ ***releasable user guide*:** A document associated with a 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: (viii) *a connection application* is made under clause 5.3.4(a) of the NT NER; (ix) a *connection agreement* is entered into under clause 5.3.7 of the NT NER;

<table>
<tr><th>NTC Clause or topic</th><th>Concerns and recommendations</th></tr>
<tr><td></td><td>
(x) 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;
(xi) 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;
(xii) connection;
(xiii) commencement of commissioning; and
(xiv) conclusion of commissioning; and
(8) the date this document was prepared or updated.
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.
</td></tr>
<tr><td>Schedule S4</td><td>
Grace periods for purpose of clause 12.3
<table>
<tr><th>Clause</th><th>Clause Title</th><th>Transition to Compliance Grace Period</th></tr>
<tr><td>3.3.5.1</td><td>Reactive power capability</td><td>13 months</td></tr>
<tr><td>3.3.5.2</td><td>Quality of electricity generated</td><td>30 days</td></tr>
<tr><td>3.3.5.3</td><td>Generation unit response to frequency disturbance</td><td>30 days</td></tr>
<tr><td>3.3.5.4</td><td>Generating System Response to Voltage Disturbances</td><td>13 months</td></tr>
<tr><td>3.3.5.5</td><td>Generating System Response to Disturbances Following Contingency Events</td><td>6 months</td></tr>
<tr><td>3.3.5.6</td><td>Quality of Electricity Generated and Continuous Uninterrupted Operation</td><td>30 days</td></tr>
<tr><td>3.3.5.7</td><td>Partial Load Rejection</td><td>30 days</td></tr>
<tr><td>3.3.5.8</td><td>Protection of Generation Units from Power System Disturbances</td><td>30 days</td></tr>
<tr><td>3.3.5.9</td><td>Protection Systems that Impact on Power System Security</td><td>30 days</td></tr>
<tr><td>3.3.5.10</td><td>Protection to Trip Plant for Unstable Operation</td><td>30 days</td></tr>
<tr><td>3.3.5.11</td><td>Frequency Control</td><td>30 days</td></tr>
</table>
</td></tr>
</table>

NTC Clause or topic	Concerns and recommendations

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

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Rev.No.	Author	Reviewer Name	Signature	Approved for Issue Name	Signature	Date
Draft A	David Bones	Ian Campbell		David Bones		28/1/2020
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