System Strength Impact Assessment Guideline

Response to Stakeholder Submissions

PowerWater

1 Introduction

Clause 3.3.5.16 of the Network Technical Code (NTC) defines the process for managing the potential adverse system strength impacts that may arise with the connection of new generating systems. This clause requires that the proponent of a generating system that creates an adverse system strength impact fund the works necessary to correct the impact.

Clause 3.3.5.16(a) of the Network Technical Code (NTC) requires the Network Operator to publish system strength impact assessment guidelines (SSAIG) which provide details regarding how system strength impacts will be assessed. When developing the SSIAG the Network Operator is required to consult with Users and to consider similar guidelines established by The Australian Energy Market Operator (AEMO). To meet this requirement, Power and Water Corporation published a proposed draft SSIAG on 31 July 2020. Consultation was held over a four-week period, with submissions due by Friday 28 August 2020. To assist stakeholders, Power and Water Corporation also held an information session on Wednesday 19 August 2020.

Submissions addressing the SSIAG were received from:

- ENI
- DigSILENT Pacific
- TGen
- NT Solar

Power and Water acknowledges and appreciates the effort of stakeholders in making submissions on the draft guidelines.

Power and Water has reviewed each issue raised and has structured this document to systematically respond to those issues. We have attempted to group like issues raised by stakeholders into themes and respond accordingly wherever possible. A table is included at the end of this document that provides a more detailed cross reference between each theme and specific stakeholder submissions.

2 Key issues raised in submissions

We believe that the issues raised by stakeholders can be grouped into the following key themes:

1. The System Strength Framework
2. System Strength Impacts Assessments
3. System Strength Mitigation Measures

In the following sections we explore the concerns raised in relation to each theme. We discuss the concerns raised, their relevance to the SSIAG and identify any revisions to the guidelines that we believe are warranted. All other feedback received from stakeholders through their submissions has been addressed in the detailed responses to submissions provided in Section 3.

2.1 The System Strength Framework

A number of stakeholders raised concerns with the broader system strength framework defined in the NTC. Concerns included:

- system strength issues not specifically triggered by a new generator connection;
- dispute resolution processes and
- assessment timeframes.

2.1.1 System strength issues not triggered by new generator connections

Stakeholders identified two potential situations that could give rise to system strength issues that may not be explicitly associated with the connection or modification of a generating system. Stakeholders raised concerns that:

- the framework defined in clause 3.3.5.16 may not adequately address any pre-existing system strength issues in Power and Water's regulated networks as they do not provide a requirement to maintain a base level of system strength, and
- the retirement of existing synchronous generation may produce system strength issues which may not be adequately addressed by the framework defined in clause 3.3.5.16

As noted in the submissions there are provisions in the NER (Clause 5.20.C) that allow AEMO to define a minimum level of systems strength of fault level require at specific locations in the transmission network. Should AEMO project that system strength will fall below the minimum levels then AEMO can declare a system strength gap and the relevant Transmission Network Service is required to procure services to address that gap. Those provisions in the NER have not been adopted in the Northern Territory. The Framework that has been implemented across Power and Water's regulated networks reflects similar provisions that also exist in the NER and require generators that create an adverse system strength impact to fund work required to address the impact.

We do not believe a revision to the SSIAG is required in response to either of the issues raised for the reasons presented in the following sections.

2.1.1.1 Pre-existing system strength issues

While reviewing the system strength framework in the NTC is beyond the scope of the work to develop the SSIAG, we note that system strength issues generally arise as a consequence of generation from Inverter Based Resources (IBR) replacing synchronous generators. While synchronous generators inherently provide system strength, IBR utilising grid following inverters tend to reduce system strength. At the same time these IBR require adequate system strength to ensure stable operation. The framework defined in clause 3.3.5.16 of the NTC will therefore address the system strength issues that arise as a direct consequence of connecting new IBR or modifying existing generating systems.

2.1.1.2 Decommissioning of existing synchronous generation

We agree with stakeholders that it is important to consider the possibility of future changes in the amount of synchronous generation available when assessing the system strength impact of new generator connections and modifications to existing generating systems. We note that section 5.2 of the SSIAG requires proposed retirements to be taken into account when carrying out system strength impact assessment. This should ensure that the potential for new IBR to have adverse system strength impacts is assessed considering known synchronous generation retirement decisions.

We recognise that a potential gap could arise if a generator announces plans to decommission synchronous generators after the assessment of an IBR connection is complete. In this scenario, clause 3.3.5.16 may not provide a mechanism to recover costs associated with addressing any system strength impact caused by the decommissioning. Power and Water understands that the

Essential System Services (ESS) reforms being considered by the NT Government are considering whether a system strength ESS may be an effective means of addressing this issue.

2.1.2 Dispute resolution

We agree with stakeholders that an appropriate dispute resolution procedure should be specified in the SSAIG. We believe that the dispute resolution procedure already defined in the NTC should be applied to address any disputes that may arise in relation to the application of the system strength framework defined in the NTC.

The SSIAG has therefore been revised to note that the dispute resolution procedure specified in clause 1.6 of the NTC will apply to any disputes regarding the application of the SSIAG to assess whether a proposed generating system is creating an adverse system strength impact.

2.1.3 Assessment timeframes

Stakeholders identified that it is important for connection applicants to receive timely information regarding the assessment of system strength impacts, this includes timely provision of technical information including key assumptions required to conduct studies.

We recognise that timely information provision is important. The SSIAG recommend that the preliminary impact assessment (PIA) be undertaken early in the connection process. Section 5.3.1 states that the PIA must be undertaken by the Network Operator in order to respond to a connection enquiry or a request to alter an existing generating system. This should ensure the PIA outcome are known well in advance of the connection agreement being executed. The PIA outcome will identify whether a full impact assessment (FIA) will be required. If a FIA is required the SSIAG requires that it is completed in the timeframes consistent with that specified in clause 5.3.6 of the NER-NT for processing a connection application. This should ensure the FIA is completed prior to a connection agreement being executed.

The transitional arrangements specified in clause 12.3 of the NTC apply to generators that were not connected by 1 April 2019 but had entered into a connection agreement prior to that date.

2.2 System Strength Impact Assessments

A number of stakeholders raised concerns with the following aspects of the proposed system strength assessment process:

- applicability of NEM experience
- the preliminary impact assessment process
- the full impact assessment process
- consideration of roof top PV in the assessment process
- consideration of grid forming inverters
- consideration network topology changes
- overlap between system strength and inertia
- consideration for system stability issues

2.2.1 Applicability of NEM experience

Stakeholders raised a concern that the use of metrics and methods adopted in the NEM may not be appropriate in Power and Water's regulated networks, and that Power and Water should instead propose methodologies that lead rather than follow the NEM.

We understand that the NEM is one of the first large power systems in the world to be confronting system strength issues and as such the guidelines developed by AEMO are a relevant reference for

developing SSIAG for Power and Water's regulated networks. This is recognised in clause 3.3.5.16 of the NTC which explicitly requires the Network Operator to consider the AEMO guidelines when developing SSIAG for Power and Water's regulated networks.

We are aware that the Australian Energy Market Commission (AEMC) is currently reviewing the system strength framework applicable in the NEM. Power and Water will monitor that review and consider whether any outcomes warrant revisions to the SSIAG for Power and Water's regulated networks.

2.2.2 The preliminary impact assessment process

Stakeholders contend that when completing the PIA the SCR calculation should disregard the capacity of any inverters installed as part of a Battery Energy Storage System (BESS) integrated within the generating system to meet its capacity forecasting requirements.

Where a BESS is installed at a solar farm and connected using an additional set of inverters to the solar farm, there is the potential for the BESS inverters and solar farm inverters to operate in parallel. In this situation, the system strength impact assessment should consider the total inverter capacity provided. This would require the combined capacity of the BESS inverters and the solar farm inverters be considered when undertaking the PIA and for both the solar farm and BESS to be included in the EMT model used for the FIA.

We agree that the SSIAG should clarify the treatment of BESS inverters. The SSIAG has been modified to clarify the treatment of a BESS when setting the rated output of the generating systems used to calculate the SCR (in section 1.2) and when calculating the fault level "consumption" of each asynchronous generating system (in section 5.3.2).

2.2.3 The full impact assessment process

A number of submissions raised concern with various aspects of the FIA process including:

- The complexity and expense of the electromagnetic transient studies (EMT) required for the FIA
- The lack on an appropriate EMT model for Power and Water's regulated networks and
- Inability for connection applicants to access that EMT model to verify a FIA performed by the Network Operator.

2.2.3.1 Complexity and cost of the assessment process

Stakeholders expressed concern regarding the complexity, cost and time required to gather the data for and conduct the proposed EMT modelling required as part of the FIA.

The SSIAG recognise that a FIA imposes additional costs through the need to undertake complex EMT analysis and therefore recommends a two-stage approach with detailed EMT analysis only undertaken where identified as necessary by the PIA. This two-stage approach should minimise costs by only requiring a FIA when necessary.

Stakeholders also suggested that Power and Water should bear the cost of undertaking the system strength impact assessment rather than the connection applicant.

It is not appropriate for Power and Water to bear the costs of undertaking PIA and FIA as those costs would be recovered from Network Users through regulated tariffs. It is more consistent with the system strength framework defined in clause 3.3.5.16 of the NTC for generation developers to fund the cost associated with undertaking a system strength impact assessment.

2.2.3.2 Availability of an appropriate EMT model

Stakeholders raised a concern that the FIA relies in the availability of a suitable EMT model which may not exist and may take time to develop.

Power and Water is developing an EMT model for its regulated networks. To support this endeavour, we note that clause 3.3.4 of the NTC now requires all new generators connecting to Power and Water's regulated networks to provide both RMS and EMT models.

2.2.3.3 Ability to verify FIA

Stakeholders contend that the EMT model should be made available specialist consultant employed by connectional applicants to enable connection applicants to independently verify the results of a system strength impact assessment completed by Power and Water.

The PIA can be undertaken by the generation developer using the positive sequence steady state model for Power and Water regulated networks, which can be obtained from Power and Water following the process specified in clause 3.3.4 of the NTC.

To allow generation developers to understand the results derived from the FIA assessment, Power and Water proposes to share those results with the generation developer. The extent of information that will be provided is defined in section 5.4.4 of the SSIAG. This information is intended to allow the generation developer to understand the key assumptions and inputs used in undertaking the FIA and the results obtained.

2.2.4 Consideration of roof top PV

Stakeholders suggested that the SSIAG clarify how roof top PV systems will be considered when assessing the system strength impact of a proposed generator.

Based on experience in NEM and internationally, there is no substantial evidence of adverse system strength impacts due to rooftop solar PV interacting with transmission network connected large-scale IBR generators.

The SSIAG describe how system strength impact assessments will be undertaken for generating systems that meet the materiality thresholds specified in clause 3.3.1 (b) of the NTC. The SSIAG therefore will not apply to smaller capacity rooftop solar PV systems.

2.2.5 Consideration of grid forming inverters

Stakeholders identified that system strength issues are predominantly associated with the connection of grid following inverters and that grid forming inverter do not experience the same problems. Stakeholders recommend that appropriate qualifications be included in the SSIAG to differentiate between issues faced by grid following and grid forming inverters.

We agree that there is merit in expanding the SSIAG to note that IBR utilising grid following inverters are more susceptible to unstable operation as system strength declines than IBR utilising grid following inverters. The SSIAG guidelines will be revised to acknowledge this and include statements in appropriate sections which acknowledge, that grid following and grid forming IBR may need to be considered differently when undertaking system strength impact assessments.

2.2.6 Consideration of network topology changes

Stakeholders noted that changes to the network can require changes to the reactive power required from generators and queried how such will be considered when undertaking an impact assessment.

Changing the topology and configuration of the network can alter the impedance between IBR and sources of system strength. These changes can also alter the contingencies that need to be consider when undertaking an impact assessment as discussed in sections 5.3.2 and 5.5.2 of the SSIAG. It is therefore important that PIA and FIA consider expected network configurations.

2.2.7 Overlap between system strength and inertia

Stakeholders noted that there is considerable potential for system strength and inertia requirements to overlap and expressed concern that system strength impact assessments should consider optimal ways of meeting inertia and system strength requirement not just constraining on synchronous generation.

Power and Water acknowledges that there is some correlation between system strength and inertia in the sense that a synchronous machine can provide both. However, power system inertia is not the focus of the SSIAG and is dealt with separately. The *Secure System Guidelines* set out the principles applied by the Power System Controller to determine whether Power and Water's regulated power systems are in a secure operating state. The guidelines describe the factors considered when assessing the adequacy of inertia and frequency control services.

Section 5.5.1 of the SSIAG identifies the need to consider an appropriate range of potential generation dispatch profiles when conducting a PIA or a FIA. A key requirement is to consider appropriate minimum synchronous generation dispatch scenarios. To the extent that constraints on generation dispatch are applied operationally to provided sufficient inertia and frequency control, those constraints should be taken into account when conducting system strength impact assessments.

2.2.8 Consideration of system stability issues

Stakeholders raised a concern that the system strength impact assess may not appropriately consider the secure transfer limits of the power system. Failing to consider the secure transfer limits may result in stability issues may be misinterpreted as system strength impacts.

Power and Water agrees that the system strength impact assessment should not be considered in isolation from the broader requirement to ensure stable operation of the power system. The generator connection process defines the secure transfer limits that exist once the generator is connected and the technical requirements the generator needs to meet to ensure stable operation of the power system.

The system strength impact assessment is focussed on identifying whether the connection of a new or modified generating system creates an adverse system strength impact and whether the system strength is being reduced by the proposed new generator connection. Section 2.4.4 of the SSIAG describes the process by which the scenario considered in the PIA and FIA are agreed between the Power System Controller and Network Operator. This process should ensure scenarios modelled reflect the secure operation of the power system as described in the System Control Technical Code, the Secure System Guidelines and the NTC.

2.3 System strength mitigation measures

A number of stakeholders identified that to ensure the most cost effective resolution of system strength issues it is important that all potential mitigation measures are considered. Specifically, they identified that the SSIAG should not lock in traditional solutions such as the deployment of synchronous condensers, but should also consider other options including redesigning protections schemes to address lower levels of system strength and the use of grid forming inverters.

Section 6 of the SSIAG identifies a wide range of available options for mitigation of adverse system strength impacts including the use of grid forming converter technology. The SSIAG avoid recommending any particular technology as the preferred method for remediation. To strength this requirement section 6 of the SSIAG have been modified to acknowledge that the Network Operator will engage with the generator to select the proposed mitigation measure. This should ensure the generator is able to provide an appropriate amount of input into the selection of the preferred mitigation measures.

3 Detailed Responses to Submissions Received

Please note that the words used in Issue/Comment column in the table below are in general our summarised interpretation of the issues raised by stakeholders and are not a verbatim quote from individual submissions. The submissions are available on our website (other than those identified as confidential). The Reference Number (Ref#) in the table is an internal tracking number to ensure all issues have been addressed. The comments made by stakeholders have, where possible, been grouped into themes so that similar issues can be addressed together. Where our response has recommended a change in the draft Procedure, this has been noted in the response.

Ref#	Theme	Stakeholder	Issue/Comment	Power and Water Response
1	System Strength Framework – Pre-existing system strength issues	ENI	Power and Water has not disclosed where on their networks the lack of system strength is a current issue and the mechanism by which it will pay for rectification, in that event. If non-network solutions to existing system strength problems are to be accommodated, the mechanism by which Power and Water will pay for these services should be specified.	System strength issues arise as a consequence of generation from inverter based resources (IBR) replacing synchronous generators. While synchronous generators inherently provide system strength IBR utilising grid following inverters tend to reduce system strength. At the same time these IBR require adequate system strength to ensure stable operation. Clause 3.3.5.16 of the Network Technical Code (NTC) provides a process for managing the potential adverse system strength impacts that may arise with the connection of new generating systems. This clause requires that the proponent of a generating system that creates an adverse impact fund the works necessary to correct the impact. The system strength impact assessment guidelines (SSAIG) define how an adverse system strength impact will be identified.
2	System Strength Assessment - applicability of NEM experience	ENI	The use of metrics and methods adopted in the NEM, while defensible, run the risk of lagging the energy transition as the technical issues faced on the DKIS often pre-empt and bear moderate resemblance to those faced on the NEM. In our view,	The NEM was one on the first power systems in the world to experience adverse system strength impacts as a consequence of continued growth in the amount of generation provided by IBR. The SSIAG proposed for Power and Water's regulated networks have been developed with due consideration of the corresponding

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			Power and Water should be proposing methodologies that are fit for purpose and "leading" the NEM, rather than what appears to be the other way around.	guidelines developed by AEMO and used in the NEM. The NEM guidelines were developed considering pioneering international research into the identification of system strength issues undertaken by CIGRE. The AEMO guidelines are therefore consider an appropriate reference for developing the SSIAG for Power and Water's regulated networks. This approach is also consistent with the direction provided in clause 3.3.5.16 of the NTC that when developing the SSIAG, Power and Water must review the equivalent NEM guidelines published by AEMO. In developing the SSIAG, Power and Water has considered the characteristics of the Power and Water regulated networks and whether they necessitate departures from the system strength impact assessment approached adopted in the NEM. Power and Water is aware that the AEMC is currently reviewing the system strength framework applicable in the NEM. Power and Water will monitor that review and consider whether any outcomes warrant revisions to the SSIAG for Power and Water's regulated networks.
3	System Strength Assessment – consideration of rooftop PV	ENI	Clarity should be provided around how these guidelines will be applied to rooftop generators in the event the relevant minimum Short Circuit Ratio (SCR) threshold is breached by aggregate rooftop solar generation at a particular substation. This is particularly relevant as they are, in aggregate, the largest source of inverter	Rooftop solar PV is generally connected to LV distribution networks and there is significant impedance between the transmission system and the point of connection of rooftop solar PV systems. Furthermore, roof top systems tend to utilise single phase inverters. Based on experience in NEM and internationally, there is no substantial evidence of adverse system strength impacts due to

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			based generation on the Darwin to Katherine Interconnected System (DKIS).	rooftop solar PV interacting with transmission network-connected large-scale IBR generators. The SSIAG describe how system strength impact assessments will be undertaken for generating systems that meet the materiality thresholds specified in clause 3.3.1 (b) of the NTC. The SSIAG therefore will not apply to smaller capacity rooftop solar PV systems.
4	System Strength Assessment - FIA	ENI	EMT modelling of both networks and generators is very time consuming and expensive to conduct and will be of limited use and accuracy until the models of all relevant system elements are accurate, which may potentially take many years to achieve. They should only be used when reasonable alternative methods have been exhausted, such as simply ensuring the control system tuning of neighbouring inverter based generators are complimentary, to ensure positive feedback effects on voltage levels do not occur. Or changing protection settings to accommodate a reduction in fault levels on parts of the power system.	Power and Water recognises that the additional complexity of EMT modelling has the potential to add cost and extend the time required to complete EMT simulation studies. Power and Water also recognises that accurate EMT simulations require all significant power system components be appropriately represented. Power and Water is developing an EMT model for its regulated networks. To support this clause 3.3.4 of the NTC now requires all new generators connecting to Power and Water's regulated networks to provide both RMS and EMT models. This added focus on model development should provide a sufficiently accurate EMT model for Power and Water's regulated networks to enable undertaking any EMT studies required to assess adverse system strength impacts. As noted below the adoption of a two-stage impact assessment process should ensure that detailed EMT simulations studies are only undertaken when necessary.
5	System Strength Assessment - FIA	ENI	Given the costly methods being proposed in a Final Impact Assessment (FIA), there needs to be robust controls on the ceiling	The proposed system strength impact assessment process utilises a two-stage assessment method comprising a PIA and where required a FIA.

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			cost to proponents of the various studies involved. At present, these appear to be completely absent. There is also a conflict of interest in the FIA approach being put forward by consultants who may financially benefit from conducting these detailed studies for Power and Water, presumably at the proponent's expense. If Power and Water will bear the cost of Preliminary Impact Assessment (PIA) and FIA studies, as well as the lost revenue to proponents of any delays in them being conducted (particularly for plants that are already constructed), then this risk to proponents can be managed.	The PIA is undertaken for every proposed generator development that exceeds the materiality threshold specified in the NTC. The PIA assessment utilises short circuit analysis undertaken using a positive sequence steady state model for the power system. The PIA is therefore a relatively simple and low cost analysis assessment process. The FIA is only undertaken in cases where the PIA indicates the potential for adverse system strength impacts. As such the PIA provides a low cost filtering technique which ensures the more detailed FIA, requiring EMT modelling, is only undertaken when necessary. The two stage approach should therefore minimise costs by only requiring a FIA when necessary. It is not appropriate for Power and Water to bear the costs of undertaking PIA and FIA as those costs would be recovered from Network Users through regulated tariffs. It is more consistent with the system strength framework defined in clause 3.3.5.16 of the NTC for generation developers to fund the cost associated with undertaking a system strength impact assessment.
6	System Strength Assessment - FIA	ENI	Related to the above point, it is unacceptable for Power and Water to be the only entity who can conduct a FIA, particularly when this modelling seems unlikely to take place in-house. Confidential network and generator models should be available to any third party consultant (under the same confidentiality obligations as would apply to Power and Water's own consultant) employed by proponents for	The PIA and FIA studies are technical requirements to ensure integrity and reliability of the power system. The PIA can be undertaken by the generation developer using the positive sequence steady state model for the Power and Water regulated networks, which can be obtained from Power and Water following the process specified in clause 3.3.4 of the NTC. To allow generation developers to understand the results derived from the FIA assessment, Power and Water

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			the verification of any studies. This does not require any particular generator, proponent or competing Original Equipment Manufacturer (OEM) to have access to confidential information. Significant errors have been made on this modelling in the past and it is therefore impossible to have confidence in any particular consultant's determination.	proposes to share those results with the generation developer. The extent of information that will be provided is defined in section 5.4.4 of the SSIAG. This information is intended to allow the generation developer to understand the key assumptions and inputs used in undertaking the FIA and the results obtained.
7	System Strength Framework – Disputes	ENI	In the event that disputes arise with Power and Water around core assumptions or methodologies to be used in PIA or FIA studies, the appropriate dispute resolution procedures should be specified and/or clarified in terms of the relevant clause of the NTC.	The guidelines will be revised to note that the dispute resolution procedure specified in clause 1.6 of the NTC will apply to any disputes regarding the application of the SSIAG to assess whether a proposed generating system is creating an adverse system strength impact.
8	System Strength Assessment - PIA	ENI	The base for the PIA calculation of SCR should be the declared sent-out capacity of the plant as specified in the GUA and not the sum of the inverter capacity of all on-site equipment. Otherwise, for those generators who cannot meet capacity forecasting requirements without matching half hour battery capacity of the same magnitude as their solar capacity, they will appear to have double the effect on system strength using this metric than their actual output can physically provide.	SCR is defined in Section 1.2 of the SSIAG as the Synchronous Three Phase Fault Level in MVA at the connection point divided by the rated output of the generating unit or generating system (expressed in MW). Where a Battery Energy Storage System (BESS) is installed at a solar farm and connected using an additional set of inverters to the solar farm, there is the potential for the BESS inverters and solar farm inverters to operate in parallel. In this situation, the system strength impact assessment should consider the total inverter capacity provided. This would require the combined capacity of the BESS inverters and the solar farm inverters be considered

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				when undertaking the PIA and for both the solar farm and BESS to be included in the EMT model used for the FIA. A solar farm that integrates a BESS by connecting it directly to the solar farm DC bus would not introduce additional inverter capacity. The SSIAG will be modified to clarify the treatment of a BESS when setting the rated output of the generating systems used to calculate the SCR (in section 1.2) and when calculating the fault level "consumption" of each asynchronous generating system (in section 5.3.2).
9	System Strength Mitigation Measures	ENI	There should be some acknowledgement that electrical grids are able to operate using up to 100% inverter based generation and that transitioning to this (desirable) future outcome will require assessments that are more elegant and sophisticated than currently contemplated. For example, rather than using synchronous condensers or out-of-merit generation to increase fault levels, there may be economic merit in modifying protection systems for lower fault levels instead. A reduction in fault levels across the power system will lead to an overall reduction in cost for consumers and this should be welcomed, pursued and accommodated to the maximum possible extent.	Section 6 – Mitigation measures – provides a wide range of available options for mitigation of adverse system strength impact. This guideline has not proposed any particular technology as the preferred method for remediation. The SSIAG note that the Network Operator must carry out power system modelling and simulation studies to demonstrate whether proposed system strength connection works or remediation schemes can mitigate all identified adverse system strength impacts. As the generator will fund the implemented mitigation measures it is appropriate for the Network Operator to engage with the generator to select the appropriate mitigation measures. Power and Water proposes that section 6 of the SSIAG be modified to acknowledge that the Network Operator will engage with the generator to select the proposed mitigation measure.

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10	System Strength Mitigation Measures	ENI	Likewise, Power and Water should note that inverter based resources can also be used as a solution to system strength issues, for example through the potential use of grid-forming inverters either setting the frequency / voltage or in droop frequency / voltage control at particular connection points. Traditional solutions to these issues are not the only solutions now available.	Section 6 – Mitigation measures – provides a wide range of available options for mitigation of adverse system strength impacts including the use of grid forming converter technology. This guideline has not proposed any particular technology as the preferred method for remediation.
11	System Strength Framework – Assessments timeframes	ENI	Reasonable time limits must be imposed on Power and Water for providing core information to project owners and proponents on technical information and agreed assumptions for the various studies. Power and Water's agreement on basic information such as the assumed fault levels at a connection point should be provided before signing a Generator User Agreement (GUA), at a minimum. At present it appears this type of information has not been specified or provided by Power and Water for projects that have already been constructed.	The SSIAG recommend that the PIA be undertaken early in the connection process. Section 5.3.1 states that the PIA must be undertaken by the Network Operator in order to respond to a connection enquiry or a request to alter an existing generating system. This should ensure the PIA outcome are known well in advance of the connection agreement being executed. The PIA outcome will identify whether a FIA will be required. Before the FIA can be undertaken the Network Operator will need to receive an EMT model for the generating system. This should be available when the connection application is made. Section 5.4 of the SSIAG requires that the Network Operator must undertaken a FIA (if required) upon receipt of an application to connect. This timing should ensure that the results of the FIA are known prior to the connection agreement being finalised. The SSIG therefore anticipate that the PIA and FIA are undertaken at particular stages of the connection process as described in clause 5.3 or 5.3A of the NT NER. As such it

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				is expect that the PIA will be completed in a timeframe, which is consistent with that specified in clause 5.3.3 of the NER-NT for response to a connection enquiry. Similarly the FIA will be completed in a timeframe, which is consistent with that specified in clause 5.3.6 of the NER-NT for making an offer to connect following receipt of a connection application. The transitional arrangements specified in clause 12.3 of the NTC apply to generators that were not connected by 1 April 2019 but had entered into a connection agreement prior to that date.
12	System Strength Assessment - overlap between system strength and inertia	ENI	There is considerable overlap between these guidelines and policies being implemented by System Control for "must run" plant in order to provide perceived levels of inertia. Noting that power systems operate in a very stable manner with much lower inertia than currently on the DKIS (including 100% inverter based power systems). Power and Water's efforts should be focussed on speeding up control systems (e.g. for frequency control), rather than mandating the status quo for inertia at considerable expense and cost to system security from what appear to be relatively slow control systems. Power and Water must ensure it does not contaminate system strength issues with requirements such as arbitrary and illdefined levels of inertia.	System inertia is not the focus of the SSIAG. Even though there is some correlation between system strength and inertia in the sense that a synchronous machine can provide both, the issue of system inertia is dealt with separately. The *Secure System Guidelines* set out the principles applied by the *Power System Controller* to determine whether Power and Water's regulated power systems are in a secure operating state. The guidelines describe the factors considered when assessing the adequacy of inertia and frequency control services. Section 5.5.1 of the SSIAG identifies the need to consider an appropriate range of potential generation dispatch profiles when conducting a PIA or a FIA. A key requirement is to consider appropriate minimum synchronous generation dispatch scenarios. To the extent that constraints on generation dispatch are applied operationally to provided sufficient inertia and frequency

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				control, those constraints should be taken into account when conducting system strength impact assessments.
13	System Strength Assessment – FIA Complexity and cost of assessment	ENI	The complexity, cost and time required to gather the data for and conduct the proposed EMT modelling does not appear to have been given sufficient consideration in these documents.	The SSIAG recognise that a FIA imposes additional costs through the need to undertake complex EMT analysis. The SSIAG recommend a two-stage approach with detailed EMT analysis only undertaken where identified as necessary by the PIA. This two-stage approach should minimise costs by only requiring a FIA when necessary.
14	System Strength Assessment – consideration of grid forming inverters	DigSILENT Pacific	The 'emerging' network stability problems from the introduction of IBRs into weak networks arises from the use of Grid Following Inverters (GFL), which are presently the most common type of inverter for connecting large scale solar, wind and battery resources to national transmission networks. The SSIAG addresses problems that are mainly due to GLFs in weak grids. However, Grid Forming Inverters (GFI) act as voltage (rather than current) sources and can potentially enhance system strength. However, these GFIs are only mentioned once in Section 6.0 of the SSIAG as a mitigation option. Although rare in large national grids, GFI IBRs have already been implemented on smaller isolated networks in Australia, so it is considered an available technology and we recommend the SSIAG clarifies at the beginning of the	Power and Water agrees that there is merit in expanding the SSIAG to note that IBR utilising grid following inverters are more susceptible to unstable operation as system strength declines than IBR utilising grid following inverters. The SSIAG guidelines will be revised to acknowledge this and include statements in appropriate sections which acknowledge, that grid following and grid forming IBR made need to be considered differently when undertaking system strength impact assessments. As grid following technology evolves and is more widely adopted for use in large-scale grid connected IBR there may be a need to refine the guidelines to provide specific guidance on how those technologies will be treated when undertaking the two-stages of the system strength impact assessment.

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			document that the problem of low SCR outcomes substantially relates to the use of GLF technologies. Alternative wording to paragraph 2 is recommended as follows: *(Refer to DigSILENT submission Page 2)*	
15	System Strength Framework – Pre-existing system strength issues	TGen	TGen believes that the foundations on which these draft SSIAG is based is unclear, primarily on what is considered the base level of system strength. TGen belives that it would be beneficial to provide the following: • How the power system controller and or network operator determine the base level system strength and how will this be done in the future? • What synchromous genereation dispatch is being assumed? • How is the maintenance of the base level of system strength now and into the future be funded? • How is the impact of the behind the meter solar PV on system strength being considered? It is noted the current draft SSIAG is based on the AEMO equivalent document, however not all surrounding regulatory	At present, there is no obligation on Power and Water to provide system strength in their network. Cl. No. 5.20 and 5.20C of the NER(NT) is not applicable in NT jurisdiction. Section 5.5.1 of the SSIAG discuss the importance of modelling appropriate generation dispatch conditions when undertaking PIA and FIA. The guidelines recommend that any constraints on the level of synchronous generation be considered when selecting appropriate generation dispatch conditions. Constraints imposed by the *Power System Controller* to maintain secure operation of the power system may need to be considered by the *Network Operator* when setting the generation dispatch conditions assumed in the PIA and FIA. Section 2.4.4 of the SSIAG therefore requires that the *Network Operator* and the Power System Controller agree that the scenarios modelled in the PIA and FIA reflect the secure operation of the power system as described in the *System Control Technical Code* and the *Secure System Guidelines* and the NTC. Power and Water believes that the system strength framework described in clause 3.3.5.16 of the NTC should

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			framework(s) that exist(s) in the NEM is in place in the NT. Accordingly, TGen suggest that if this guideline was to be implemented it should be accompanied by the activation of the equivalent regulations applicable in the NEM, for example clause 5.20.C of NTNER. If clause 5.20.C is unlocked it would clarify roles and responsibilities and increase transparency.	be sufficient to identify and correct any adverse system strength impacts caused by the connection of IBR.
16	System Strength Framework – Decommissioning of synchronous generators	TGen	SSIAG focuses on new additions or alterations to the generation system. TGen believes that the decommissioning or permanently disconnection a generator form the system is an alteration to the generation system that is not sufficiently covered. It is important to consider whether future disconnections and decommissioning of generators will likely have an impact on system strength.	Section 5.2 – Facilities to be considered – of the SSIAG requires proposed retirements to be taken into account when carrying out system strength impact assessment. This should ensure that the potential for new IBR to have adverse system strength impacts is assessed considering known synchronous generation retirement decisions. Clause 3.3.5.16 of the NTC requires that the developer of the IBR fund any mitigation measures necessary to address system strength issues that result from the combined effect of new generation connections and known retirements of synchronous generation. Power and Water recognises that a potential gap could arise if a generator announces its plan to decommission synchronous generators after the assessment of an IBR connection is complete. In this scenario, clause 3.3.5.16 may not provide a mechanism to recover costs associated with addressing any system strength impact caused by the decommissioning. PWC understands that the Essential System Services (ESS) reforms being considered by the NT

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				Government are considering whether a system strength ESS may be an effective means of addressing this issue[1].
17	System Strength Assessment – consideration of network topology changes	TGen	Generators' ability to import/export real and reactive power are affected by the network configuration. If the network operator is performing additions/alterations, how is the impact on generator dispatch assessed? Is a system strength impact assessment required to be undertaken? How will the results be shared with participants?	Generators are expected to provide technical capabilities necessary to meet the technical requirements specified in clause 3.3.5 of the NTC. This includes the provision of required capacity to generator or absorb reactive power. Providing a specified level of reactive power should not materially alter the contribution of the generator to the three phase fault level and therefore changing the reactive power dispatch should not materially effect the outcome of PIA or FIA. Changing the topology and configuration of the network can alter the impedance between IBR and sources of system strength. These changes can also alter the contingencies that need to be consider when undertaking an impact assessment as discussed in sections 5.3.2 and 5.5.2 of the SSIAG. It is therefore important that PIA and FIA consider expected network configurations.
18	System Strength – consideration of system stability issues	NT Solar	**Adverse System Strength Impact** – To determine an adverse system strength impact for a new generator connection (or change to an existing generator connection), there is an underlying assumption that the power system is stable for credible contingency events under test without the new or altered generator connection. It's our knowledge this has not	Power and Water agrees that the system strength impact assessment should not be considered in isolation from the broader generator connection assessment processes. Those broader assessment processes will consider the ability of the generator to comply with the technical requirements specified in clause 3.3.5 of the NTC. Those requirements include providing control systems and capability to ensure stable operation, contribute to

[1] https://business.nt.gov.au/business-reforms-and-initiatives/northern-territory-electricity-market-priority-reform-program

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			been objectively proven to be the case. Power and WaterC need to undertake modelling to demonstrate the stability of the system or otherwise per a new or altered generator connection. Only with this baseline assessment can a new or altered generator connection be assessed objectively.	voltage control, frequency control and ride through system disturbances. The system strength impact assessment is focussed on identifying whether the connection of a new or modified generating system creates an adverse system strength impact. The studies performed particularly for a FIA explore whether any stability issues arise under dispatch scenarios and contingency events that reduce the system strength seen by the IBR that is seeking to connect. In undertaking the FIA it is important to stay within the secure operating limits of the power system. Section 2.4.4 of the SSIAG describes the process by which the scenario considered in the PIA and FIA are agreed between the *Power System Controller* and *Network Operator*. This process should ensure scenarios modelled reflect the secure operation of the power system as described in the *System Control Technical Code*, the *Secure System Guidelines* and the NTC.