Attachment 1: Inter-network Test Initiation Guidelines

IRPC

Inter Regional Planning Committee

Inter-Network Test Initiation Guidelines

Prepared by: Inter-Network Test Working Group

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Revision History

Version	Date	Author	Comments
1.0	7 February 2008	Inter-network test working group	As determined by IRPC

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1. Introduction

a) Rule 5.7.7 (k) states:

> The *Inter-Regional Planning Committee* may develop, *publish* and amend from time to time, in accordance with the *Rules consultation procedures*, a set of guidelines to assist *Registered Participants* to determine when an *inter-network test* may be required.

b) This document contains the Inter-Network Test Initiation Guidelines (**Guidelines**), which commence on 7 February 2008

c) The Guidelines may be amended in accordance with Rule 5.7.7(k).

d) If there is any inconsistency between the Guidelines and the *Rules*, the *Rules* will prevail to the extent of that inconsistency.

2. Purpose

The purpose of these Guidelines is to assist *NEMMCO* and *Registered Participants* to determine when an *inter-network test* may be required.

3. Application and enforceability of these Guidelines

NEMMCO or the *Relevant TNSP* must consider these Guidelines before they give notice to a *Registered Participant* under Rule 5.7.7(g) that *NEMMCO* or the *Relevant TNSP* (as the case may be) believes that an *inter-network test* is required in relation to a development or activity contemplated by items 1, 2, 3 or 4 of chart 1 of Rule 5.7.7(a).

NEMMCO must consider the Guidelines before it determines that an *inter-network test* is required for a reason contemplated by item 5 or 6 of chart 1, and before it prepares a draft *test program* for the *inter-network test* and submits it to each member of the *Inter-regional Planning Committee* under Rule 5.7.7(n).

A circumstance may arise that is not covered by the guidelines, or for which the reasoning currently thought to apply might not be appropriate. Consequently, the guidelines do not diminish the responsibility of *NEMMCO* or the *Relevant TNSP* to exercise professional judgement and arrange for *inter-network tests* to be conducted whenever, in the surrounding circumstances, this is considered to be reasonably necessary.

4. Principle

The *IRPC* has developed these Guidelines on the principle that a test that is conducted for the purpose of verifying the magnitude of the *power transfer capability* of more than one *transmission network* should not be conducted under the Rule 5.7.7 if the same purpose can reasonably be achieved by testing under any other *Rules*.

5. Process summary

The process for determining when an *inter-network test* may be required follows the steps illustrated in Figure 1.

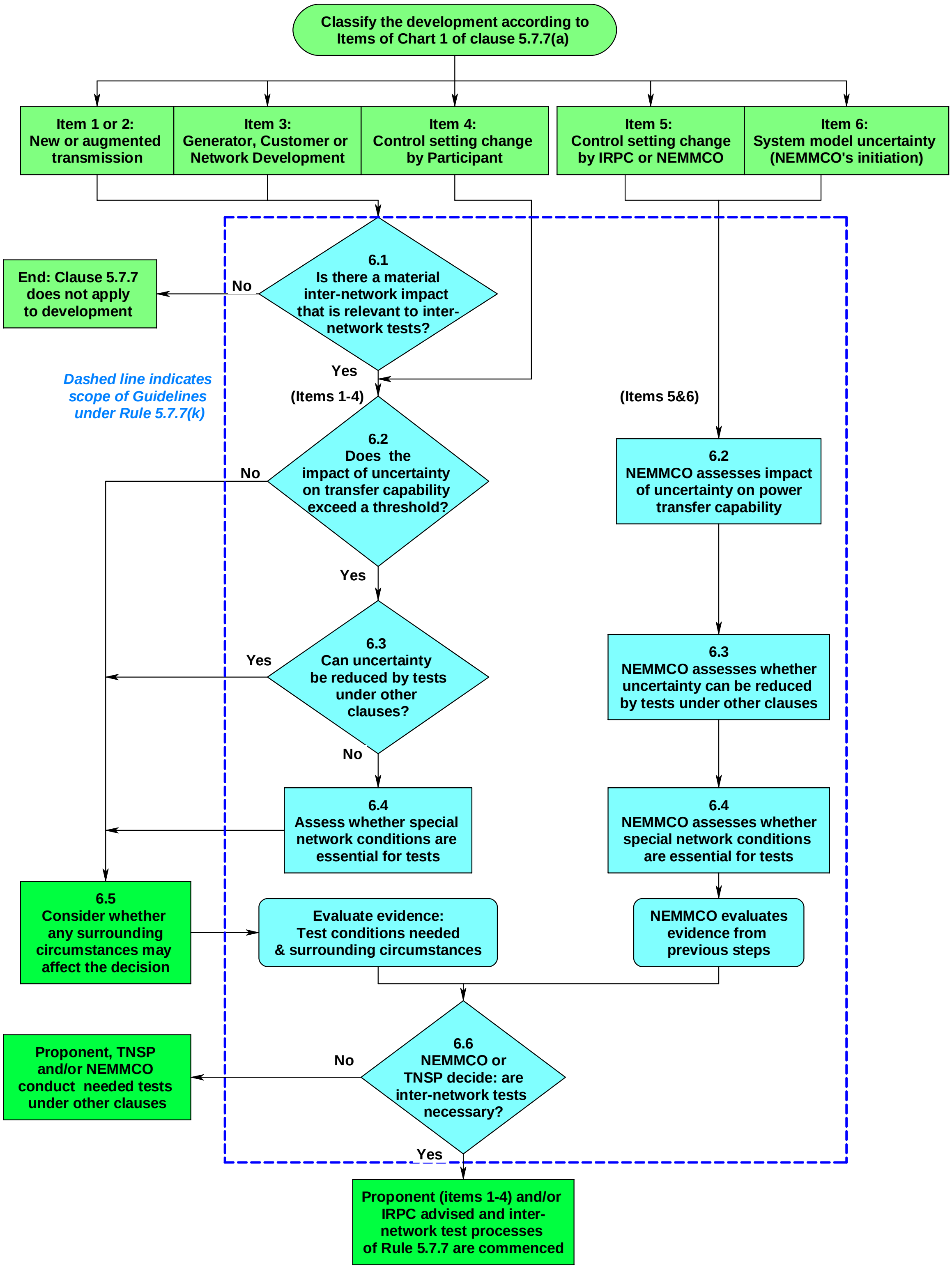

Figure 1: Guideline steps (numbers in blue coloured boxes) in the context of Rule 5.7.7

Chart 1 in clause 5.7.7(a)[1] lists the six kinds of development or activity that may give rise to a decision to conduct an *inter-network test*. There are two decision paths, one applicable to developments or activities that are classified as item 1, 2, 3 or 4, and the other applicable to items 5 or 6 of Chart 1 of clause 5.7.7(a).

The heading numbers in some boxes in Figure 1 are references to steps in the process that are described in the sections of chapter 6 that have that number. The analysis and reasoning is the same for some steps in the two decision paths, so that the same chapter 6 section numbers appear in each.

For items 1 to 4 analysis and reasoning at some step may permit later steps of the process to be omitted, and the decision is made on the basis of evidence examined to that point and the surrounding circumstances. For items 5 and 6 *NEMMCO*, as the *decision-maker*, must consider all steps of the process before deciding that an *inter-network test* is required, but is not required to consider the surrounding circumstances

Actions that are required by *Rule* 5.7.7 over and above what is contained in these Guidelines are indicated in green.

6. Process Steps and decision criteria

6.1 Is there a material inter-network impact relevant to inter-network tests?

6.1.1 Context

Step 6.1 is the entry point to the process for developments or activities described by items 1, 2 and 3 in chart 1.

6.1.2 Guideline

To assess the materiality of inter-network impact for developments described by items 1 to 3 of Chart 1 of clause 5.7.7(a) the *Relevant TNSP* or *NEMMCO* must apply the criteria and method contained in Appendix B.

6.1.3 Actions

If it is determined by applying Appendix B to an item 1, 2 or 3 that there is a *material inter-network impact,* the *Relevant TNSP* or *NEMMCO* (as the case may be) should advise the *Registered Participant* that it must make a timely notification to *NEMMCO* under clause 5.7.7(e). Clause 5.7.7 does not apply to item 1 to 3 developments for which there is no *material inter-network impact*.

[1] A copy of this chart is included as Appendix A to the Guidelines for convenience of reference only, and in the event of any conflict with the Rules the Rules prevail.

6.2 Assess the impact of uncertainty on power transfer capability

6.2.1 Context

This step is applicable to all developments or activities that are described in chart 1 of clause 5.7.7(a).

It is the point of entry to the guideline processes for items 4 to 6 of chart 1.

For items 1 to 4 the process is formally commenced after the *Registered Participant* notifies *NEMMCO* about the development or activity in accordance with clause 5.7.7(e), although the *Rules* do not preclude earlier commencement, at the sole discretion of the *decision-maker*.

For items 5 and 6 the *Proponent* is *NEMMCO*, and no notification is required.

6.2.2 Guideline

To require *inter-network testing* at the time of its commissioning, a new development or activity under items 1 to 5 of chart 1 would need to:

(a) require consideration of the establishment of new *network* limits, where the mechanisms underlying those new limits are not well understood (e.g. interactions between *control systems* for some stability limits); or

(b) require consideration of the establishment of new or updated *network constraint* equations that are particularly sensitive to certain model parameters; or

(c) increase uncertainty in *network constraint* equations to the extent that a significant (and additional) safety margin would need to be considered.

Developments described by items 1 to 5 of chart 1 that introduce, or change the control parameters of, controlled *plants*[2] that are located so that their *control systems* may interact with the *transmission networks* and other *Network Users' plant* should be assessed by the conduct of analysis. This analysis will estimate the amount of uncertainty in calculated *power transfer capability* that is attributable to the potential range of errors in the parameters of the model of the *plant* and its *control system*.

The methodology and criteria for this assessment are described in Appendix C.

If a development substantially changes the configuration of the *network*, or permits large changes in power transfer to occur, so that it would be possible for non-linear interactions that were not material to the pre-existing *network* to become evident, it may be assessed that there is a requirement to verify the *network* impact, irrespective of the assessed magnitude of the uncertainty.

For item 6 of chart 1 uncertainty is implied to be present by the description of the activity, and *NEMMCO*, as the proponent, may exercise its discretion as to how to assess the amount of uncertainty in *power transfer capability*.

[2] These include, without limitation, *generating units*, direct current links and static var compensators

6.2.3 Action

If the specified threshold of uncertainty is not exceeded for any kind of development according to items 1 to 4 of Chart 1 proceed to step 6.5 and consider the surrounding circumstances, otherwise proceed to step 6.3.

6.3 Assess the ability for uncertainty to be reduced by tests under other clauses

6.3.1 Context

This step considers the types of test that will be necessary to either reduce the uncertainty of *plant* model parameters, or to determine an empirical adjustment that sufficiently allows for the shortcomings of the *power system* model.

6.3.2 Guideline

The *Proponent*, *Relevant TNSP* and *NEMMCO* should assess whether methods of testing exist to estimate the uncertain parameters that can be carried out within the *Rules* and that are likely to be sufficiently accurate to reduce the model uncertainty so that it will be below the threshold, or better than can be achieved by using an inter-network test at step 6.4.

They should also establish whether these tests are already planned to be conducted as part of a commissioning program, or whether the *Proponent* is willing to carry them out, either as an addition to the commissioning program or separately. If this is the case, the *decision-maker* must obtain an undertaking from the Proponent that the required tests will be carried out.

Alternatively, it may be determined that such tests are not available or applicable.

6.3.3 Action

If there is a method of testing available that is capable of reducing the uncertainty and that can be carried out under clauses of the *Rules* other than 5.7.7 then for items 1 to 4 of Chart 1 consider the surrounding circumstances at step 6.5, otherwise proceed to step 6.4.

6.4 Assess whether special network conditions are essential for tests

6.4.1 Context

This step considers whether special *power system* conditions will need to be achieved in order to conduct test activities. This requires the decision-maker to anticipate the methodology for conduct of the test.

6.4.2 Guideline

An *inter-network test* will be assessed as being required only under unusual circumstances, in particular where a test method or activity that is necessary to achieve an acceptable result would not be permitted, or where *Registered*

Participants would not be required to participate in those activities, if clause 5.7.7 did not exist.

Classification as an *inter-network test* should be limited to those activities that:

- are conducted for the purpose of verifying the magnitude of the *power transfer capability* of more than one *transmission network*;
- would cause a *Registered Participant* to incur a cost through either direct or indirect participation in the test; and
- would not be permitted under any other *Rules* requirement.

Classification of a test as an *inter-network test* may be indicated if a preliminary assessment of the methodology for conduct of the test indicates a need to consider at least one of:

- the application and/or removal of special purpose power transfer *constraints* that will affect *dispatch*;
- a variation of the *central dispatch* outcome in a manner that is not otherwise permitted by the *Rules*;
- a requirement for procurement of test facilitation services, as provided under clause 5.7.7(u);
- the changing of a *plant* operating condition in a manner that is not otherwise permitted, and that may affect the *market*; or
- a requirement for a *Registered Participant* to incur a cost through its participation in the *inter-network test*.

6.4.3 Actions

For items 1 to 4 proceed to step 6.5 irrespective of the above outcome, and for items 5 and 6 proceed to step 6.6.

6.5 Consider whether surrounding circumstances may affect the decision

6.5.1 Context

This step is required only for those developments or activities that are described by items 1 to 4 of chart 1. It may be entered as a result of considerations at step 6.2, 6.3 or 6.4.

As illustrated in Figure 1, consideration of the surrounding circumstances interacts with the decision-making process, while formally being outside of that process.

6.5.2 Action

Having considered the surrounding circumstances proceed to step 6.6.

6.6 Evaluate evidence and make decision

6.6.1 Guideline

In respect of all developments or activities listed in chart 1 of clause 5.7.7(a) the decision-maker must consider these Guidelines. For items 1 to 4 of chart 1 the *decision-maker* must also consider the surrounding circumstances.

6.6.2 Actions

For items 1 to 4 of chart 1 *NEMMCO* or the *Relevant TNSP* (as the case may be) may notify the *Proponent* of the development or activity that *NEMMCO* or the *Relevant TNSP* believes that an *inter-network test* is required in relation to that development or activity under clause 5.7.7(g). If a notice is given the *decision-maker* must also promptly give a copy of the notice to each member of the *Inter-regional Planning Committee*.

If the decision is that an *inter-network test* is not required the *Rules* do not require notification.

If *NEMMCO* determines that an *inter-network test* is required for a reason contemplated in item 5 or 6 of chart 1, it must prepare a draft *test program* for the *inter-network test* and submit it to each member of the *Inter-regional Planning Committee* at least 40 *business days* prior to the proposed test in accordance with clause 5.7.7(n).

7. Definitions and interpretation

a) In these Guidelines, a word or phrase *in this style*, has the meaning set out opposite that word or phrase in the Glossary (Schedule 1) of the Guidelines.

b) If a word or phrase *in this style* is not defined in the Glossary, the term has the same meaning as given to that term in the *Rules*.

c) Unless the context otherwise requires, the Guidelines shall be interpreted in accordance with Schedule 2 of the *National Electricity Law.*

SCHEDULE 1 - GLOSSARY

[Defined Term]	***[Definition]***
IRPC	*Inter-Regional Planning Committee*, established under clause 5.6.3(a) of the *Rules*
TNSP	*Transmission Network Service Provider*
decision-maker	The *Relevant TNSP* defined by column 4 in Chart 1 of clause 5.7.7(a) or *NEMMCO* when either of them undertakes their responsibilities to make a notification under clause 5.7.7(g), or *NEMMCO* when it makes a determination under clause 5.7.7(n)
plant tests	Tests that are not classified as *inter-network tests* that are undertaken in accordance with clauses other than 5.7.7.
MINI Criteria	The *material inter-network impact* criteria established under clause 5.6.3(i) and described in “Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations”, dated 21st October 2004 and published on behalf of the *IRPC* on the *NEMMCO* website at http://www.nemmco.com.au/transmission_distribution/170-0024.htm

Appendix A : Information copy of Chart 1 of Rule 5.7.7(a)

Chart 1

No.	Kind of development or activity	*Proponent*	*Relevant TNSP*
	column 1	**column 2**	**column 3**
1.	A new *transmission line* between two *networks*, or within a *transmission network*, that is anticipated to have a *material inter-network impact* is commissioned.	*Network Service Provider* in respect of the new *transmission line.*	*Proponent* and the *Transmission Network Service Provider* in respect of any *network* to which the *transmission line* is *connected*.
2.	An existing *transmission line* between two *networks*, or within a *transmission network*, that is anticipated to have a *material inter-network impact* is *augmented* or substantially modified.	*Network Service Provider* in respect of the *augmentation* or modification of the *transmission line*.	*Proponent* and the *Transmission Network Service Provider* in respect of any *network* to which the *transmission line* is *connected*.
3.	A new *generating unit* or *facility* of a *Customer* or a *network* development is commissioned that is anticipated to have a *material inter-network impact*.	*Generator* in respect of the *generating unit* and associated *connection assets*. *Customer* in respect of the *facility* and associated *connection assets*. *Network Service Provider* in respect of the relevant *network*	*Transmission Network Service Provider* in respect of any *network* to which the *generating unit*, *facility* or *network* development is *connected* and, if a *network* development, then also the *Proponent*.
4.	Setting changes are made to any *power system* stabilisers as a result of a *generating unit*, *facility* of a *Customer* or *network development* being commissioned, modified or replaced.	*Generator* in respect of the *generating unit*. *Customer* in respect of the *facility*. *Network Service Provider* in respect of the relevant *network*.	*Transmission Network Service Provider* in respect of any *transmission network* to which the *generating unit*, *facility* or *network* development is *connected*.
5.	Setting changes are made to any *power system* stabilisers as a result of a decision by the *Interregional Planning Committee* or *NEMMCO*, which are not covered by item 4 in this chart.	*NEMMCO*	None
6.	*NEMMCO* determines that a test is required to verify the performance of the *power system* in light of the results of planning studies or simulations or one or more system incidents.	*NEMMCO*	None

Appendix B: Criterion and method for assessing material inter-network impact

B.1 Criterion

Material inter-network impact occurs if there is a decrease or increase in *power transfer capability* between *transmission network*s or in another *TNSP's network* of more than the lesser of 3% of maximum transfer capability and 50 MW.

B.2 Method

If the analysis described below has already been carried out in an equivalent form through other processes under the *Rules*, it need not be repeated for the purpose of clause 5.7.7(a). However the materiality of the impact must be assessed using the criterion in section B.1.

For the types of development or activity described by items 1, 2 and 3 of chart 1 of clause 5.7.7(a), the following method and criteria are to be applied by the *Relevant TNSP* when determining whether there is a *material inter-network impact* for that development or activity for the purposes of these Guidelines.

Assessments of *material inter-network impact* must use the best available models and take into account the equipment in service in the *national grid* that will exist at the time the augmentation is brought into service and those projects committed at the time of the assessment being made.

A *material inter-network impact* is determined by:

- comparing the augmented case with an unaugmented (base) case;
- ensuring the augmented case conditions are as near as possible to the base case, while adjusting the demand and/or *generation dispatch* conditions to define the new *network* capabilities; and
- carrying out contingency studies over a reasonable range of base cases (i.e. various assumptions about load demand, *generation dispatch* and *network* topology conditions).

The inter-network impact for each possible type of impact is calculated as follows:

$$I = A - B$$

where:

I = base case impact

A = network capability for the augmented case

B = network capability for the unaugmented (base) case

Each calculated impact is compared with the relevant materiality threshold as described above.

The above analysis must be carried out for *power system* normal conditions and, at the discretion of the *decision-maker*, for planned or unplanned *plant outage* and *dispatch* conditions that are relevant to *market* and *power system* operation.

Appendix C: Quantification of uncertainty in power transfer capability

C.1 Basic methodology

To assess the uncertainty in the estimation of *inter-network impact*, studies should be carried out in which selected model parameters are adjusted within a feasible range of variation. Selection of model parameters for study would concentrate on those that are likely to remain uncertain after completion of plant commissioning tests. These studies should be done for a selection of the critical *material inter-network impact* studies, to determine a set of new impacts I_s as follows:

$$I_s = A_s - B_s$$

where:

I_s = sensitivity case impact

A_s = network capability for the augmented sensitivity case

B_s = network capability for the unaugmented (base) sensitivity case

The model uncertainty is the difference between the base case and sensitivity case studies.

The need for a test is therefore indicated by comparing the absolute value of the difference against a defined threshold:

$$| I - I_s | > \text{threshold}$$

which can be expressed as:

$$| (A - B) - (A_s - B_s) | > \text{threshold}$$

C.2 Method for an activity or development described by items 1 to 5 of Chart 1:

Sensitivity studies are to be carried out to estimate the uncertainty of the calculated power transfer capability that is attributable to uncertainty of the *plant* model that represents the new or modified development. For the purpose of this assessment these studies must ignore pre-existing uncertainty in the model that is not related to the development under consideration.

Model uncertainty should be determined by sensitivity studies such as the following:

Source of uncertainty	***Possible sensitivity study***
New or augmented *plant* model	Adjust model parameters by estimated parameter accuracy
Models of *plant* that may interact with the new development	Adjust model parameters for *plant* by estimated parameter accuracy, or taking critical controllers out of service (e.g. *power system* stabilisers)
Stochastic or lumped models	Adjust model parameters over expected (or reasonably possible) range

The above analysis must be carried out for *power system* normal conditions and, at the discretion of the *decision-maker*, for planned or unplanned *plant outage* and *dispatch* conditions that are relevant to *market* and *power system* operation. In the case of impacts due to sub-synchronous resonance, multiple contingencies that are relevant to the design criteria of the installation may be analysed.

C.3 Method for an activity described by item 6 of chart 1:

Where feasible under the circumstances, such as where the cause of the system model uncertainty is tentatively attributable to planning studies or simulations, the situation should be assessed by sensitivity studies such as the following:

Source of uncertainty	***Possible sensitivity study***
Models of suspected critical *plant*	Adjust model parameters for suspected critical *plant* by estimated parameter accuracy, or taking critical controllers out of service (e.g. *power system* stabilisers)
Stochastic or lumped models	Adjust model parameters over expected (or reasonably possible) range

No guidance is provided on how the cause of *power system* incidents should be analysed, and *NEMMCO* will use its discretion in this matter.

C.4 Size of threshold of additional uncertainty in power transfer capability

The uncertainty threshold is the lesser of 3% of maximum transfer capability of the affected part of the *transmission network* and 50 MW.[3]

The assessment of the types of test that are undertaken at step 6.3 of these Guidelines should include analysis of the ability of these tests to resolve uncertainties in the magnitude of the calculated uncertainty threshold.

[3] For a maximum power transfer capability of 1667MW or above, the uncertainty threshold is 50MW; for a maximum power transfer capability below 1667MW, the uncertainty threshold is 3% of the transfer capability (for example for a transfer capability of 1000MW, the threshold is 30MW).

Appendix D: Examples of application of the Guidelines

Disclaimer: This appendix has been prepared to provide a general understanding of the processes contained in the Guidelines. The *decision-maker* should not rely on these examples as being indicative of the outcomes to be expected in real-life examples. To the extent that there is any inconsistency between the Guidelines and this Appendix, the Guidelines prevail in all circumstances.

D.1 Introduction

This appendix postulates four hypothetical examples of developments, and discusses typical considerations that might influence the decision about the need for an *inter-network test*. These examples are:

Example 1: An *interconnector* augmentation

Example 2: A *network* augmentation is commissioned that has a risk of causing sub-synchronous resonance (**SSR**)

Example 3: *Connection* of a *Network User*, whose characteristics may affect an existing transient stability limit

Example 4: Replacement of the excitation control system at a large power station located near an interconnection between *regions*

In these examples, proposed test conditions and arrangements are for illustration purposes only and not intended to suggest particular approaches to analysis and testing that should be adopted.

D.2 Example 1: An *interconnector* augmentation

This hypothetical example considers a new high capacity AC *interconnector* between South Australia (SA) and New South Wales (NSW). The interconnector has a maximum transfer capacity of 300 MW (in either direction).

The development incorporates several *static VAR compensators*, to which power oscillation damping control will be fitted. The development is intended to permit significant power flows between NSW and SA, but in a configuration that significantly changes *network* topology.

D.2.1 Classify the type of development in chart 1 of Rule 5.7.7(a)

As a new *transmission line* between two *networks*, this development is classified as an ***Item 1*** type development.

D.2.2 Is there a *material inter-network impact* relevant to *inter-network tests?*

This example postulates an increase in inter-*regional power transfer capability* of 300 MW in either direction, and significantly increased transfers on *network* paths.

Based on Appendix B: Criterion and method for assessing material inter-network impact, as the increase in *power transfer capability* is greater than 50 MW the development is assessed as having a *material inter-network impact* [4].

D.2.3 Assess the impact of uncertainty on power transfer capability

Uncertainty is associated with the controlled *plant*, and the changed topology of the *transmission network* with the new interconnection connecting the SA and NSW *transmission networks* directly.

For this example, dynamic and small signal stability studies show the following;

- Prior to the development, the *power transfer capability* from New South Wales to Victoria was limited by transient stability. Following the development, the *power transfer capability* from New South Wales to Victoria and South Australia changes to a small signal stability (damping) limitation for typical operating conditions; and
- the development causes a previously non-critical oscillatory mode to become critical to *power system* operation.

To assess the uncertainty, sensitivity studies should be carried out in which key model parameters are adjusted within a feasible range of variation. The model parameters to be varied in sensitivity studies would probably include load indices, and gain parameters in the *static VAR compensators*. Consideration may also be given to varying key parameters of controllers for the most critical nearby *generating units* to assess the *generating unit*'s impact on *power transfer capability*.

With reference to Appendix C: Quantification of uncertainty in power transfer capability in the guidelines, if the impact of the uncertainty in these sensitivity studies is greater than 9 MW (3% of the maximum transfer capability), then the need for an inter-network test to reduce the uncertainty of *power transfer capability* should be assessed.

As stated in section 6.2.2 of the guidelines, this example postulates a significant change to the configuration of the network, and it is possible for non-linear interactions that were not material to the pre-existing network to become evident, and these interactions may require the impact to be verified, regardless of the assessed uncertainty.

[4] there is no existing *power transfer capability* directly between the SA and NSW *transmission networks*. However power is transferred indirectly between NSW and SA through the Victorian grid via Heywood and the NSW–Snowy interconnectors, and the Victorian country and western NSW networks via Murraylink interconnector.

D.2.4 Assess the ability for uncertainty to be reduced by tests under other clauses

Plant tests are planned to verify the model and operation of the *static VAR compensators* only. It is assumed that uncertainty in the combined response of this plant and nearby loads will remain.

If sensitivity studies suggest nearby *generating units* have a significant impact on *power transfer capability*, it is unlikely the planned *plant tests* will improve the certainty of their models. This example assumes no issues with nearby *generating units*.

For this example, the *plant tests* conducted under clauses other than 5.7.7 will not be sufficient to reduce the uncertainty.

D.2.5 Assess whether special network conditions are essential for tests

For this example, it is assumed that *power transfer capability* limitations due to transient stability can be adequately characterised from the *power system* models (following *plant tests* where relevant). The response to naturally-occurring faults, captured by high speed monitors, can be checked by simulation to verify the overall model at a later date.

However, the uncertainty is such that there needs to be verification of the *power system damping*, prior to the unrestricted release of capacity to the market. It is assumed that *power system damping* can be adequately verified using on-line monitoring and simulation studies. Off-line analysis will be used to check the *power system damping* at the transfer levels that arise from central dispatch.

It is therefore likely that, to avoid manipulation of the *central dispatch* process and to minimise the impact on the market, full capacity will be released progressively through a corresponding increase in the *constraint* on *power transfer* across the *interconnector.*

Because the full capacity is not available until released by NEMMCO, and special purpose *power transfer constraints* will be required to limit power transfer below the nominal 300 MW capacity, special network conditions are essential for the tests.

In light of the above considerations, an *inter-network test* will be conducted to achieve the special transfer conditions needed for measuring the *power system damping.*

Conclusion – Without regard to the surrounding circumstances (which this example does not seek to describe), it is likely that an inter-network test will be required.

D.3 Example 2: A *network* augmentation is commissioned that has a risk of causing sub-synchronous resonance (SSR)

This hypothetical example considers an *augmentation* of an existing *interconnector* using a series compensation installation, to increase the *power transfer capacity*.

The nominal transfer capacity of the existing connection is 1500 MW. Following the planned development the transfer capacity increases to 1900 MW under some power system conditions. *The proponent* in this example is also the *relevant TNSP* who owns the network to which the series capacitors are being connected.

D.3.1 Classify the type of development in chart 1 of Rule 5.7.7(a)

As a new network development, this is classified as an ***Item 3*** type development.

D.3.2 Is there a *material inter-network impact* relevant to *inter-network tests*?

The example postulates a significant increase in *inter-regional power transfer capability*.

Based on Appendix B: Criterion and method for assessing material inter-network impact, as the increase in *power transfer capability* is greater than 45 MW (3% of the existing maximum transfer) the development is assessed as having a *material inter-network impact.*

D.3.3 Assess the impact of uncertainty on power transfer capability

For this example, *power system* analysis at the planning stage of the development has identified the level of series compensation of particular transmission lines to be implemented and the consequent increase in the transient stability transfer limits.

Planning studies have also identified the reduction in damping of torsional oscillation modes of particular generators caused by the connection of the series capacitors, and how these calculated damping reductions change due to outages of particular transmission lines, transformers and generators. For particular combinations of prior outages, the studies have identified that the series compensation level will need to be reduced (by by-passing particular series capacitor banks), so that for the next worst-case outage, adequate damping of all the torsional oscillation modes is maintained.

There is a large level of uncertainty in the estimation of the torsional mode damping, due to uncertainties in the calculated damping contribution from the turbine, the electrical models of generators and their control systems, and system loads at the sub-synchronous frequency associated with the critical torsional modes. The model parameters that affect how these processes contribute torsional mode damping would be varied in sensitivity studies.

With respect to Appendix C: Quantification of uncertainty in power transfer capability, an effect of the uncertainty in the SSR studies is that by-passing of some of the series capacitors (thereby reducing the transient-stability limit) could be necessary for the prior outage of fewer system elements than in the base case.

Based on Appendix C: Quantification of uncertainty in power transfer capability, if (for a particular prior-outage condition) the uncertainty in these sensitivity studies results in a reduction in the transient-stability transfer capability that is greater than 3% of the maximum, then the need to conduct an *inter-network test* should be assessed.

D.3.4 Assess the ability for uncertainty to be reduced by tests under other clauses

Plant tests are planned to verify the protection and control of the *series capacitors*. The *plant tests* alone will not be sufficient to reduce the uncertainty associated with damping of the torsional oscillation modes.

As stated above, *power system* analysis has identified how the damping of particular torsional oscillation modes will be changed by the outages of particular system elements. *The proponent* has requested that tests be conducted to verify this predicted behaviour. To achieve particular outage arrangements, different combinations of transmission lines, transformers and generators must be removed from service, which may impact on the dispatch of certain *generators*. This test cannot be conducted outside the provisions of clause 5.7.7.

D.3.5 Assess whether special network conditions are essential for tests

For this example, it is assumed that *power transfer capability* limitations due to transient stability can be adequately characterised from the *power system* models (following *plant tests* where relevant). The response to naturally-occurring faults, captured by high speed monitors, can be checked by simulation to verify the overall model at a later date.

However, the uncertainty in the modelling of the damping of particular torsional oscillation modes is such that there needs to be tests done to validate the relevant models.

To confirm the levels of damping of particular torsional oscillation modes, *the proponent* would seek to conduct an *inter-network test*, comprising the removal from service of the key *transmission lines*, transformers and/or generators and the monitoring of the parameters of the critical torsional oscillation mode(s). These special network conditions are expected to be essential for the tests. It is therefore most likely that the provisions of clause 5.7.7 will be required to carry out the testing.

Conclusion – Without regard to the surrounding circumstances (which this example does not seek to describe), it is likely that an inter-network test will be required.

D.4 Example 3: Connection of a *Network User*, whose characteristics may affect an existing transient stability limit

This hypothetical example considers the connection of a 100 MW wind farm to the transmission network, on one of the major transmission corridors.

The wind farm will be made up of many turbines, whose individual *plant* model has been verified, but whose aggregated response is difficult to predict due to the operating points of individual turbines being different due to wind diversity across the farm. The response of the individual units to disturbances at the connection point depends on the relative impedance from the turbine to the connection point, causing uncertainty in the total wind farm response.

Note that this example could similarly apply to the connection of a large industrial *load* that incorporates high levels of controlled equipment.

D.4.1 Classify the type of development in chart 1 of Rule 5.7.7(a)

As a new *generating system*, this *facility* would be classified as an ***Item 3*** type development.

D.4.2 Is there a *material inter-network impact* relevant to *inter-network tests*?

In this example, planning studies by the relevant *TNSP* show that if the absolute worst case response of the wind farm following a contingency is assumed, the import capability for the main interconnector into the region must be reduced by 40 MW.

Based on Appendix B: Criterion and method for assessing material inter-network impact, as the decrease in *power transfer capability* on the interconnector is 40 MW, the development is assessed as having a *material inter-network impact* if the *interconnector* has a maximum *power transfer* capability of 1200 MW [5] or less.

D.4.3 Assess the impact of uncertainty on power transfer capability

Planning studies by the *relevant TNSP* assume that the wind farm will trip and disconnect for faults on the surrounding transmission network. However, there is uncertainty in the actual response of the wind farm and it is likely that, following a contingency, not all of the wind farm units would trip and, if so, the reduction in import capability for the main interconnector into the region would be only 20 MW. Therefore, the TNSP proposes to reduce the interconnector limit by the full 40 MW, until such time as operational experience with the wind farm in service allows the conservative operating principles to be relaxed.

In this example, the main source of uncertainty is the response of the wind farm to disturbances at the connection point. While the proponent has supplied a model for the individual turbine, the aggregated response for the overall wind farm is difficult to predict. Assumptions regarding the expected wind diversity across the wind farm, likely operating points of the individual turbines, to determine a probable worst case operating condition (as opposed to an absolute worst case operating condition) wind farm output, would be required to conduct planning studies.

[5] From appendix B, 40 MW is 3% of a maximum *power transfer capability* of 1200 MW

With respect to Appendix C: Quantification of uncertainty in power transfer capability, the impact of the uncertainty in the wind farm response to system disturbances has been identified as requiring the nearby interconnector to have its transfer reduced by 20 MW. If the *interconnector* has a maximum *power transfer* capability of 600 MW [6] or less, this uncertainly is above the relevant threshold, and an inter-network test may be required.

D.4.4 Assess the ability for uncertainty to be reduced by tests under other clauses

In this example, *plant* tests are to be carried out on an individual wind *generating unit*, and on the protection and control features of the wind farm as a whole. These later *plant tests* will incorporate step changes to set points for the overall wind farm control system (i.e. set points for the power factor, or voltage control) and will contribute to the reduction of uncertainty for the aggregated wind farm model.

To reduce the uncertainty in the response of the overall wind farm to disturbances, it is not proposed to apply actual faults or other disturbances which could jeopardise power system security. Rather, it is proposed that operational experience with the wind farm in service be gained by NEMMCO and the relevant TNSP to allow the conservative operating constraints to be relaxed. In addition, the wind farm response will be captured on high speed recording devices and analysed following any system faults or disturbances.

D.4.5 Assess whether special network conditions are essential for tests

To reduce the impact of the new development, such that the reduction in the import limit is only 20 MW, as opposed to 40 MW, uncertainty in the aggregated wind farm model would need to be removed.

It is possible that the *Relevant TNSP* or the *proponent* could request a test program that involves application of actual faults and disturbances at the transmission connection point. However, such tests have the potential to jeopardise power system security, and quality of supply for network users, especially if applied to lines along a major transmission corridor. For this example, it is unlikely that such a test would be conducted.

Conclusion – Without regard to the surrounding circumstances (which this example does not seek to describe), it is unlikely that an inter-network test will be required.

NEMMCO may decide to conduct an inter-network test to verify the aggregated wind farm model. However, such a test would be conducted as an item 6 type development in Chart 1 of clause 5.7.7(a). A decision to conduct an *inter-network test* under item 6 would be more likely if there had been a number of recent developments, each of which had a measure of uncertainty, but whose cumulative effect met the relevant criteria for conducting an *inter-network test*.

[6] From appendix C, 20 MW is 3% of a maximum *power transfer capability* of 600 MW

D.5 Example 4: Replacement of the excitation control system at a large power station located near an *interconnection* between regions

This hypothetical example considers the refurbishment of a power station which is close to a major industrial load. No new primary *plant* is being installed, but the opportunity has been taken by *the proponent* to upgrade the *generating unit* excitation and *power system* stabiliser control systems using new technology with improved capability.

Planning studies show that the new control system will improve the export capability of the region where the *generating unit* is located.

D.5.1 Classify the type of development in chart 1 of Rule 5.7.7(a)

Because new *power system* stabiliser setting changes are being made as a result of a *generating unit* being modified, this development is classified as an ***Item 4*** type development.

D.5.2 Is there a *material inter-network impact* relevant to *inter-network tests*?

An item 4 development does not require assessment of *inter-network impact*.

D.5.3 Assess the impact of uncertainty on power transfer capability

Planning studies show that the new control system will improve the export capability of the region where the *generating unit* is located. However, there is uncertainty in the model of the nearby industrial *load* which can impact on the magnitude of the expected increase regional export power transfer capability. To assess the uncertainty, sensitivity studies should be carried out in which the industrial load model parameters are adjusted within a feasible range of variation.

Based on <u>Appendix C: Quantification of uncertainty in power transfer capability</u>, if the impact of the uncertainty in these sensitivity studies is greater than 30 MW (which is 3% of the maximum regional export transfer capability of 1000 MW), then an *inter-network test* may be required.

D.5.4 Assess the ability for uncertainty to be reduced by tests under other clauses

Plant commissioning tests will be conducted to verify the model and performance of the new generating unit's control systems.

There are no tests which could be conducted under other clauses to reduce the uncertainty in the major industrial load located near the power station.

D.5.5 Assess whether special network conditions are essential for tests

In this example, as identified previously, there is uncertainty in the extent to which the generating unit's new control systems improve the export capability for the region, primarily due to the uncertainty in the model for the nearby major industrial load.

While 30 MW is above the threshold for consideration of an *inter-network test*, to remove this uncertainty would require a test to verify the model of the load. A disturbance could be applied but to minimise the impact on the load, and to minimise any system security issues, it would be preferable if the model could be verified using non-intrusive methods, such as monitoring the load's response over a period of time. With suitable equipment, it would be possible to verify the load model with minimal impact on either the load or the market.

In light of the above, it is unlikely that an inter-network test would be conducted.

Conclusion – Without regard to the surrounding circumstances (which this example does not seek to describe), it is unlikely that an inter-network test will be required.

Note that NEMMCO may decide to conduct an *inter-network test* to verify the system model, which would be equivalent to an item 6 development in Chart 1 of clause 5.7.7(a). A test under this item would be more likely if there had been a number of developments, each of which had a measure of uncertainty, but whose cumulative uncertainty met the criteria for conducting an *inter-network test*. A relevant consideration would be whether such tests could be conducted outside the provisions of rule 5.7.7.