RELIABILITY PANEL AEMC

REVIEW

Reliability Panel AEMC

DRAFT REPORT

GENERATOR COMPLIANCE TEMPLATE REVIEW - 2019

19 SEPTEMBER 2019

INQUIRIES

Reliability Panel
c/- Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

E aemc@aemc.gov.au
T (02) 8296 7800
F (02) 8296 7899

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ABOUT THE RELIABILITY PANEL

The Panel is a specialist body established by the Australian Energy Market Commission (AEMC) in accordance with section 38 of the National Electricity Law and the National Electricity Rules. The Panel comprises industry and consumer representatives. It is responsible for monitoring, reviewing and reporting on reliability, security and safety on the national electricity system, and advising the AEMC in respect of such matters.

RELIABILITY PANEL MEMBERS

Mr Charles Popple (Chairman), Chairman and AEMC Commissioner
Trevor Armstrong, Chief Operating Officer, Ausgrid
Stephen Clark, Technical and Economic Lead – Project Marinus, TasNetworks
Kathy Danaher, Chief Financial Officer and Executive Director, Sun Metals
Gavin Dufty, Manager Policy and Research, St Vincent de Paul Society, Victoria
John Titchen, Managing Director, Goldwind Australia
Chris Murphy, Strategic Advisor, Meridian Energy; General Manager - Energy Market Interfaces, Telstra
Damien Sanford, Chief Operations Officer, AEMO
Richard Wrightson, Executive General Manager, Wholesale Markets, AGL Energy

SUMMARY

1 On 26 February 2019, the Commission issued terms of reference for the Reliability Panel to conduct a review of the template for generator compliance programs.[1]

2 The template outlines principles and processes for generator compliance program development and specifies a range of test methods for each technical standard requirement in the rules for consideration by generators when developing their compliance programs.[2]

3 The template provides clarity on what constitutes good electricity industry practice with respect to technical standard compliance. By defining an appropriate compliance framework, it assists generators with developing and designing their compliance programs. While generators are responsible for instituting and maintaining their own compliance programs, they need to ensure their programs are consistent with the template.[3] The template may also assist the Australian Energy Regulator (AER) with its enforcement and monitoring of generators' compliance with the technical requirements under the NEM.

4 The last review of the template for generator compliance was in 2015 with the next scheduled review due in 2020. In 2018, however, the Commission made the *Generator Technical Performance Standards* (GTPS) rule, which altered and added technical performance requirements applying to connecting generators in a range of areas.[4] In the final determination of the GTPS rule, the AEMC committed to directing the Reliability Panel to review the template for generator compliance prior to its next scheduled review.[5]

5 Therefore, this review both fulfils the requirements of a periodic review of the template as required under the rules and updates the template to reflect the changes made to generator technical requirements in the Generator Technical Performance Standards rule change.

6 The Panel engaged GHD Pty Ltd (GHD) to support the review by providing detailed technical advice. GHD performed a stakeholder survey on behalf of the Panel to identify options and make recommendations for changes to the template to address the review's scope.

7 Building on the feedback gained through the stakeholder survey, GHD developed an initial set of recommended changes to the template. Those changes were further refined following feedback from members of a technical working group convened by the Panel. Appendix B includes the full GHD report which includes details of survey results, initial recommendations, technical workshop participant views and how those views were incorporated into final recommendations.

8 In addition to their recommended changes, GHD's report for the Panel also considered a range of potential changes which were not incorporated in the Panel's recommendations. GHD's report also provided stakeholder views on a range of generator compliance issues that are beyond the scope of this review of the template for generator compliance template. For

1 AEMC, terms of reference to the Reliability Panel, generator compliance template review - 2019.
2 Technical standards for generator compliance are set out in Schedule 5.2.5 of the NER.
3 Clause 4.15(c)(1) of the NER
4 AEMC, Generator technical performance standards, rule determination, 27 September 2018.
5 Ibid.

further information and detail on these issues, stakeholders should refer to GHD's report, which is included in Appendix B.

9 The Panel's draft recommendations on changes to the template are summarised below, with full details provided in the body of the report and in a marked up copy of the template, provided in Appendix A.

BOX 1: DRAFT RECOMMENDATIONS - SUMMARY

As discussed above, the Panel's review of the template was on the basis of considering what changes were needed subsequent to the GTPS rule made in 2018, as well as those general changes that may be warranted to keep the template up to date.

In respect of template arrangements to account for the amended Generator Technical Performance Rule change:

For assessing compliance with S5.2.5.5, the Panel's draft recommendations are to:

- amend the suggested frequency of testing for method 3 to be: When the plant trips during or immediately following a significant voltage disturbance and at least one major event every 3 years when the generating system maintains continuous uninterrupted operation, and
- implement definitions of template terms including for: significant disturbance, major disturbance, or major event

In respect of assessing compliance with S5.2.5.13, the Panel's draft recommendations are to:

- add the following note to the methods under S5.2.5.13 - "Tests should address all control modes specified in the generator performance standard", and
- require testing " Every 4 years and after plant change. Testing frequency may be reduced for modes that are not routinely used to control the output of the generator."

In respect of other issues identified by GHD and stakeholders as justifying amendment to the template.

The Panel's draft recommendations in respect of other changes to S5.2.5.1 are to:

- specify the basis for compliance assessment for methods 1, 2 and 3 of S5.2.5.1, to require a generating system to "be capable of achieving reactive power requirements of the performance standards subject to not exceeding network voltage limits." and
- include a new section 2.8 in the template providing additional guidance on the inclusion of remote plant relevant to the generating system achieving its performance standards.

The Panel's draft recommendations in respect of other changes to S5.2.5.3 method 4(a) are to:

- specify the suggested frequency of testing to be every three years and after plant change by reviewing the response to a disturbance where the system frequency moves outside of the operational frequency tolerance band, and

- remove "which may include control system settings or protection system change" from the suggested frequency of testing under method 3.

The Panel's draft recommendation in respect of other changes to S5.2.5.5 is to:

- remove method 1 for S5.2.5.5 requiring direct testing of a generator response to disturbance by instigating a network trip.

The Panel's draft recommendation in respect of other changes to S5.2.5.6 is to:

- revise the suitable testing and monitoring methodology listed for method 2 of S5.2.5.6 to read, "Monitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth."

The Panel's draft recommendation in respect of other changes to S5.2.5.7 is to:

- amend the frequency of testing advice for method 3(a) to read "on every event where high frequency moves out of the operational frequency tolerance band or every 5 years (whichever is more frequent) and after plant change as appropriate to the technology of the relevant sub-system".

The Panel's draft recommendations in respect of changes to the definition of 'plant change' are to:

- amend the definition of plant change to explicitly include changes to software or firmware associated with digital control and protection systems
- provide additional guidance on the application of the definition of plant change to changes to software and firmware that are relevant to generating system performance, to align with power system models, as described in the following two dot points.

The Panel's draft recommendations in respect of changes to the alignment with power system models are to:

- replace the references in the template to "the plant models used to establish initial compliance " with the latest plant models provided under clause S5.2.4.", and
- add additional guidance on model validation and the initial compliance program as a new section 2.9 of the template. This guidance is for the generator to consider completing any model validation that couldn't be achieved during the commissioning period as part of its compliance testing program.

The Panel's draft recommendations in respect of the notification of non-compliance are to:

- delete the section 1.3 reference to the AER's Generator Performance Standards, Information Booklet, published in August 2013, and
- include a footnote reference to the AEMO website on which non-compliance notice forms are available.

The Panel's draft recommendations in respect of removing technology bias are to:

- re-word the notes provided for S5.2.5.8 method 3 to include both solar and wind farms

- remove reference to turbine control from S5.2.5.8 method 3 and S5.2.5.9 method 3 and instead reference changes to generating unit control, and
- amend S5.2.5.11 methods 2 through to 4 to include a reference to other control systems designed to arrest frequency disturbances but retain the existing reference to governor system performance.

CONTENTS

FIGURES

1 INTRODUCTION

On 26 February 2019, the Commission issued terms of reference for the Reliability Panel to conduct a review of the template for generator compliance programs (template).[6] This draft report sets out the Panel's draft recommendations for this review.

The template provides clarity on what constitutes good electricity industry practice with respect to technical standard compliance. By defining an appropriate compliance framework, it assists generators with developing and designing compliance programs to verify the performance of their plant complies with their technical performance standard obligations. While generators are responsible for instituting and maintaining their own compliance programs, they need to ensure their programs are consistent with the template. The template may also assist the Australian Energy Regulator (AER) with its enforcement and monitoring of generators' compliance with the technical requirements under the NEM.

Effective compliance with performance standards by registered participants contributes to the delivery of a reliable and secure electricity supply to customers in the National Electricity Market (NEM). The template is designed to assist registered participants who own or operate plant to which performance standards apply, generally generators, with developing and designing their compliance programs.

1.1 Role and purpose of the template under the NER

Under the NER, registered participants have obligations to ensure that their plant meets or exceeds applicable performance standards and that their plant does not materially adversely affect power system security.[7] In that regard, a registered participant who controls or operates plant to which a performance standard applies must institute and maintain a compliance program.[8]

The template aims to provide assistance and clarity to stakeholders, particularly generators and the Australian Energy Regulator (AER), on what constitutes good electricity industry practice with respect to the development of such compliance programs.[9] The template outlines principles and processes for generator compliance program development and specifies a range of test methods for the generator technical standards set out in the rules for consideration by generators when developing their compliance programs.[10]

The rules require generator compliance programs to:[11]

- be consistent with the template for generator compliance programs;
- include procedures to monitor the performance of the plant in a manner that is consistent with good electricity industry practice; and

6 AEMC, terms of reference to the Reliability Panel, generator compliance template review - 2019.
7 Clause 4.15(a) of the NER
8 Clause 4.15(b) of the NER
9 Clause 4.14(ca) of the NER
10 Technical standards for generator compliance are set out in rules schedule S5.2.5.
11 Clause 4.15(c) of the NER.

- provide reasonable assurance of ongoing compliance with each applicable performance standard.

Under the NER, the template must:[12]

- cover all performance standards; and
- define suitable testing and monitoring regimes for each performance standard so that a registered participant can select a regime that complies with its obligations above for its plant.

1.2 Purpose of the review

The NER require the Reliability Panel (Panel) to determine, modify as necessary and publish the template.[13] The rules also require the Panel to undertake regular reviews of the template. Clause 8.8.3(ba) of the NER requires the Panel to conduct a review of the template at least every five years and at such other times as the AEMC may request.

The last review of the template for generator compliance was in 2015 with the next scheduled review due in 2020. In 2018, however, the Commission made the Generator Technical Performance Standards (GTPS) rule which altered and added technical performance requirements applying to connecting generators in a range of areas.[14] In the final determination of the GTPS rule, the AEMC committed to directing the Reliability Panel to review the template for generator compliance prior to its next scheduled review.[15] Further information on the changes to generating system performance standards made in the GTPS rule can be found of the AEMC website.[16]

Clause 4.15(b)(1) of the NER also requires generators to have a compliance program which is consistent with the template for generator compliance within 6 months of connecting to the power system. As a result, the template needs to be updated to reflect the amended rule requirements prior to the next scheduled review.

1.3 Requirements for the review

On 26 February 2019, the Commission issued terms of reference for the Reliability Panel to conduct a review of the template.[17] In undertaking this review, the AEMC requested the Panel to consider whether:[18]

- there have been any changes to technology and cost that should be reflected in the template
- stakeholder experiences with the template which indicate ways in which the template may be improved

12 Clause 4.15(ca) of the NER
13 Clause 8.8.1(a)(2b) of the NER
14 National Electricity Amendment (Generator Technical Performance Standards) Rule 2018.
15 AEMC, generator technical performance standards rule, final determination, p. 246
16 https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards
17 AEMC, terms of reference to the Reliability Panel, generator compliance template review - 2019.
18 Ibid

- there are any other factors, including outcomes of power system incidents, that should be considered to further clarify and improve the template
- changes or additions to the template necessary to account for the changes to performance standards made in the GTPS rule, and
- any other material changes to the NER that impact the template or its use.

While the Commission was motivated to issue terms of reference to the Panel to address changes made in the GTPS rule, the review's terms of reference are not limited to considering changes required due to the making of the GTPS rule. The Commission's terms of reference also cover those applying to a regular review of the template.

The review terms of reference also require the Panel to carry out the review of the template in accordance with the following process:

- publish notice of review, including particulars of the terms of reference for the review, and the deadlines for the receipt of any submissions and public meeting requests
- publish a draft report and invite submissions for a period of at least four weeks
- if a public meeting has been requested, notify stakeholders that a public meeting will be held. At least two weeks' notice of the public meeting must be given, and
- publish a final report and submit this report to the AEMC no later than eight weeks after the period for consultation on the draft report has closed.

1.4 Review process

This section describes the process via which the review has been conducted. It describes the role of GHD in providing specialist technical advice and stakeholder engagement services to support the review and introduces the stakeholder survey conducted by GHD, the technical working group meeting convened by the Panel, and the review's timeline and deliverables.

1.4.1 Survey process and draft recommendations

The Panel engaged GHD Pty Ltd (GHD) to support the review and conduct its initial consultation with stakeholders. Specifically, GHD was engaged to provide detailed technical advice and identify options and recommendations for changes to the template necessary to:

- address the changes made to generator technical performance standards in the GTPS rule change, and
- update and improve the template in line with the other elements of the review's terms of reference.

Initial consultation was conducted via a survey of market bodies and market participants. GHD and Panel staff jointly identified a set of organisations to survey. A balance of generation technology types and new and existing market participants were surveyed in order to provide a range of views and experiences in using the template. Network service providers, AEMO, and the AER were also represented. The organisations surveyed by the Panel are listed in Figure 1.

Figure 1.1: Surveyed organisations

Generators	NSPs and Regulators
Goldwind	AEMO
Snowy Hydro	AER
Pacific Hydro	Powerlink
Stanwell	TransGrid
Energy Australia	TasNetworks
AGL	ElectraNet
Origin Energy	Energy Queensland
Neoen	Powercor
Hydro Tasmania	
Wirsol	

Source: GHD

The survey consisted of a set of questions developed by GHD and Panel staff. These questions included:

- suggested revisions to the template to reflect changes to technical performance requirements in the GTPS rule
- feedback on possible revisions and clarifications identified via an initial review of the template completed by GHD
- feedback on which compliance methods used by stakeholders and the reason for that choice, and
- general views on areas in which the template could be improved.

GHD interviewed each selected stakeholder to discuss the topics covered by the survey. Stakeholders were also invited to provide written submissions to supplement the information provided during interviews.

Building on the feedback gained through the stakeholder survey, GHD then developed an initial set of recommended changes to the template. Those changes were further refined following feedback from members of a technical working group convened by the Panel. The working group was made up of representatives from the AER, AEMO, the Panel, and representatives from members of the Clean Energy Council, Energy Networks Australia, and the Australian Energy Council.

The members of the working group were invited to a workshop hosted by the AEMC on 5 July 2019 during which survey results and initial recommendations developed by GHD were discussed. Appendix B includes the full GHD report which includes details of survey results, initial recommendations, technical workshop participant views and how those views were incorporated into final recommendations.

1.4.2 Review timeline and consultation

This draft report substantially reflects the recommendations put forward by GHD as considered by the review's technical working group. The Panel will provide further detailed consideration of these recommendations in light of stakeholder submissions. Following the publication of this draft report, the review will proceed according to the following milestones:

- Publication of a draft report - 19 September 2019
- Deadline for submissions to the draft report - 18 October 2019
- Public hearing (Optional and only if requested) - 1 November 2019
- Publication of a final report - 21 November 2019

Written submissions on this request must be lodged with the Panel by 18 October 2019 via the Commission's website, www.aemc.gov.au, using the "lodge a submission" function and selecting the project reference code REL0070.

The submission must be on letterhead (if submitted on behalf of an organisation), signed and dated.

All submissions will be published on the AEMC website, subject to a claim of confidentiality. If you are not able to lodge submissions online, please contact us and we will provide instructions for alternative methods to lodge the submission.

In accordance with the terms of reference for this review, stakeholders may request a public meeting on the draft report within five business days following publication. If such a request is received, stakeholders will be notified of the public meeting at least two weeks in advance of it being held. A tentative date of 1 November 2019 has been set aside for a public meeting, if requested.

All enquiries on this project should be addressed to Graham Mills on (02) 8296 1636 or graham.mills@aemc.gov.au.

2 ASSESSMENT FRAMEWORK

This section describes the assessment framework that the Panel has applied in undertaking this review. This includes a description of the Panel's general approach to conducting reviews of the template, the National Electricity Objective, and the assessment principles used applied by the Panel in coming to its draft decisions.

2.1 Panel's general approach to reviews of the template

The template is designed to assist registered participants who own or operate plant to which performance standards apply with developing and designing their compliance programs to meet the relevant performance standards. It is also intended to assist the AER with the enforcement and monitoring of the generators'compliance with the technical requirements under the NER.

The template supports a flexible application of compliance programs within appropriate controls. It does not provide a prescriptive list of compliance choices. This is because the template covers different generation technologies, newly connecting and existing generation of varying types and ages. Because of its wide application, some flexibility in the compliance process is needed to accommodate varying requirements.

A sufficiently flexible, and regularly reviewed, template may also account for new technologies that enter the electricity market and other changes in future circumstances. Such flexibility supports the minimisation of any potential barriers to entry to the market that may exist for new generators in regard to administrative compliance.

Accordingly, the Panel's review of the template is considering:

- the clarity of the template
- balancing prescription and flexibility, and
- usefulness of the template in supporting compliance.

Each of these principles is further described in section 2.3.

2.2 National Electricity Objective

The Panel is required to have regard to the NEO in conducting the review. The NEO is set out in section 7 of the NEL as follows:

"The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:

(a) price, quality, safety, reliability and security of supply of electricity;and

(b) the reliability, safety and security of the national electricity system."

For this review, the relevant aspect of the NEO is the efficient operation of electricity services for the long term interests of consumers of electricity, with respect to the security of the national electricity system.

2.3 Assessment principles

In its consideration of the NEO, the Panel also has had regard to the following factors to assist in its review of the template.

2.3.1 Clarity of the template

The template should provide assistance to generators in developing compliance programs as required under the NER, and the AER in carrying out its compliance functions. Any amendments to the template should clarify how the provisions in the template should be applied to give effect to the template's overall role and purpose. The template may also help generators develop performance standard compliance programs that include monitoring procedures that they consider to be consistent with 'good electricity industry practice'.[19]

2.3.2 Balancing prescription and flexibility

The template should be able to be flexibly applied within appropriate controls. It should be sufficiently flexible to accommodate different generation technologies, and a broad range of generation plants which may have unique attributes and varying requirements. At the same time, the template should provide a basis for generators to develop compliance programs that are suited to their facilities, as required under the NER.

2.3.3 Compliance principles

To provide clarity, with respect to the development of the template and its application by generators and the AER, the Panel has regard to ten compliance principles when assessing potential amendments to the template. These principles are:

- **Principle 1:** Where plant system performance may be variable with time, as for example with plant protection, control and alarm (PCA) systems, generators are accountable for managing the functionality and integrity of systems and settings in accordance with the performance standards compliance program.
- **Principle 2:** The corollary of Principle 1 is that where plant parameters are not subject to variability with time, the compliance regime should be restricted to confirmation that the plant continues to perform as intended with repeat testing when there are reasonable grounds to believe that the plant performance may have changed.
- **Principle 3:** The materiality of the issue must be considered when contemplating a compliance testing regime.
- **Principle 4:** A generator's active use and implementation of a compliance program that is consistent with the approved template and the generator's compliance management framework will provide a reasonable assurance of compliance with the generator's registered performance standards.

19 Chapter 10 of the NER defines "good electricity industry practice" to mean: "The exercise of that degree of skill, diligence, prudence and foresight that reasonably would be expected from a significant proportion of operators of facilities forming part of the power system for the generation, transmission or supply of electricity under conditions comparable to those applicable to the relevant facility consistent with applicable regulatory instruments, reliability, safety and environmental protection. The determination of comparable conditions is to take into account factors such as the relative size, duty, age and technological status of the relevant facility and the applicable regulatory instruments."

- **Principle 5:** The template must therefore support the development of compliance programs which represent "good electricity industry practice". The template should specify the objectives and outcomes to be achieved by the testing or monitoring, and an appropriate test interval. The generator should exercise diligence and good electrical industry practice to determine the detailed methods and procedures to be employed for its plant.
- **Principle 6:** The compliance testing regime must be efficient, and reflect an equitable balance between risk management and the risk created by the test regime itself.
- **Principle 7:** Where appropriate, analysis of performance during an event or disturbance could be used to demonstrate compliance in lieu of a performance test.
- **Principle 8:** Where compliance to a performance standard cannot be directly tested, the compliance program should include a range of other compliance testing methods to provide reasonable assurance that the performance standard continues to be met.
- **Principle 9:** When developing a compliance program and operating under that program, a generator can only be reasonably held accountable for the compliance of its plant to its registered performance standards and to equipment settings approved or provided by AEMO and/or the transmission network service provider.
- **Principle 10:** Compliance programs should be reviewed and updated periodically.

3 DRAFT RECOMMENDATIONS

This section sets out the Panel's draft recommendations on changes to the template. The Panel's draft recommendations reflects those made by GHD in their report to the Panel. In addition to their recommended changes, GHD's report for the Panel also considered potential changes which were not incorporated amongst the Panel's recommendations. GHD's report also provides stakeholder views on a range of generator compliance issues that are beyond the scope of this review of the template for generator compliance template. Stakeholders should refer to GHD's report, presented in Appendix B, for more detail on these issues.

This section first introduces draft changes to the template in response to the GTPS rule. Following this, additional changes are introduced addressing the other review scope items.

3.1 Changes in response to the GTPS rule

The GTPS rule introduced significant changes to the generator performance standard provisions in October 2018.[20] To identify adjustments to the template necessary to reflect these changes, GHD completed an initial review of the template against the updated generator performance standards. GHD's initial analysis was then consulted on via the stakeholder survey and the review's technical working group. The Panel's draft recommendations on changes to the template in response to the GTPS rule change reflects GHD's recommendations set out in its report contained in Appendix B.

GHD found that existing methods described in the template were generally suitable for assessing ongoing compliance, considering the changes introduced through the GTPS rule. While the GTPS rule introduced more detailed and in some case more onerous generator performance standards, compliance with those revised performance standards can generally be assessed utilising data captured by high speed monitors. The current version of the template provides methods that allow for the use of high speed monitoring to assess compliance with amended performance standards.

Two areas were identified as requiring adjustment to reflect changes made in the GTPS rule. Specifically, the methods for assessing compliance for performance standards S5.2.5.5 and S5.2.5.13. The following sections outline the Panel's draft decisions in respect of these two performance standards.

3.1.1 Assessing compliance with S5.2.5.5

S5.2.5.5 specifies the performance requirements for generating systems to ride through disturbances. The GTPS rule changed S5.2.5.5 to require a generating system to ride through multiple disturbances as well as requiring a generating system to inject or absorb reactive current to support power system voltages during a fault. To incorporate these changes, the Panel's draft recommendations are to make changes to template arrangements in the following areas:

20 Additional information on the changes made in the GTPS rule can be found on the Commission's website at https://www.aemc.gov.au/rule-changes/generator-technical-performance-standards

- Suggested frequency of testing in method 3
- Defining major event, significant disturbance, major disturbance

Suggested frequency of testing in method 3

Method 3 of S5.2.5.5 provides for continuous monitoring using high speed recorders. The existing template suggests that method 3(a) be applied "on disturbances when the plant trips or at least one major event every 3 years". The frequency of testing suggested for method 3(a) indicates that it would be adequate to just review performance following disturbances where the plant trips or to just test performance for one major event every 3 years, or some combination of these.

If compliance assessments only review performance following plant trips performance may not be assessed for events where the generating system rides through the disturbance. To confirm compliance with the new reactive current injection and absorption requirements under S5.2.5.5 of the GTPS rule, performance also needs to be assessed when the generating system rides through the disturbance and not only on occasions when the plant trips.

GHD consulted on changing the suggested frequency of testing under method 3(a) by changing the "or" to "and", to clarify that assessments should also be performed when the generating system successfully rides through disturbances. This change would provide a basis on which to assess the compliance of generating system reactive current injection and absorption performance against amended performance standard obligations. Stakeholders generally considered the proposed change to be reasonable and that high speed recordings of events where the generator successfully rode through faults should be investigated to confirm compliance with reactive current response requirements.

GHD considered it unnecessary for a generator to assess performance against all major events. If a generator has successfully demonstrated performance for a recent major event and there has been no plant change there would be little value in assessing performance for subsequent major event occurring within a reasonable period from the first major event.

The Panel's draft recommendation is therefore to amend the suggested frequency of testing under S5.2.5.5 for method 3(a), (applying to continuous monitoring using high speed recorders) to suggest testing occur "When the plant trips during or immediately following a significant voltage disturbance and at least one major event every 3 years when the generating system maintains *continuous uninterrupted operation*"

Definition of major event, significant disturbance, major disturbance

Existing methods for assessing response to disturbances following contingency events under S5.2.5.5 include requirements to investigate plant performance following 'significant disturbances' and 'major events'. The template also refers to 'major disturbance' in a number of areas.[21] None of these terms are currently defined in the template. Stakeholders identified uncertainty as to the interpretation of what constitutes a 'major event', 'significant

21 S5.2.5.4 makes reference to a major voltage disturbance, S5.2.5.11 makes reference to major frequency disturbance.

disturbance', or 'major disturbance' as an issue creating uncertainty for generators in applying the template.

GHD and panel staff considered this issue in light of a number of stakeholder suggestions as to ways to clarify the meaning of 'major event'. Stakeholder suggestions included defining a major event as an event on the power system that the generator considers best tests the ability of the generating system to meet its performance standard. A major event may also include: a disturbance that triggers AEMO to undertake a review of system performance; disturbances that result in voltage variations comparable with the minimum access standard specified in S5.2.5.4; or frequency variations that meet or exceed the minimum access standard in S5.2.5.3.

It is difficult for generators to know when a major event has occurred by solely relying on triggers, protection operations and alarms that can be generated from quantities visible to the generator, particularly if the generator successfully rode through the fault. A number of stakeholders suggested that AEMO or the NSP may be better placed to identify when major events had occurred and if that information was published in a timely manner it could provide effective triggers for assessing compliance of performance during major events. The Panel notes that a rule change would be required to implement a new obligation on NSPs to notify generators following the occurrence of a major event. As a result, this is an issue that is beyond the scope of this review of the template to address. Interested stakeholders may consider submitting a rule change request on this matter.

Noting that similar issues apply to interpretation of 'significant disturbance' and 'major disturbance', the Panel's draft recommendation is for the template to define 'major event', 'major disturbance', and 'significant disturbance' in the manner set out in the box below.

BOX 2: DRAFT RECOMMENDATIONS - ASSESSING COMPLIANCE WITH S5.2.5.5

The panel's draft recommendations are to:

- amend the suggested frequency of testing for method 3 to be: When the plant trips during or immediately following a significant voltage disturbance and at least one major event every 3 years when the generating system maintains continuous uninterrupted operation, and
- define significant disturbance, major disturbance, or major event as follows -
  - *Significant disturbance* for the purposes of this template means a power system disturbance that significantly varies frequency, voltage or power quality at the connection point beyond normal system conditions. Significant disturbances provide a trigger for investigating plant trips to assess whether the trip indicates an inability of the *generating system* to remain in *continuous uninterrupted operation* as required by its performance standard.
  - *Major disturbance* for the purposes of this template means a power system disturbance that the generator considers will provide a significant test of the ability of

the *generating system* to remain in *continuous uninterrupted operation* as required by its performance standard.

- *Major event* for the purposes of this template means an event on the power system that the generator considers best tests the ability of the *generating system* to meet its performance standard.

3.1.2 Assessing compliance with S5.2.5.13

S5.2.5.13 specifies performance requirements for control of voltage and reactive power. The GTPS rule made a number of changes to performance requirements under S5.2.5.13 including a requirement for a generator connecting at the automatic access standard to have facilities to control reactive power in multiple modes being reactive, power factor, or voltage control modes.[22] The amended automatic access standard also requires generators to be able to switch between control modes.[23] The Panel has made draft recommendations to amend the template to address these new requirements by clarifying:

- Compliance testing of multiple reactive power control modes, and
- Suggested test frequency for primary and secondary control modes

Compliance testing of multiple reactive power control modes

The test methods specified in the template do not currently contemplate a scenario where a generating system might be required to operate in multiple reactive power control modes and switch between control modes on request. In order to align template provisions with amended technical standard requirements, GHD identified a need for template methods to be updated.

S5.2.5.13, as amended by the GTPS rule change, draws a distinction between a newly connecting generator having the capability to operate in multiple reactive power control modes and having those modes commissioned and in operation. While a generator connecting at the automatic access standard is required to have facilities allowing operation in all reactive power control modes,[24] It is only required to be able to operate in a set of modes that AEMO and the NSP require to be commissioned.[25] The rules require an initial operating mode, and other operating modes, to be recorded as part of the performance standard.

GHD considered a generator which is required to have control systems configured and commissioned to operate in the different reactive power control modes, and be able to switch between these modes on line / in real time, should validate the ongoing ability to deliver this control. If on the other hand the generator was only required to demonstrate that capability exists for multiple control modes, but to operate in the single control mode agreed with

22 Clause S5.2.5.13(b)(2A) of the NER
23 Clause S5.2.5.13(g1) of the NER
24 Clause S5.2.5.13(b)(2A) of the NER.
25 Clause S5.2.5.13(g1) of the NER.

AEMO and the NSP, it is reasonable for compliance assessments to only consider the single commissioned control mode.

Stakeholders noted that it is quite uncommon for AEMO or the connecting NSP to require generators to be able to switch between active control modes while online and generating power. Most generators only operate in one control mode and it is generally not practical to activate another mode without testing and reconfiguration of the generating system. If however a situation does exist where a generator has agreed that multiple control modes will be available, stakeholders considered it reasonable that the compliance program consider each commissioned control mode.

To clearly provide for the testing of multiple reactive power control modes, the Panel's draft recommendations are to add the following note to the methods under S5.2.5.13 - "Tests should address all operating control modes listed in the generator performance standard as commissioned control modes."

Test frequency applying to primary and secondary control modes

S5.2.5.13, as amended by the GTPS rule, draws a distinction between a newly connecting generator having the capability to operate in multiple reactive power control modes and having those modes commissioned and in operation. The GTPS rule requires an initial operating mode, as agreed by AEMO and the NSP, to be specified in the connection agreement separate from other available modes.[26] These other available modes may be considered secondary commissioned operating modes that are only periodically required by AEMO and the NSP.

Generating systems will generally operate in a single reactive power control mode. GHD considered the template should provide for reduced test frequency for control modes that the generator is seldom instructed to use. GHD therefore recommended that the suggested frequency of testing for S5.2.5.13 provides for a lower frequency of testing any commissioned reactive power control modes that are not the generating system's primary control mode.

The Panel agrees with GHD and considers it reasonable for a generator to distinguish between its primary mode of operation and modes that would only be used occasionally. The Panel's draft recommendation is to amend the suggested frequency of testing in S5.2.5.13 method 1(a) to suggest a test frequency of "every 4 years and after plant change. Testing frequency may be reduced for modes that are not routinely used to control the output of the generator." Guidance as to the frequency of testing for secondary control modes is provided in section 2.7 of the template. The Panel does not propose changes in this area.

26 Clause S5.2.5.13(g1) of the NER.

BOX 3: DRAFT RECOMMENDATIONS - ASSESSING COMPLIANCE WITH S5.2.5.13

The Panel's draft recommendations are to:

- add the following note to the methods under S5.2.5.13 - "Tests should address all control modes specified in the generator performance standard.", and
- require testing " Every 4 years and after plant change. Testing frequency may be reduced for modes that are not routinely used to control the output of the generator"

3.2 Other template changes

In addition to changes to address the GTPS rule change, a range of other issues were also identified by GHD and stakeholders in respect of the template. This section presents Panel decisions on those issues. These are:

- Feasibility of testing full reactive power capability
- Performance of remote equipment
- Frequency of testing for S5.2.5.3
- References to the definition of plant change
- Fault throw test viability
- Clarifying 'appropriate metering'
- Frequency of testing for S5.2.5.7
- Definition of 'plant change'
- Alignment with Power System Models
- Notification of non-compliance process, and
- Removing technology bias.

The Panel's draft recommendations in respect of each of these issues are grouped according to the performance standards they primarily relate to.

3.2.1 Other changes applying to S5.2.5.1

S5.2.5.1 is the performance standard that specifies the reactive power capability required from a connecting generator. GHD and stakeholders have identified the feasibility of testing full reactive power capability and performance of remote equipment as issues justifying changes to the template. This section discusses and presents the Panel's draft recommendations for each of these issues.

Feasibility of testing full reactive power capability

S5.2.5.1 methods 1 and 2 test a generating system's reactive power capability by adjusting the reactive power output to the maximum level agreed in the performance standard. These

methods therefore require exercise of the entire reactive power range of the generating system or triggering over and under excitation limits.

Such tests have implications for voltages in the power system and by extension system security during the test period. Methods 1 and 2 may therefore not be achievable for some generators due to the impact on power system voltages. For large power stations with a single generating unit or for wind and solar farms connected into relatively weak areas of the network, the network may not be able to accommodate the full reactive power range without breaching voltage limits.[27]

Feedback from generators and NSPs confirm that circumstances do exist where the network is not always able to accommodate the full reactive power capability without adverse system impacts. Prior approval by the NSP and AEMO should be sought well in advance to have the best chance of being able to perform the test without creating adverse outcome for the network and surrounding power system. Stakeholder feedback confirmed that even with advanced notice, testing involving full reactive power range may not be possible.

As the current template does not qualify this issue, GHD recommended the basis for compliance assessment be amended to specify that testing must not exceed network voltage limits.

The Panel agrees with GHD and stakeholders that generator compliance testing should not present a risk to system security by producing network voltages that exceed limits. The Panel's draft recommendation is therefore to amend the basis for compliance assessment applying to methods 1, 2 and 3 of S5.2.5.1 to require a generating system to "be capable of achieving reactive power requirements of the performance standards, subject to not exceeding network voltage limits."

Performance of remote equipment

S5.2.5.1 allows for performance standards to be met by reactive plant installed beyond the connection point. S5.2.5.1 specifically provides for a negotiated access standard that allows a generator to meet an agreed level of performance by funding the provision of additional reactive power capability via plant and equipment installed at a location which differs from the connection point.[28]

Circumstances may exist where the performance of the generating system relies on the output of this remotely located plant. If the remotely located plant is either unavailable or not performing as required, the generator may be unable to meet its performance standard requirements. At present the template doesn't contemplate the performance of plant and equipment installed at a location which differs from the connection point in assessing compliance.

Panel staff, GHD, and stakeholders considered whether generator compliance processes should extend to cover off site plant. Stakeholders generally agreed that all plant that is

27 Generating systems with multiple units may be able to safely conduct such tests by using one unit to absorb reactive power produced by the unit under test, or using another unit to produce the reactive power being absorbed by the unit being tested.

28 Clause S5.2.5.1(d) of the NER.

critical for achieving required levels of performance should be subject to an appropriate compliance assessment process. The obligation for developing and executing the compliance program for off-site plant should however lie with the owner and operators of the off site asset rather than the generator itself.[29] As the generator's performance standard specifies the performance expected to be seen at the generator's connection point, stakeholders considered that generator compliance programs should assess compliance limited to performance at the generator's connection point.

If the availability of any remote equipment impacts the ability of the generator to satisfy its performance standards at its connection point, there was general stakeholder agreement that the generator's operating procedures should provide for the output of the generator to be adjusted as necessary should the remote plant be unavailable. The performance standard, connection agreement or operating protocol should therefore specify an obligation for the operator of the remote plant to inform the generator if the plant is not available and control actions that the generator should take in response. The generator compliance program should confirm this control scheme continues to operate as specified.

As the compliance template already provides test methods sufficient to confirm the ongoing performance of key generator controls, no change is required to the test methods specified in the template to address remote plant. GHD however recommended that a new sub-section be added to section 2 of the template to provide guidance on the potential for remote plant to impact generator performance and on the roles expected of different parties in assessing ongoing compliance of the remote plant and changes in its availability.

The Panel agrees with GHD and stakeholders that guidance should be provided regarding the performance of remote equipment. The Panel's draft recommendation is therefore to include a new section 2.8 in the template providing the guidance as set out in the box below.

BOX 4: DRAFT RECOMMENDATIONS - OTHER CHANGES TO S5.2.5.1

The Panel's draft recommendations is to:

- specify the basis for compliance assessment for methods 1, 2 and 3 of S5.2.5.1 to require a generating system to "be capable of achieving reactive power requirements of the performance standards subject to not exceeding network voltage limits."
- include a new section 2.8 in the template providing the following guidance:

"Some of the performance standards specified in section S5.2.5 allow a generator to provide plant and equipment at the connection point that delivers a level of performance which is lower than the level of performance acceptable to AEMO and the relevant TNSP provided the generator arranges the provision of additional capability via plant and equipment located elsewhere in the power system. For example S5.2.5.1 allow a generator to fund the provision of additional reactive power capability via plant and equipment installed at a location which

29 This applies to the case where the generator has contracted with the NSP or reached a commercial agreement with another market participant to provide the off-site facilities.

differs from the connection point. The compliance program developed by the generator should not be required to assess the ongoing ability of the remote plant and equipment. Where a control system has been installed to ensure correct operation of the generator should the remote equipment be unavailable, the functionality of that control system should be tested as part of the generator compliance program."

3.2.2 Other changes applying to S5.2.5.3

S5.2.5.3 is the performance standard that applies to generating system response to frequency disturbances. GHD and stakeholders identified a lack of clarity in the suggested frequency of testing and requirements applying to 'plant change' as justifying amendments to the template. This section discusses and presents the Panel's draft recommendations on each of these issues.

Clarification of test frequency

S5.2.5.3 method 4(a) has a suggested test frequency of "every 3 years and after plant change". This provision does not provide guidance on the event trigger for testing. It is therefore unclear when in this 3 yearly period testing should occur. GHD surveyed stakeholders on whether providing additional guidance on the trigger for testing was warranted. In particular, GHD proposed a review of the response to a disturbance be triggered where the system moves outside the operational frequency tolerance band.

Stakeholders agreed that GHD's proposal to require the generator to review the response to a disturbance where the system moves outside the operational frequency tolerance band was a sensible change to clarify the circumstances under which a generator should assess its performance.

The Panel's draft recommendation is therefore to provide additional guidance under the suggested frequency of testing specified for method 4(a) of S5.2.5.3. Specifically to specify the suggested frequency of testing to be every three years and after plant change by reviewing the response to a disturbance where the system frequency moves outside of the operational frequency tolerance band.

References to the definition of plant change

Plant change is defined in section 2.9 of the existing template and covers both changes to primary plant and changes to control and protection systems as types of plant change. In addition to this definition, which applies to all parts of the template, the suggested frequency of testing in method 3 of S5.2.5.3 requires testing following plant change "which may include control system settings or protection system change." Other references to plant change in the template do not include this stipulation.

GHD considered it unclear why S5.2.5.3 method 3 in the template stipulates this requirement which is already covered by the overarching definition of plant change. GHD considered this stipulation to be unnecessary and risks creating confusion that control system changes are only relevant for some performance standards and not others.

Stakeholders thought it reasonable to have this term defined once in section 2.9 and for additional references to control system settings or protection system change in respect of plant change removed from Table 1.

The Panel agrees with GHD that unnecessary duplication of definitions can cause confusion. For this reason the Panel's draft recommendation is to remove "which may include control system settings or protection system change" from the suggested frequency of testing under method 3.

BOX 5: DRAFT RECOMMENDATIONS - OTHER CHANGES TO S5.2.5.3

The Panel's draft recommendations are to:

- specify the suggested frequency of testing in nethod 4(a) to be every three years and after plant change by reviewing the response to a disturbance where the system frequency moves outside of the operational frequency tolerance band, and
- remove "which may include control system settings or protection system change." from the suggested frequency of testing under method 3.

3.2.3 Other changes applying to S5.2.5.5

S5.2.5.5 is the performance standard that applies to generator response to disturbances following contingency event. In addition to changes made to address the GTPS rule, GHD identified method 1 of S5.2.5.5 (direct testing by instigating a network trip) as a candidate for removal from the template. This section presents the Panel's draft recommendations on this issue.

Fault throw test viability

Method 1 of S5.2.5.5 requires direct testing of performance by initiating a network trip. As 'network trip' is not defined in the template, the exact nature of this test is unclear. GHD does not consider a network switching event in the absence of a fault to be a valid disturbance for testing compliance. Therefore, 'performance by initiating a network trip' appears to require the deliberate application of a network fault (i.e. a fault throw test).

A fault deliberately applied to the network to assess generator performance under S5.2.5.5 creates risks for power system security. A fault throw test should therefore not be conducted unless it is in a highly controlled manner with close involvement of both AEMO and the relevant NSP. GHD questioned whether such a test is advisable and appropriately undertaken as part of a generator's compliance testing regime.

The Panel notes that there are circumstances where a fault throw test may be appropriate. In particular, it notes stakeholder feedback that TasNetworks uses fault throw tests as part of the commissioning process for new generators. TasNetworks uses fault throw tests in commissioning given the criticality of such events within the Tasmanian network and the importance of being able to verify the measured generator response against the modelled

response. In carrying out this test TasNetworks however minimises the risk to system security and sets the network up under optimal test/control conditions.

One NSP stakeholder advised that rigorous fault investigations would require a generator to approach the NSP for provision of information on the network state, both pre and post fault, along with requests for any fault recordings available to supplement their own analysis. The NSP in question has no record of any generator making such an approach - this is consistent with advice from other stakeholders that fault throw tests are not used by generators to assess ongoing compliance.

Most stakeholders agreed that, for this method to be effective in assessing compliance with S5.2.5.5, a fault throw test would be needed. None of the surveyed respondents support using such a test to assess ongoing compliance given the risks involved. No surveyed generators currently utilise this test method as other template methods can provide an appropriate assessment of compliance with S5.2.5.5.

The Panel agrees with GHD and stakeholders that generator compliance testing should not create significant risks to power system security. While TasNetworks may use fault throw tests in commissioning new generators, the Panel notes that ongoing generator compliance testing is not comparable to commissioning testing. For these reasons, the Panel's draft recommendation is to remove method 1 requiring direct testing of a generator response to disturbance by instigating a network trip from the template.

BOX 6: DRAFT RECOMMENDATION - OTHER CHANGES TO S5.2.5.5

The Panel's draft recommendation is to:

- Remove method 1 requiring direct testing of a generator response to disturbance by instigating a network trip.

3.2.4 Other changes applying to s5.2.5.6

S5.2.5.6 is the performance standard relating to the quality of electricity generated and continued uninterrupted operation. GHD identified uncertainty as to the type of metering that qualified as 'appropriate metering' under method 2. This section presents the Panel's draft recommendation on this issue.

Clarifying 'appropriate metering'

S5.2.5.6 specifies a requirement for generating systems to remain in continuous uninterrupted operation provided the power quality at the connection point remains within the level specified in the system standard. Method 2 specifies the monitoring of in-service performance using 'appropriate metering', however the term 'appropriate metering' is not defined. It is therefore uncertain what types of metering and metering equipment qualifies as 'appropriate metering'.

Stakeholder feedback indicates that appropriate metering has been generally interpreted to mean power quality metering. In addition to specialised power quality metering however,

generators report that high speed monitoring systems can provide continuous power quality monitoring which may also be considered to be 'appropriate metering'.

Stakeholders however noted that appropriate metering requires accurate harmonic measurements made using appropriate measurement transformers. Some commonly used measurement transformers, such as indicative voltage transformers, were noted as not being able to provide accurate measurement of harmonics at higher orders. Metering using such measurement transformers may therefore not be appropriate metering irrespective of the measurement system being utilised.

The Panel's draft recommendation is therefore to provide further guidance on what constitutes 'appropriate metering' in the template. Specifically, that suitable testing and monitoring methodology listed for method 2 of S5.2.5.6 be revised to read: "monitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth."

BOX 7: DRAFT RECOMMENDATION - OTHER CHANGES TO S5.2.5.6

The Panel's draft recommendation is to:

- amend the suitable testing and monitoring methodology listed for method 2 of S5.2.5.6 to read, "Continuous monitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth. "

3.2.5 Other changes applying to S5.2.5.7

S5.2.5.7 is the technical performance standard applying to partial load rejection, which is the ability of a generating system to rapidly reduce generation in response to a rapid reduction in power system load. GHD identified that there was a need to clarify the frequency of testing specified in S5.2.5.7 method 1(a) and 3(a) and the event definition in method 3(a). This section presents the Panel's draft recommendation on this issue.

Frequency of testing for S5.2.5.7

Method 1(a) of S5.2.5.7 suggests testing occur "on every event where the frequency moves beyond the operational frequency tolerance band or every five years whichever is more frequent". Method 3(a) in contrast suggests testing "on every event or 10 years (whichever is more frequent) as appropriate to the technology of the relevant subsystem." Method 1(a) therefore includes an event trigger for testing, being a frequency excursion beyond 51 Hz on the mainland, and a default test frequency of 5 years. Method 3(a) on the other hand does not include an event trigger and utilises a default test period of 10 years.

GHD noted this discrepancy and consulted on whether the suggested testing frequency be unified for methods 1(a) and 3(a) to be a frequency excursion beyond 51 Hz on the mainland, and a 5-year default test period applied to both.

Most stakeholders supported GHD's proposal to align the frequency of testing requirements for 1(a) and 3(a). Some stakeholders however noted this change as increasing the

suggested default frequency for 3(a) from 10 to 5 years. Some stakeholders were concerned that a test on every event may introduce a high test burden particularly in situations where variations in performance are unlikely due to the generating technology used and where a test has already confirmed performance within the last 5 years. GHD considers that the proposed qualification of the test frequency for method 3(a) will help address this concern as every event will be qualified to only mean those events where the frequency moves outside the operational frequency tolerance band. This is a relatively rare occurrence in the NEM, typically only occurring when a very large non-credible contingency results in the triggering of automatic under frequency load shedding.

GHD also notes that section 2.7 of the template allows generators to utilise a testing frequency different from that suggested in Table 1 if justifiable. Therefore, unifying the test frequency and trigger requirements in methods 1(a) and 3(a) of S5.2.5.7 should not represent an undue additional burden for generators that can show that a more frequent test regime is not required by their plant.

The Panel accepts GHD's view and its draft recommendation is to amend the frequency of testing advice for Method 3(a) to read "on every event where high frequency moves out of the operational frequency tolerance band or every 5 years (whichever is more frequent) and after plant change as appropriate to the technology of the relevant sub-system".

BOX 8: DRAFT RECOMMENDATION - OTHER CHANGES TO S5.2.5.7

The Panel's draft recommendation is to:

- amend the frequency of testing advice for method 3(a) to read "on every event where high frequency moves out of the operational frequency tolerance band or every 5 years (whichever is more frequent) as appropriate to the technology of the relevant sub-system".

3.2.6 Other changes to template provisions

In addition to the changes that primarily relate to particular performance standards, GHD identified a range of issues which are either general in nature or apply across a number of different standards. These are discussed below and include:

- Definition of plant change
- Alignment with Power System Models
- Notification of non-compliance process

Definition of 'plant change'

During consultation, stakeholders raised a range of issues relating to the template's definition of plant change. Stakeholders noted that not all changes justify a reassessment of compliance, such as where changes including replacement of a piece of equipment with an identical piece of equipment with the same performance characteristics, which stakeholders argued should not trigger a requirement for reassessing compliance.

A particular area of concern amongst stakeholders however was the extent to which any changes in firmware/software (which includes remotely and automatically downloaded upgrades and patches) should qualify as plant changes, given their potential to, sometimes inadvertently, change plant performance. A number of stakeholders considered software updates to be a material issue which required generator attention and careful assessment given their potential to affect a generator's performance.

Stakeholders suggested that the definition of plant change should also consider the need for consistency with the triggers that give rise to a clause 5.3.9 application in the NER.[30] Consideration was also needed to balance the timely installation of patches to ensure cyber security and the need to confirm that any such change does not impact plant performance. Stakeholders considered additional guidance in the template was justified to raise awareness of the risk of a firmware/software change changing the performance of the plant.

The Panel agrees with stakeholders that the definition of plant change should be consistent with the triggers that give rise to a clause 5.3.9 application in the NER. The Panel also considers additional guidance as to the treatment of changes in firmware/software be required. Therefore, the Panel proposes the definition of plant change be amended to include the following additional element:

- "A plant change may include a change to software or firmware associated with digital control and protection systems"

Following the amended definition of plant change the Panel has determined to provide additional guidance as presented in the following box.

BOX 9: DRAFT RECOMMENDATIONS - DEFINITION OF 'PLANT CHANGE'

The Panel's draft recommendation is to:

- amend the definition of plant change to include:

  "A plant change may include a change to software or firmware associated with digital control and protection systems", and

- provide the following additional guidance on the application of the definition of plant change:

  " The generator should pay careful attention to software and firmware changes, and carefully assess whether they have the potential to modify the performance of the generating system. A software or firmware change that is assessed as having the potential to change the performance of the generating system should be treated as a plant change. Changes to a generating system that would trigger the process described in clause 5.3.9 of the NER would also constitute a plant change."

30 clause 5.3.9 of the NER relates to the procedure to be followed by a Generator proposing to alter a generating system.

Alignment with Power System Models

A number of methods rely on use of "plant models used to establish initial compliance" to assess compliance against a performance of a model of the plant. These include method 2 of S5.2.5.3, method 2 of S5.2.5.4, method 3 of S5.2.5.5, method 1 of S5.2.5.8, methods 1 and 3 of S5.2.5.11, methods 1, 2, and 3 of S5.2.5.13.

GHD noted that the use of "plant models used to establish initial compliance" could overlook new issues being identified through the use of updated plant models. Both Powercor and AEMO considered that a greater emphasis should be placed on ensuring that compliance testing not only acts to ensure the agreed performance standards are met, but also that the agreed generating system models used to verify those standards remain accurate. In addition to this, Powercor noted that the manufacturers of newer generating system equipment (e.g. inverter systems) are constantly updating the models of their existing equipment and those models are crucial in understanding how the generating system will respond to events on weak networks. AEMO and Powercor were concerned that revised models may reveal non-compliance with agreed performance standards, yet existing generators may not be actively seeking to update their equipment models or to highlight this to NSP's and AEMO.

Members of the technical working group also suggested that the reference to "plant model used to establish initial compliance" in the template should be amended to read "the latest plant model provided in accordance with clause S5.2.4". GHD agreed with stakeholder views that compliance methods that rely on comparison of measured and modelled performance should consider the latest plant model.

Feedback provided from the technical working group also identified that tests performed during the R2 generator model validation phase often do not provide sufficient validation of a generator model. This could arise if significant system events did not occur during the test period. Members of the working group suggested that when this occurs, it is reasonable to expect a generator to consider the need to finalise the model validation by collecting data via the initial compliance program. Stakeholders suggested a need for the template to provide this guidance.

The Panel agrees with stakeholder concerns and considers the use of up to date models to be necessary for establishing ongoing compliance. In addition, the Panel consider it reasonable for guidance to be added to the template regarding the provision of additional information addressing any gaps remaining in model validation testing performed as part of commissioning and R2 testing. The Panel's draft recommendation is therefore to:

- replace the references in the template to "the plant models used to establish initial compliance " with the latest plant models provided under clause S5.2.4."

And add the additional guidance in section 2.9 of the template on model validation and initial compliance program presented in the box below.

BOX 10: DRAFT RECOMMENDATIONS - ALIGNMENT WITH POWER SYSTEM MODELS

The Panel's draft recommendations are to:

- replace the references in the template to "the plant models used to establish initial compliance " with the latest plant models provided under clause S5.2.4.", and
- add the following additional guidance in section 2.9 of the template on model validation and initial compliance program:

> "When establishing the initial compliance program a generator should consider whether any gaps remain in the model validation performed as part of commissioning and R2 testing. This could arise if significant system events did not occur during the test period resulting in incomplete model validation. In situations where the model validation is incomplete the generator should take this into account in developing the compliance program and where appropriate choose test methods that support gathering data necessary to demonstrate compliance and complete the validation of the model."

Notification of non-compliance process

The AER requested that the generator compliance template remind generators of their obligations in rules clauses 4.15(c) and (f) of the NER to report potential non-compliances. The AER also suggested including a link to the AEMO web page where generators can access the form developed to advise AEMO of any non-compliance with their registered performance standards. GHD and other stakeholders were supportive of the AER's requests.

The AER also advised that the generator performance standards information booklet published in August 2013 and referred to in section 1.3 of the template is no longer current and is being updated. GHD recommends that reference to the August 2013 guideline be deleted and a reference to the new guideline be added if it becomes available prior to finalising the amended template.

The Panel's draft recommendation is to delete reference to AER's generator performance standards information booklet published in August 2013 and provide an additional footnote providing a reference to the AEMO website on which non-compliance notice forms are available.

BOX 11: DRAFT RECOMMENDATIONS - NOTIFICATION OF NON-COMPLIANCE PROCESS

The Panel's draft recommendation is to:

- delete the following reference in section 1.3 to the AER's Generator Performance Standards, Information Booklet, published in August 2013.

Removing technology bias

In its initial review of the template GHD identified a number of instances of technology specific language, specifically:

- S5.2.5.8 method 2 refers to wind farms and could be re-worded to include both solar and wind farms
- Test methods for performance standards S5.2.5.8, S5.2.5.9, and S5.2.5.11 contain notes that refer to turbine control parameters when they could apply to all generating system control parameters.
- S5.2.5.11 method 2 only applies to governor systems while method 3 limits analytical simulations to turbine controls and governors. This use of the term turbine and governor could be interpreted as excluding active power controls on batteries and solar farms.

Most stakeholders supported GHD's recommendation that inappropriate technology bias should be removed from the template. One stakeholder expressed the view that S5.2.5.11 – method 1 appeared to cover off the performance of "non-governor plant" such as batteries and solar, which method 2 appeared to apply specifically to those generators that have a governor system for the control of frequency. In this case a reference to governor system performance may be justified. GHD agreed with the point made by this stakeholder and considered that a reference to governor system performance was justified in this case.

The Panel agrees with GHD and stakeholders that inappropriate technology bias should be removed from the template. The Panel's draft recommendations are therefore to:

- Re-word the notes provided for S5.2.5.8 method 2 to include both solar and wind farms
- Remove reference to turbine control from S5.2.5.8 method 2 and S5.2.5.9 method 3 and instead reference changes to generating unit control
- Amend S5.2.5.11 method 2 to include a reference to other control systems designed to arrest frequency disturbances but retain the existing reference to governor system performance.

BOX 12: DRAFT RECOMMENDATIONS - N**OTIFICATION OF NON-COMPLIANCE PROCESS**

The Panel's draft recommendations are to:

- re-word the notes provided for S5.2.5.8 method 3 to include both solar and wind farms
- remove reference to turbine control from S5.2.5.8 method 3 and S5.2.5.9 method 3 and instead reference changes to generating unit control, and

- amend S5.2.5.11 methods 2 through 4 to include a reference to other control systems designed to arrest frequency disturbances but retain the existing reference to governor system performance.

ABBREVIATIONS

Delete and add abbreviations as appropriate.

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
Commission	See AEMC
MCE	Ministerial Council on Energy
NEL	National Electricity Law
NEO	National electricity objective
NERL	National Energy Retail Law
NERO	National energy retail objective
NGL	National Gas Law
NGO	National gas objective

Reliability Panel AEMC

TEMPLATE FOR GENERATOR COMPLIANCE PROGRAMS

11 September 2019

Inquiries

Reliability Panel
c/o Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

E: panel@aemc.gov.au
T: (02) 8296 7800
F: (02) 8296 7899

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About the Reliability Panel

The Reliability Panel (Panel) is a specialist body established by the AEMC and comprises industry and consumer representatives. It is responsible for monitoring, reviewing and reporting on reliability, security and safety of the national electricity system and advising the AEMC in respect of such matters. The Panel's responsibilities are specified in section 38 of the National Electricity Law.

[Please note: the PDF version of the template is the controlled document and is available on the AEMC Reliability Panel website.]

Contents

Purpose of this document

Under the National Electricity Rules (Rules), the Reliability Panel (Panel) must determine, modify as necessary, and publish the template for generator compliance programs (template).[1] The Rules also require the Panel to conduct a review of the template at least every three years from the date the template is determined, and at such times as the Australian Energy Market Commission (AEMC) may request.[2] Following such a review, the Panel may amend the template in accordance with any recommendations that it makes in a report that is submitted to the AEMC.[3]

Under the Rules, the template must:[4]

- cover all performance standards; and
- define suitable testing and monitoring regimes for each performance standard so that a registered participant can select a regime that complies with its obligations as set out in the Rules for its plant.

Registered participants have performance standards obligations requiring that their plant meets or exceed applicable performance standards and that their plant does not materially adversely affect power system security.[5] In that regard, a registered participant who controls or operates plant to which a performance standard applies, must institute and maintain a compliance program which:[6]

- is consistent with the template;
- includes procedures to monitor the performance of the plant in a manner that is consistent with good electricity industry practice;
- is modified to be consistent with any amendments made under clause 8.8.3(ba) of the Rules to the template, by no later than 6 months after amendments to the template are published, or by a date determined by the Panel; and
- provides reasonable assurance of ongoing compliance with each applicable performance standard.

The purpose of this document is to provide assistance and clarity to registered participants, particularly Generators, to develop performance standards compliance programs that include monitoring procedures that they consider to be consistent with good electricity industry practice. It is also intended to assist the Australian Energy Regulator (AER) with the enforcement and monitoring of the Generators' compliance with the technical requirements under the Rules. Effective compliance

1 Rules clause 8.8.1(a)(2b). The Panel must determine the template in accordance with clause 8.8.3 of the Rules.
2 Rules clause 8.8.3(ba).
3 Rules clause 8.8.3(j).
4 Rules clause 4.15(ca).
5 Rules clause 4.15(a).
6 Rules clause 4.15(b) and (c).

with performance standards contributes to the delivery of reliable and secure electricity to customers in the National Electricity Market (NEM).

This document is structured as follows:

- Chapter 1 presents:
  - the ten compliance principles;
  - a general overview of the compliance framework;
  - information on continuous plant monitoring;
  - general information on dry-storage generators; and
- Chapter 2 presents:
  - a detailed table for developing generator compliance programs.

Further information on the template can be obtained by either emailing the Panel secretariat (telephone (02) 8296 7800, or email panel@aemc.gov.au), or by accessing previously published Panel reports for past reviews of the template from the Panel's website (www.aemc.gov.au).

1 Supporting information for compliance programs

1.1 Introduction

This chapter presents material that may be considered useful by registered participants in terms of helping to inform their compliance programs.

1.2 Compliance principles

The Panel used the following compliance principles in developing its template. These principles should also be considered by generators in developing and modifying their compliance programs.

Principle 1: Where plant system performance may be variable with time, as for example with plant protection, control and alarm (PCA) systems, Generators are accountable for managing the functionality and integrity of systems and settings in accordance with the performance standards compliance program.

Principle 2: The corollary of the Principle #1 is that where plant parameters are not subject to variability with time, the compliance regime should be restricted to confirmation that the plant continues to perform as intended with repeat testing when there are reasonable grounds to believe that the plant performance may have changed.

Principle 3: The materiality of the issue must be considered when contemplating a compliance testing regime.

Principle 4: A *Generator's* active use and implementation of a compliance program that is consistent with the approved template and the Generator's compliance management framework will provide a reasonable assurance of compliance with the Generator's registered performance standards.

Principle 5: The template must therefore support the development of compliance programs which represent "good electricity industry practice". The template should specify the objectives and outcomes to be achieved by the testing or monitoring, and an appropriate test interval. The *Generator* should exercise diligence and good electricity industry practice to determine the detailed methods and procedures to be employed for its plant.

Principle 6: The compliance testing regime must be efficient, and reflect an equitable balance between risk management and the risk created by the test regime itself.

Principle 7: Where appropriate, analysis of performance during an event or disturbance could be used to demonstrate compliance in lieu of a performance test.

Principle 8: Where compliance to a performance standard cannot be directly tested, the compliance program should include a range of other compliance testing methods to provide reasonable assurance that the performance standard continues to be met.

Principle 9: When developing a compliance program and operating under that program, a *Generator* can only be reasonably held accountable for the compliance of its plant to its registered performance standards and to equipment settings approved or provided by AEMO and/or the transmission network service provider (TNSP).

Principle 10: Compliance programs should be reviewed and updated periodically.

1.3 General overview of the compliance framework

It is important to recognise that the template is only one element of the broader compliance framework.

The Panel recognises that the template cannot be a prescriptive list of compliance choices. Such an approach would not be efficient, or representative of good electricity industry practice. The approach taken is to support a flexible application of the template with appropriate controls. The Panel, therefore, designed the template on the basis that it forms part of a Generator's overall compliance management process. A generator may wish to refer to applicable standards such as ASISO 19600:2015 for guidance on compliance management systems.

Provided below is a general overview of the compliance framework. However, registered participants are advised to seek their own independent professional advice as to the compliance framework that is specific to their individual circumstances and how it will be applied.

Generally speaking, the compliance framework should be viewed in the context of the connection arrangements that allow the Generator to connect to the electricity network. Under the Rules, a Generator must plan and design its facilities and ensure that they are operated to comply with the performance standards applicable to those facilities, its connection agreement which is applicable to those facilities, and the system standards.[7] Except in cases where a Generator's facilities meet all aspects of the 'automatic access standards', performance standards are generally negotiated and form part of a Generator's connection agreement with the relevant network service provider.[8]

Following the receipt of a proposed negotiated access standard, the relevant network service provider is required to consult with AEMO with regard to the proposed negotiated access standard.[9] AEMO then establishes and maintains a register of the

7 Rules clause 5.2.5(a).

8 The automatic access standards, minimum access standards and performance criteria required for the connection of generators are set out in Rules schedule 5.2. These form the basis for specific performance standards that are registered with AEMO.

9 Rules clause 5.3.4A.

performance standards that is applicable for that particular plant, as advised by the relevant network service provider or Generator.[10]

Under the Rules, a Generator is required to comply with the performance standards applicable to its facilities.[11] That is, it is required to comply with those standards that are set out in its connection agreement. A Generator is also required to develop and maintain a performance standards compliance program that is consistent with the template.[12] Such a program must be developed as soon as reasonably practicable, but no later than:

- six months after the day that AEMO gives notice to the registered participant of registration of the performance standards; or
- six months after the day on which the relevant plant commences operation.[13]

A Generator is also required to modify its compliance program to be consistent with any amendments made to the template by the Panel, by no later than 6 months after amendments to the template are published, or by a date determined by the Panel.[14]

The AER is responsible for monitoring whether Generators' compliance programs meet the mandatory requirements and for investigation of breaches, or possible breaches, of performance standards obligations under clause 4.15 of the Rules. A Generator is required to maintain compliance program records and other prescribed records[15] for seven years, and if requested, deliver such records to the AER within five business days or other specified period.[16]

A Generator is also required to immediately notify AEMO if its plant is breaching a performance standard or is likely to breach.[17] It must also notify AEMO and the relevant network service provider when the plant has returned to compliance with the relevant performance standard.[18] AEMO forwards a copy of all non-compliance notices to the AER and the relevant network service provider.

~~Further details of the compliance framework for Generator performance standards are provided in the AER's Generator Performance Standards, Information Booklet, published in August 2013.[19]~~

10 Rules clause 4.14(n).
11 Rules clauses 5.2.1(b)(2) and 5.2.5(a)(1).
12 Rules clause 4.15(c).
13 Rules clause 4.15(b).
14 Rules clause 4.15(c)(3).
15 Relating to tests to demonstrate compliance with connection requirements under clause 5.7.3 of the Rules.
16 Rules clause 4.15(e).
17 Rules clause 4.15(f).
18 Rules clause 4.15(h).
19 www.aer.gov.au/node/21331

1.4 Continuous plant monitoring

Where plant is normally running (that is, not "peaking plant" that operates intermittently), continuous plant monitoring could have a number of benefits over periodic testing, or if used in conjunction with periodic testing. Benefits are likely to accrue not only in relation to demonstrating compliance with technical performance standards, but also in providing information to plant owners about the ongoing performance of their plant.

Continuous plant monitoring is increasingly becoming a more affordable option than it has been in the past. ~~AEMO has advised the Panel that the adoption of affordable continuous plant monitoring options is increasingly an outcome of the connection negotiation process for new plants.~~[20]

Generators could also consider whether continuous high speed monitoring could be considered in lieu of staged testing in some instances where staged tests cannot be implemented, such as for response to system disturbances.

For a number of performance standards in Table 1 in Chapter 2 of this document, continuous plant monitoring has been included as an option for a ~~–~~suitable monitoring and testing methodology. Where continuous plant monitoring has not been included in the table, Generators should also consider the suitability of applying continuous plant monitoring as a monitoring and testing methodology in these other situations.

1.5 Dry stored generators

The term "dry stored" is used to identify the status of a generation facility (or plant) that is not in a state of readiness to allow it to be dispatched in the NEM, but remains physically intact, and, after a period of restoration, would be capable of being returned to service. Similar terminology used to refer to this state includes "care and maintenance" or "mothballing".

The Rules require all generating facilities, including dry stored Generators, to develop and maintain compliance programs that are consistent with the template.[21] While the Rules do not prohibit a Generator from entering a period of "dry storage" and maintaining registration throughout, ongoing registration with AEMO obliges the Generator to retain compliance with the Rules.

When a generating plant is being prepared for a significant period of dry storage, a Generator should consider whether the plant's existing compliance program for performance standards is appropriate. There are a range of factors that a Generator should consider before implementing any amendment to its existing compliance program for the plant in question, some of which may include:[22]

20 ~~AEMO submission, 16 December 2014, p.2~~Confirmed through feedback received via survey of from representative stakeholders completed by GHD in July 2019 ~~.~~

21 Rules clause 4.15(c).

22 These suggested range of factors have been based on information contained in the AEMO document, *Guidance for Dry-Stored Generators* (version 1, published 9 August 2013), as referenced in AEMO's submission to the Issues Paper for the 2015 review.

- The period of time likely to elapse before the facility might be returned to service, and how the Generator would communicate any return to service arrangements to AEMO;
- How the Generator would inform AEMO of the status of the facility and the facility's expected time to return to service after a period of storage;
- When the Generator is preparing its dry stored plant for a return to service, any required testing that can be conducted off-line should occur prior to the plant's return to service. For example, this may include any steps that are considered necessary to verify plant changes that may have occurred during and after the period of storage, or where there has been a change to a performance standard. The Generator should also consider how and when it will advise AEMO of its plans to bring the plant back into service. The Generator should also keep all compliance related information up to date.
- If compliance testing is due, but the Generator has not been able to verify its compliance with all standards prior to re-synchronisation with the power system, then all residual verifications should be carried out as soon as practicable following re-synchronisation. For example, this may include making prior arrangements for the necessary tests to be carried out without avoidable delay after synchronisation in order to minimise risk to other power system users, and for the timing and results of tests to be independently verifiable at a later time. Consideration should also be given to whether certain tests need to be advised to AEMO and/or the relevant network service provider(s).

2 Table for developing generator compliance programs

2.1 Introduction

Table 1, included at the end of this chapter, has been provided to assist Generators to develop their own compliance programs ('the table'). The following material provides explanatory notes to this table and defines important terms used in its development. Generators should read this explanatory material before referring to the table as it provides important context for the application of the table's provisions.

The terms defined in section 2.9 of this chapter and underlined in the table, are only intended to be used for the purposes of the template. Italicised terms are defined in Chapter 10 of the Rules.

2.2 Applying the table

The table provides a series of options for Generators to assist in developing compliance programs. It is not a prescriptive list of tests and methodologies to demonstrate compliance. The template has been designed on the basis that it is one of a number of resources that should be consulted in implementing and modifying a Generator's overall compliance management process.

The template is not designed to take the place of alternative advice. Generators should consider the compliance principles, set out in Chapter 1 of this document, most of which illustrate that Generators will need to exercise judgement in how best to apply the template to meet their compliance requirements.

2.3 Pre-existing compliance

The table is designed on the assumption that any analysis undertaken at the time of connection and subsequent commissioning tests conducted by the Generator have established the plant's compliance with its performance standards. This is also assumed for older plant, that were connected in accordance with older versions of the Rules or Code. As a result, a Generator's connection agreements for older plant may, in some cases, specify the testing and monitoring requirements, which may be based on the need to maintain compliance with older versions of the Rules or Code that applied at the time when such connection agreements were established.

2.4 Power system security

The AEMO power system security responsibilities are provided under clause 4.3.1 of the Rules. The Generator needs to take care that its compliance testing regime does not jeopardise power system security. Otherwise, under clause 4.8.1 of the Rules, the Generator must promptly advise AEMO or a relevant System Operator at the time that the Generator becomes aware, of any circumstance which could be expected to adversely affect the secure operation of the power system or any equipment owned or under the control of the Generator or a network service provider (NSP). Nothing in the table seeks to override these responsibilities and all testing should be devised and undertaken recognising the need to maintain power system security.

2.5 Performance standards

The Panel has sought to take into account all the relevant versions of the performance standards that may apply to a particular Generator. However, Generators should be aware in developing their compliance programs that the particular requirements under a performance standard may have changed over time. There may also have been changes in the version of the Rules, clause numbering and title in some places. At the time that this template was last updated, version 123~~71~~ of the Rules was the latest version. Reference to version 123~~71~~ of the Rules in the table should be taken to mean the latest version of the Rules unless there have been changes to the particular provision in the table. Until the template is next updated, Generators should base their compliance programs in regard to any such matters on other information in the template, the application of their management program and good electricity industry practice.

2.6 Compliance methods

The table lists a number of different compliance methods for the applicable performance standards. These different methods can be selected by the Generator to suit its specific plant characteristics. The method or methods on which a particular plant's compliance program is based should be selected within the broader compliance management framework of the Generator, and should include consideration of all relevant factors including:

- the technology of the plant, including whether its performance is likely to drift or degrade over a particular timeframe;
- experience with the particular generation technology, including manufacturer's advice;
- the connection point arrangement; and
- an assessment of the risk and costs of different testing methods, including consideration of the relative size of the plant.

2.7 Frequency of tests

In the table, the column titled, "Suggested frequency of testing", indicates the suggested cycle of recurrent tests for a particular method. The actual frequency of testing on which a particular plant's compliance program is based should be determined within the broader compliance management framework of the Generator, and should include consideration of all relevant factors including:

- the technology of the plant specific to that performance standard;
- experience with the particular generation technology;
- manufacturer's advice with respect to the particular model;[30] and

[30] This could include considering any specific requirements related to the minimum number of operational hours required prior to undertaking 'major inspections'.

- an assessment of the frequency required to provide reasonable assurance of compliance.

The frequency may also be managed within the broader framework to integrate NEM compliance testing with safety and other compliance programs and the overall asset management program for the plant.[31] The actual frequency of testing may be described in terms of the:

- elapsed time;
- plant operating hours;
- MWhrs generated; or
- number of plant starts

between testing.

28 Performance of remote equipment

Some of the performance standards specified in section S5.2.5 allow a generator to provide plant and equipment at the connection point that delivers a level of performance which is lower than the level of performance acceptable to AEMO and the relevant TNSP provided the generator arranges the provision of additional capability via plant and equipment located elsewhere in the power system. For example S5.2.5.1 allow a generator to fund the provision of additional reactive power capability via plant and equipment installed at a location which differs from the connection point. The compliance program developed by the generator should not be required to assess the ongoing ability of the remote plant and equipment. Where a control system has been installed to ensure correct operation of the generator should the remote equipment be unavailable, the functionality of that control system should be tested as part of the generator compliance program.

29 Model validation and initial compliance program

When establishing the initial compliance program a generator should consider whether any gaps remain in the model validation performed as part of commissioning and R2 testing. This could arise if significant system events did not occur during the test period resulting in incomplete model validation. In situations where the model validation is incomplete the generator should take this into account in developing the compliance program and where appropriate choose test methods that support gathering data necessary to demonstrate compliance and complete the validation of the model.

~~2.8~~2.10 Basis for compliance assessment

In the table, the column titled, "Basis for compliance assessment", indicates the type of measure required as the benchmark for a particular method. The specific measure for the acceptance or otherwise of test results should be developed by the Generator when applying the template to develop their compliance program.

~~2.9~~2.11 Defined terms

In the design of the template, it was decided that certain terms used in the table should be defined to aid clarity and assist Generators in using the template to develop their specific compliance programs:

plant change means when the replacement of components or equipment or the refurbishment or change of system takes place and that the relevant *Generator* considers that event may affect the plant's capability to meet the particular *performance standard*. A plant change may include a change to software or firmware associated with digital control and protection systems. An appropriate process needs to be established under the *Generator's* compliance management framework to ensure all changes to plant are noted and appropriately reviewed as to whether they constitute a plant change event in respect to each *performance standard*.

The generator should pay careful attention to software and firmware changes, and carefully assess whether they have the potential to modify the performance of the generating system. A software or firmware change that is assessed as having the potential to change the performance of the generating system should be treated as a plant change.

Changes to a generating system that would trigger the process described in clause 5.3.9 of the NER would also constitute a plant change.

relevant sub-system means any subcomponents which contribute to a *generating system* achieving its capability to meet the particular *performance standard* (e.g. excitation systems, connection equipment including associated reactive plant, auxiliary power supplies, protection relays, circuit breakers, etc.). An appropriate process needs to be established under the *Generator's* compliance management framework to identify what sub-systems are relevant to achieving and maintaining the plant's performance with respect to each *performance standard*.

Appropriate testing for relevant sub-systems needs to be devised taking into account:

[31] Generators may need to consider whether plant that is less often employed should be subject to more rigorous compliance testing to ensure that it would operate when required.

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- the technology of the particular sub-system, including whether its performance is likely to drift or degrade over a particular timeframe;
- experience with the particular generation technology;
- manufacturer's advice with respect to the particular model; and
- an assessment of the frequency required to provide reasonable assurance of compliance.

routine testing may require testing and calibration of equipment.

type testing means testing, on a regular basis, a reasonable sample of plant within a larger population of plant of the identical type and model.

monitoring means active routine monitoring of the system to ensure ongoing compliance and not just mere logging. All monitoring should include quantitative analysis to confirm plant performance against:

- past performance;
- known performance characteristics; or
- plant performance models.

This definition should not be confused with *monitoring equipment* as defined in the Rules.

plant trip for the purposes of this template means the trip of a generating unit or a generating system, or when a generating system consists of more than ten identical units, the trip of a significant number of those units or of critical ancillary plant.

significant disturbance for the purposes of this template means a power system disturbance that significantly varies frequency, voltage or power quality at the connection point beyond normal system conditions. Significant disturbances provide a trigger for investigating plant trips to assess whether the trip indicates an inability of the *generating system* to remain in *continuous uninterrupted operation* as required by its performance standard.

major disturbance for the purposes of this template means a power system disturbance that the generator considers will provide a significant test of the ability of the *generating system* to remain in *continuous uninterrupted operation* as required by its performance standard.

major event for the purposes of this template means an event on the power system that the generator considers best tests the ability of the *generating system* to meet its performance standard.

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Table 1 Table to assist development of generator compliance programs

This table is intended as a guide to Generators that is one of a number of potential resources for developing and modifying compliance programs. It is not an exhaustive list of tests and methodologies, as new, and more effective, approaches may develop over time. Generators should consider the compliance principles set out in Chapter 1 of the document when applying this table. Chapters 1 and 2 of this document provide important context for the application of this table and emphasises that Generators should exercise their own judgement in determining how best to apply the template to meet their compliance requirements.

Performance Standard/Rules/Code Provision	**Suitable testing and monitoring methodology[25]**	**Suggested frequency of testing[26]**	**Notes**	**Basis for compliance assessment**
Reactive Power Capability (as required under S5.2.5.1 in versions 1-71 of the Rules, the initial Code, and all amended versions of the Code)[27]	Method 1 (of 5): At rated power output, adjust the reactive power at the connection point to specified levels	Every 3 years and after plant change	Directly Measurable. Applies to synchronous and conventional plant, entire wind farms and solar farms	Be capable of achieving reactive power requirements of the performance standard subject to not exceeding network voltage limits
	Method 2 (of 5): Exercise the over and under excitation limits at as close to rated power output as practical	Every 3 years and after plant change	Directly Measurable. Applies to synchronous and conventional plant	Be capable of achieving reactive power requirements of the performance standard subject to not exceeding network voltage limits

25 Where there is more than one method provided, only **one** method is required to be used.

26 See section 2.7 of the template for more information on the factors to be considered when determining the actual frequency.

27 This provision was amended in the Code on 9 August 2001 and on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Reactive Power Capability (as required under S5.2.5.1 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[28]	Method 3 (of 5): Step testing of AVR limiters	Every 3 years and after plant change	Applies to conventional plant	Be capable of achieving reactive power requirements of the performance standard subject to not exceeding network voltage limits
	Method 4 (of 5): (a) Capability will be tested by component: and	Testing of ancillary plant and type testing of sample turbines/solar installation following plant change	Applies to wind farms plant and solar farms	Be capable of achieving performance standard
	(b) Capability will be monitored using SCADA under normal wind and solar farm operation.	Annual review of a selection of events		Consistency with plant characteristics
	Method 5 (of 5): Routine testing of relevant sub-systems	As appropriate to the technology of the relevant sub-system	Applicable to a wide range of generating plant and systems	Consistency with plant characteristics

[28] This provision was amended in the Code on 9 August 2001 and on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Power Factor Requirements (as required under S5.3.5 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)	Method 1 (of 1): Direct measurement and calculation of power factor when not generating	Every 3 years and following plant change	Only applies where there is a circuit breaker, allowing auxiliary supply to be drawn through the main connection point	Power factor within allowable range / specification
Quality of Electricity Generated (as required under S5.2.5.2 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[29]	Method 1 (of 2): (a) Direct measurements using power quality meters to derive: i. voltage fluctuation levels; ii. voltage balance; and iii. harmonics, flicker and negative phase sequence voltage; and	Following plant change	Performance of generator and its contribution to power quality needs to be separated from the contribution of others	Achieve performance standard or demonstrate consistency with plant characteristics used in determining original compliance

29 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Quality of Electricity Generated (as required under S5.2.5.2 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[30]	(b) Routine testing of any relevant sub-systems.	As appropriate to the technology of the relevant sub-system	Important when power quality at the connection point is dependent on ancillary plant of power electronic control systems	As above
	Method 2 (of 2): (a) Monitoring in-service performance through use of Power Quality Monitors; and	Routine monitoring Specific review every 3 years and following plant change		Monitors set against the performance standard are not raising alarms. Consistency with plant characteristics (no deterioration).
	(b) Testing and/or calibration of any relevant sub-systems.	As appropriate to the technology of the relevant sub-system	Important when power quality at the connection point is dependent on ancillary plant of power electronic control systems	Consistency with plant characteristics.
Response to Frequency	Method 1 (of 4):			

30 ~~This provision was amended~~ in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Disturbances (as required under S5.2.5.3 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[31]	(a) Investigating plant trips that occur during significant frequency disturbances; and	On every event		Achieve performance standard
	(b) Routine testing and/or calibration of relevant sub-systems including: i. testing of control system and/or protection system response to disturbances by the injection of simulated frequency / speed control signals; and ii. Routine tests of electrical / mechanical over speed devices.	As appropriate to the technology of the relevant sub-system		As above
Response to Frequency Disturbances (as required under S5.2.5.3 in versions 1-~~71~~123 of the Rules, the	Method 2 (of 4): (a) Investigating system performance using high speed data recorders; and	Every event where the plant trips and disturbances where	Appropriate to use where high speed monitors are available	Consistency of operation with plant models used to establish initial

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31 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
initial Code, and all amended versions of the Code)[32]		the frequency moves out of the *operational frequency tolerance band*	and models have been used in establishing compliance	compliance if the models are available; OR consistency with past performance only if the models are not available or sufficiently sophisticated.
	(b) Routine testing and/or calibration of relevant sub-systems including: i. testing of control system and/or protection system response to disturbances by the injection of simulated frequency / speed control signals; and ii. Routine tests of electrical / mechanical over speed devices.	As appropriate to the technology of the relevant sub-system		As above

[32] This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Response to Frequency Disturbances (as required under S5.2.5.3 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[33]	Method 3 (of 4): (a) Verify the modelled performance of a sample of turbines/solar inverter units;	Following plant change~~, which may include control system setting or protection system setting change~~	Only applicable to small asynchronous generators with digital controls that are aggregated and that do not materially differ in terms of their design and settings	Operation over the frequency range specified and agreed in the Generator Performance Standard
	(b) Verify the performance by testing response to an introduced disturbance;	Type testing and verification every 10 years	Each unit is not material and performance slippage is unlikely	Consistent with the performance standard registered at the connection point
	(c) Continuous monitoring (high speed) of performance at the connection point; and		Appropriate to use where high speed monitors are available and models have been used in establishing compliance	Operation over the frequency range specified and agreed in the Generator Performance Standard
Response to Frequency Disturbances (as required under S5.2.5.3 in	(d) Routine testing and/or calibration of relevant sub-systems including:	As appropriate to the technology of the relevant sub-system		As above

33 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[34]	i. testing of control system response to disturbances by the injection of simulated frequency / speed control signals; and ii. Routine tests of electrical / mechanical over speed devices.			
	Method 4 (of 4): (a) Performance of relevant sub-systems will be monitored using the following systems under normal machine operation: digital protection relays; other data-logging equipment as required; and	Every 3 years and after plant change by reviewing the response to a disturbance where the system frequency moves outside of the *operational frequency tolerance band*		Achieve performance standard

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	(b) Routine testing and/or calibration and validation of relevant sub-system performance including: i. electrical protection; and	As appropriate to the technology of the relevant sub-system		As above

34 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	ii. turbine protection.			
Response to Voltage Disturbances (as required under: S5.2.5.4 in versions 13-~~71~~123 and S5.2.5.3 in versions 1-12 of the Rules ; and S5.2.5.3 in the initial Code, and all amended versions of the Code)[35]	Method 1 (of 3): (a) Investigating plant trips that occur during significant voltage disturbances; and	On every event		Achieve performance standard
	(b) Routine testing and/or calibration of relevant sub-systems including: i. AVR systems; ii. Auxiliary power systems; and iii. Protection relays.	As appropriate to the technology of the relevant sub-system		Consistency with plant characteristics
Response to Voltage Disturbances (as required under: S5.2.5.4 in versions 13-~~71~~123 and S5.2.5.3 in versions 1-12 of the Rules; and S5.2.5.3 in the initial Code,	Method 2 (of 3): (a) Continuous high speed monitoring; and	On every event where the plant trips or on at least one major voltage disturbance every 3	Appropriate to use where high speed monitors are available and models have been used in establishing	Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR

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35 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
and all amended versions of the Code)[36]		years	compliance	consistency with past performance only if the models are not available
	(b) Routine testing and/or calibration of relevant sub-systems including: i. AVR systems; ii. Auxiliary power systems; and iii. Protection relays.	As appropriate to the technology of the relevant sub-system	Where possible, testing of auxiliary power systems should include simulated disturbance testing	As above
	Method 3 (of 3): (a) With the generator out of service, test the ability of nominated 415 V drives to sustain a specified voltage interruption; and	Every 4 years and after plant change	Applies only to 415 V drives	Successful ride through of system voltage disturbances, as per the agreed performance standard
	(b) In-service monitoring and investigation of any occurrence of a plant trip which may have been associated with a significant~~system~~	On every event	This type of monitoring will be acceptable only if high speed monitoring is not	As above

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36 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	voltage disturbance.		available	
Response to Disturbances following Contingency Events (as required under S5.2.5.5 in versions 13-~~71~~123 of the Rules)[37]	~~Method 1 (of 3):~~ ~~Direct testing by instigating a network trip~~	~~Following plant changes~~	~~Preferred method where possible and where risks can be managed~~	~~Achieve performance standard~~
	Method 2 (of 3): (a) Investigate plant trips that occur during or immediately following major ~~system~~ events; and	On every event		Achieve performance standard
Response to Disturbances following Contingency Events (as required under S5.2.5.5 in versions 13-~~71~~123 of the Rules)[38]	(b) Routine monitoring and testing and/or calibration of relevant sub-systems including suitable testing to confirm circuit breaker operating times.	As appropriate to the technology of the relevant sub-system		As above

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[37] This provision was amended in version 13 of the Rules.

[38] This provision was amended in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	Method 3 (of 3): (a) Continuous monitoring using high speed recorders; and	~~On disturbances~~ Ww~~h~~en the plant trips during or immediately following a significant voltage disturbance and~~or~~ at least one major event every 3 years where the generating system maintains *continuous uninterrupted operation*	Appropriate to use where high speed monitors are available and models have been used in establishing compliance	Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance only if the models are not available
	(b) Routine monitoring and testing and/or calibration of relevant sub-systems.	As appropriate to the technology of the relevant sub-system		As above

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Quality of Electricity Generated and Continuous Uninterrupted Operation (as required under S5.2.5.6 in versions 13~~-71~~123 of the Rules)[39]	Method 1 (of 2): (a) Direct measurements using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth to test: i. voltage fluctuation levels; ii. voltage balance ; and iii. harmonics, flicker and negative phase sequence voltage prior to	Following plant changes		Achieve performance standard and ensure protection settings are consistent with the performance standard.

[39] This provision was amended in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	synchronisation and to ensure protection settings align to the performance standard;			
	(b) Investigating plant trips to ensure the trip is not caused by power-quality protection (harmonics or voltage unbalance); and	Following each event		Achieve performance standard.
	(c) Routine monitoring and testing and/or calibration of any relevant sub-systems.	As appropriate to the technology of the relevant sub-system		As above
Quality of Electricity Generated and Continuous Uninterrupted Operation (as required under S5.2.5.6 in versions 13-~~71~~123 of the Rules)[40]	Method 2 (of 2): Continuous m~~M~~onitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth. ~~appropriate metering~~	On significant disturbances when the plant trips including at least one major event every 3 years	Appropriate to use where suitable metering is available	Consistency of operation with plant performance specifications
Partial Load Rejection (as required under: S5.2.5.7 in versions 13-~~71~~123 and S5.2.5.4 in	Method 1 (of 3): (a) Measure response of the generator to system over-	On every event where high	Directly measurable	Achieve performance standard

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40 This provision was amended in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
versions 1-12 of the Rules ; and S5.2.5.4 of the initial Code, and all amended versions of the Code)[41]	frequency and analyse the unit performance; and	frequency moves out of the operational frequency tolerance band or every five years (whichever is more frequent) and after plant change as appropriate to the technology of the relevant sub-system		
	(b) Investigation of plant trips.	On every event		As above
Partial Load Rejection (as required under: S5.2.5.7 in versions 13-~~71~~123 and S5.2.5.4 in versions 1-12 of the Rules; and S5.2.5.4 of the initial Code, and all amended versions of the Code)[42]	Method 2 (of 3): (a) Routine testing and/or calibration of relevant sub-systems including: i. Analytical simulation of generator, auxiliary systems and critical protections; and	As appropriate to the technology of the relevant sub-system		Simulation demonstrates ride through of load rejection event specified in Performance Standard.

41 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

42 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	ii. Secondary injection testing of critical protection systems; and			
	(b) Assess any plant trip for relationship to load rejection event.	On every event	Type Test permissible where multiple units are involved	Operation over the conditions specified and agreed in the Generator Performance Standard.
	Method 3 (of 3): (a) Response to partial load rejection to be assessed by in-service performance; and	On every event ~~or every~~ where high frequency moves out of the operational frequency tolerance band or every 5 years ~~10 years~~ (whichever is more frequent) as appropriate to the technology of the relevant sub-system		Achieve performance standard.
	(b) Test for correct operation of turbine overspeed trips.	Every 4 years and after plant change	Overspeed protection checked off-line after major overhauls	That turbine trip operates to within acceptable tolerance of nominal trip setting for overspeed protection.

Protection from Power System Disturbances (as required under S5.2.5.8 in	Method 1 (of 3): (a) Continuous monitoring using high speed recorders;		Appropriate to use where high speed	Consistency of operation with plant models used

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[43]			monitors are available and models have been used in establishing compliance This may not be relevant where alarms are incorporated into the design of the recorder	to establish initial compliance if the models are available; OR consistency with past performance if the models are not available.
	(b) Routine testing and/or calibration of relevant sub-systems including applicable protection relays; and	As appropriate to the technology of the relevant sub-system		That protection system operated in accordance with design and the Performance Standard.
	(c) Investigate unit electrical protection trips.	On every event		As above
Protection from Power System Disturbances (as required under S5.2.5.8 in versions 1-~~71~~123 of the Rules, the	Method 2 (of 3): (a) Routine testing and/or calibration of relevant sub-systems including:	As appropriate to the technology of the relevant sub-system		Achieve performance standard

43 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
initial Code, and all amended versions of the Code)[44]	i. Injection of simulated signals (secondary injection) to demonstrate correct operation of the protection; and ii. Repair or recalibrate protection relays as required; and			
	(b) Investigate plant trips.	On every event		As above
Protection from Power System Disturbances (as required under S5.2.5.8 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[45]	Method 3 (of 3): (a) Performance is monitored, in-service; and	At each major overhaul; and/or every 5 years by routine functional testing of unit electrical protection systems and verification of	Applicable for generating systems with multiple generating units (solar and wind farms)~~wind farms~~ Changes to generating unit~~turbine~~ control parameters will be controlled such that the performance of the generating system	Performance is confirmed by the generating system ~~remaining synchronised~~ maintaining *continuous uninterrupted operation* during power system disturbance conditions where required under a provision of the Rules.

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44 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.
45 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
		database registered protection settings to occur annually	and generating units is not compromised in relation to the generator performance standard Appropriate to use where data is available	
	(b) Routine testing and/or calibration of relevant sub-systems including testing by secondary injection all protection system relays, between the generating unit terminals but within the generating system.	As appropriate to the technology of the relevant sub-system		Performance will be assessed against the performance standard requirements.
Protection Systems that Impact on Power System Security (as required under S5.2.5.9 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended	Method 1 (of 3): (a) Routine testing and/or calibration of protection systems including: i. CB opening times; and ii. Protection relay injection	As appropriate to the technology of the protection system At least every 5 years	Directly measurable	Achieve performance standard

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
versions of the Code)[46]	testing; and	and after plant change		
	(b) Confirmation from fault recorder records of actual performance.	Every plant trip	Fault recorder should be specified and calibrated to provide accurate time stamped measurements suitable for assessing compliance	As above
Protection Systems that Impact on Power System Security (as required under S5.2.5.9 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[47]	Method 2 (of 3): (a) Routine testing and/or calibration of relevant sub-systems including: i. protection system testing by secondary injection; ii. checking of circuit breaker opening times; iii. redundancy of primary protection systems; and iv. timing of trip signal issued by the breaker fail protection system; and	As appropriate to the technology of the relevant sub-system At least every 5 years and after plant change		That all protection relays operate satisfactorily and to within design tolerance of setting value.
	(b) Assessment of protection	On every event		That protection system is

46 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

47 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	system performance in the event of protection system operation.			operated in accordance with design and the Performance Standard.
Protection Systems that Impact on Power System Security (as required under S5.2.5.9 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[48]	Method 3 (of 3): (a) Performance is monitored, in-service, where data is available;	At each major overhaul; and/or every 5 years by routine functional testing of unit electrical protection systems and verification of database registered protection settings to occur annually	Changes to ~~turbine~~ generating unit control parameters will be controlled such that the performance of the generating system and generating units is not compromised in relation to the Generator Performance Standard	Performance is confirmed by assessing operation of protection systems against the requirements of the standard when a generating unit trips as a result of fault occurring between the generating unit stator and the connection point.
	(b) Relevant testing and or/calibration of any relevant sub-systems including protection system relays shall be tested by secondary injection; and	As appropriate to the technology of the relevant sub-system		Performance will be assessed against the performance standard requirements following a unit trip as a result of a relevant system event in which the unit should

48 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
				have remained synchronised.
	(c) Verification of database registered protection settings to occur in conjunction with injection testing.	Every 5 years		As above
Asynchronous Operation of Synchronous Generating Units / Protection to Trip Plant for Unstable Operation (as required under S5.2.5.10 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[49]	Method 1 (of 1): (a) Routine testing and/or calibration of relevant sub-systems including protection system testing by secondary injection; and	As appropriate to the technology of the relevant sub-system At least every 5 years and after plant change		That all protection relays operate satisfactorily and to within design tolerance of setting value.
	(b) Assessment of protection system performance in the event of protection system	On every event		That protection system is operated in accordance with design and the

49 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	operation or of asynchronous operation.			Performance Standard.
Frequency Control / Frequency Responsiveness and/or Governor Stability and Governor System (as required under: S5.2.5.11 in versions 1-~~71~~123 of the Rules; S5.2.5.11 and S5.2.6.4 in the initial Code, and all amended versions of the Code before 27 March 2003; and S5.2.5.11 of all amended versions of the Code from 27 March 2003 onwards)[50]	Method 1 (of 4): Monitor in-service performance using high speed frequency data	After every major frequency ~~excursion~~disturbance	Appropriate to use where high speed monitors are available and models have been used in establishing compliance or when plant has no capability of responding to frequency deviations ie asynchronous machines	Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance only if the models are not available
	Method 2 (of 4): Assessment of the performance of governor system ~~performance~~or other controls designed to arrest frequency disturbances during events involving significant variation to system frequency	On every event	Assessment takes into account inertial response, overall governor droop setting etc	That governor system response is within the tolerance specified by the Performance Standards
	Method 3 (of 4): (a) Analytical simulation of	Type Test		Achieve performance

50 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Frequency Control / Frequency Responsiveness and/or Governor Stability and Governor System (as required under: S5.2.5.11 in versions 1-~~71~~123 of the Rules; S5.2.5.11 and S5.2.6.4 in the initial Code, and all amended versions of the Code before 27 March 2003; and S5.2.5.11 of all amended versions of the Code from 27 March 2003 onwards)[51]	turbine and governor systems or other controls designed to arrest frequency disturbances; and	permissible where multiple units are involved		standard
	(b) Assess generator response to disturbances using high speed recording data.	On every event where the frequency moves out of the operational tolerance band or at least every four years and after plant change		Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance only if the models are not available
	Method 4 (of 4): (a) Step response test of the governor or other controls designed to arrest frequency disturbances to test damping and droop characteristics; and	Every 4 years and after plant change		Plant performance complies with the Generator Performance Standard
	(b) Routine calibration tests.	Every 4 years		As above

51 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Stability / Impact on Network Capability (as required under S5.2.5.12 in versions 1-~~71~~123 of the Rules, and all amended versions of the Code from 27 March 2003 onwards)[52]	Method 1 (of 1): (a) Monitor in-service performance for relevant performance characteristics not otherwise tested; and	Following plant changes	Generator can only be held responsible for ensuring the performance of their generating system as it contributes to meeting this standard	Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance if the models are not available
	(b) Routine monitoring and testing and/or calibration of relevant sub-systems including suitable testing to confirm power system stabiliser performance (if relevant).	As appropriate to the technology of the relevant sub-system		As above

Voltage and Reactive Power Control / Excitation Control System (as required under: S5.2.5.13 in versions 1~~-71~~123 of the Rules;	Method 1 (of 3): (a) Transfer function measurements and step response tests with the unit unsynchronised and at full	Every 4 years and after plant change. Testing frequency may be reduced for modes that are not routinely used to control the output of the generator	Tests should address all control modes specified in the generator performance standard.	Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models

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52 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
S5.2.5.13 and S5.2.6.5 in the initial Code, and all amended versions of the Code before 27 March 2003; and S5.2.5.13 of all amended versions of the Code from 27 March 2003 onwards)[53]	load; and			are available; OR consistency with past performance if the models are not available
	(b) Assess the stability of limiter operation; and	Every 4 years and after plant change for main control mode		As above
Voltage and Reactive Power Control / Excitation Control System (as required under: S5.2.5.13 in versions 1-~~71~~123 of the Rules; S5.2.5.13 and S5.2.6.5 in the initial Code, and all amended versions of the Code before 27 March 2003; and S5.2.5.13 of all amended versions of the Code from 27 March 2003 onwards)[54]	(c) Monitoring in-service performance or undertake transfer function measurements.	On every event or every 4 years for main control mode		As above
	Method 2 (of 3): (a) AVR step response tests; and	Every 4 years and after plant change for main control mode		Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance if the models are not available
	(b) AVR step response test of	Every 4 years and		As above

53 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.
54 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Voltage and Reactive Power Control / Excitation Control System (as required under: S5.2.5.13 in versions 1-~~71~~123 of the Rules; S5.2.5.13 and S5.2.6.5 in the initial Code, and all amended versions of the Code before 27 March 2003; and S5.2.5.13 of all amended versions of the Code from 27 March 2003 onwards)[55]	OEL and UEL operation; and	after plant change for main control mode		
	(c) AVR and PSS transfer function measurements over required frequency range.	Every 4 years and after plant change for main control mode		As above
	Method 3 (of 3): Performance of relevant sub-systems will be monitored using the following systems: digital protection relays or~~;~~ other data-logging equipment as required	As appropriate to the technology of the relevant sub-system	Applicable for Wind and Solar Farms Changes to generating unit~~turbine~~ control parameters will be controlled such that the performance of the generating system and generating units is not compromised in relation to the Generator Performance Standard	Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance if the models are not available

55 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Active Power Control (as required under S5.2.5.14 in versions 13-~~71~~123 of the Rules)[56]	Method 1 (of 2): One-off installation	Following plant change		Achieve performance standard
	Method 2 (of 2): Monitor non-compliance with dispatch market systems	After major event		Achieve performance standard
Remote Monitoring (as required under S5.2.6.1 in versions 1-~~71~~123 of the Rules, the initial Code, and all amended versions of the Code)[57]	Method 1 (of 2): (a) Calibration of Transducers; and	Following plant change and every 5 years		Confirmation at each end of the communications system by both parties
	(b) Verification of the accuracy of transmitted data.	Following plant change and every 5 years		As above
	Method 2 (of 2): (a) SCADA monitored values and farm panel metering will be routinely checked; and	Every 5 years	Applicable for Wind and Solar Farms	Achieve performance standard
	(b) The calibration of transducers	At each major outage		As above

56 This provision was amended in version 13 of the Rules.
57 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

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Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
	and Wind and Solar Farms panel metering will be checked.	or once every 5 years		
Communications Equipment (as required under: S5.2.6.2 in versions 13-~~71~~123 and S5.2.6.3 in versions 1-12 of the Rules ; and S5.2.6.3 of the initial Code, and all amended versions of the Code)[58]	Method 1 (of 1): (a) Confirmation of the availability of communication links, including any backup links with AEMO; and	Annual and after plant change		Achieve performance standard
	(b) Testing of relevant sub-systems including any power backup or UPS system.	As appropriate to the technology of the relevant sub-system		As above
Power Station Auxiliary Transformers / Supplies (as required under: S5.2.7 in versions 13-~~71~~123 and S5.2.8 in versions 1-12 of the Rules ; and S5.2.8 of the initial Code, and all amended versions of the Code)[59] **Power Station Auxiliary**	Method 1 (of 2): (a) Metering of active and reactive power at the auxiliary supply connection point; and	Every 4 years and after plant change	Only applicable when auxiliary supplies are taken from some other point different to generator connection point Access Standards must be established	Power factor, quality of supply and protection and control requirements within allowable range / specification

58 This provision was amended in version 13 of the Rules.

59 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
Transformers / Supplies (as required under: S5.2.7 in versions 13-~~71~~123 and S5.2.8 in versions 1-12 of the Rules ; and S5.2.8 of the initial Code, and all amended versions of the Code)[60]			under clause S5.3.5	
	(b) Testing and/or calibration of any relevant sub-systems including capacitor banks and circuit breakers.	As appropriate to the technology of the relevant sub-system		Performance to specification
	~~Method 2 (of 2):~~ ~~Performance will be monitored as part of condition monitoring and maintenance routines~~		~~This standard only applies to generating systems that takes auxiliary supplies from a separate supply.~~ ~~Unit auxiliary supplies on wind farms are taken from within connection point when units are on line. Very small wind farm station service auxiliary load requirements are considered negligible under NEM CMP~~	~~Achieve performance standard~~

60 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
			requirements.	
Fault Level / Current (as required under: S5.2.8 in versions 13-~~71~~123 and S5.2.9 in versions 1-12 of the Rules ; and S5.2.9 in all amended versions of the Code from 27 March 2003 onwards)[61]	Method 1 (of 3): (a) Monitoring in-service performance during faults near the connection point; and	Review following any event		Calculation confirms current fault current contribution
	(b) Review and recalculation of fault levels; and	Following plant change		As above
	(c) Routine testing of any relevant sub-systems.	As appropriate to the technology of the relevant sub-system		As above
	Method 2 (of 3): (a) Modelling and simulation of plant characteristics to make sure the plant is capable of meeting agreed standards; and	Following plant change		Calculation confirms current fault current contribution
Fault Level / Current (as required under: S5.2.8 in versions 13-~~71~~123 and S5.2.9 in versions 1-12 of the Rules; and	(b) Monitoring of generator contribution on fault event.	Review following any event		As above
	Method 3 (of 3):			

61 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Performance Standard/Rules/Code Provision	Suitable testing and monitoring methodology[25]	Suggested frequency of testing[26]	Notes	Basis for compliance assessment
S5.2.9 in all amended versions of the Code from 27 March 2003 onwards)[62]	(a) Performance of relevant sub-systems will be monitored using the following systems: digital protection relays; other data-logging equipment as required; and	As appropriate to the technology of the relevant sub-system		Achieve performance standard.
	(b) Where recorded data is available, comparison to be made of measured fault currents and computer simulations; and	Following a fault		Consistency of operation with ~~plant models used to establish initial compliance~~the latest plant model provided in accordance with clause S5.2.4 if the models are available; OR consistency with past performance if the models are not available.
	(c) Review and recalculation of fault levels.	Following plant change		As above

62 This provision was amended in the Code on 27 March 2003, and in version 13 of the Rules.

Australian Energy Market Commission

AEMC - Compliance Template Review

Survey Results

7 August 2019

Executive summary

The National Electricity Rules (NER) requires the Reliability Panel to determine the template for generator compliance programs (template). The template outlines principles and processes for generator compliance program development and specifies a range of test methods for each technical standard requirement in the rules under NER clause s5.2.5 for consideration by generators when developing their compliance programs as required under NER clause 4.15. The template aims to provide assistance and clarity to stakeholders, particularly generators and the Australian Energy Regulator (AER), on what constitutes good electricity industry practice with respect to the development of such compliance programs.

In 2018, the AEMC made the Generator Technical Performance Standards (GTPS) rule which altered and added the access standards applying to connecting generators in a range of areas. Given the end of the transitional period of the GTPS rule on 1 February 2019, all new generator connections are now subject to new requirements made in the GTPS rule.

As generators are required to have a compliance program which is consistent with the template for generator compliance within 6 months of connecting to the power system, it is appropriate that the Reliability Panel review the template to ensure it aligns with the amended performance standards introduced via the GTPS rule.

GHD has completed a review of the template to identified recommended changes to improve the template. The review considered the alignment of the template with the changes to the Rules introduced through the GTPS rule and feedback provided from a representative set of 18 stakeholders regarding the application of the template for assessing the ongoing compliance of generating systems with their agree generator performance standards.

The template of generator compliance programs has a specific purpose as defined in the National Electricity Rules and articulated in the current version of the template. The template also includes 10 compliance principles adopted by the Reliability Panel in developing the template. GHD recommends the Reliability Panel implement the following set of changes to the template for generator compliance programs. The recommendations have been developed by considering the survey responses provided by stakeholders and input provided through the technical working group convened by the AEMC to provide feedback on the proposed changes to the template. We have also attempted to ensure the revisions support the purpose of the template and are consistent with the compliance principles:

- To align with the revisions introduced by the GTPS rule change the following changes should be made to the template:
    - The entry in table 1 of the template providing advice on the frequency of testing for Method 3(a) for S5.2.5.5 should be revised to read, “When the plant trips during or immediately following a significant voltage disturbance and at least one major event every 3 years where the generating system maintains *continuous uninterrupted operation*”
    - The term major event be defined as an event on the power system that the generator considers best tests the ability of the *generating system* to meet its performance standard. A major event may include a disturbance that triggers AEMO to undertake a review of system performance, disturbances that result in voltage variations comparable with the minimum access standard specified

in S5.2.5.4 or frequency variations comparable with the minimum access standard in S5.2.5.3.

- The terms significant disturbance and major disturbance should be defined. A **significant disturbance** means a power system disturbance that significantly varies frequency, voltage or power quality at the connection point beyond normal system conditions. Significant disturbances provide a trigger for investigating plant trips to assess whether the trip indicates an inability of the generating system to remain in continuous uninterrupted operation as required by its performance standard.

  A **major disturbance** means a power system disturbance that the generator considers will provide a significant test of the ability of the generating system to remain in continuous uninterrupted operation as required by its performance standard.

- The basis for compliance notes against the methods in Table 1 of the compliance template for S5.2.5.13 be revised to require testing of all control modes specified in the generator performance standard.

- The compliance template can be simplified by deleting S5.2.5.5 Method 1 as stakeholders have identified this method is not being used for compliance testing and system security concerns are unlikely to allow the method to be used.
- The compliance template can be simplified by deleting S5.2.7 Method 2 as stakeholders have identified this method is not being used for compliance testing.
- A new sub-section be added to section 2 of the template to raise the potential for remote plant to impact generator performance and to articulate the roles expected of different parties in assessing ongoing compliance of the remote plant notifying changes in availability and responding to those notifications.
- The basis for compliance assessment notes for S5.2.5.1 methods 1, 2 and 3 be revised to read, “be capable of achieving reactive power requirements of the performance standards subject to not exceeding network voltage limits.”
- The test frequency specified for S5.2.5.3 method 4(a) be clarified to specify the test is completed at least every 3 years by reviewing the response of the relevant sub-systems to a disturbance where the frequency moves outside of the operational frequency tolerance band
- That the term plant change be defined in section 2.9 of the template and that any qualifications of that term to be removed from Table 1.
- The definition of the plant-change be reviewed to clarify when compliance needs to be reassessed. The definition should make it clear that changes that replacing a piece of equipment with an identical piece of equipment with the same performance characteristics are not expected to change generator performance and therefore should not trigger a requirement for reassessing compliance, while software and firmware may well trigger a requirement to reassess compliance. The definition should provide consistency with the triggers that give rise to a 5.3.9 application in the Rules
- S5.2.5.6 Method 2 be revised to read, “Monitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth”

- Amending the frequency of testing advice for S5.2.5.7 Method 3(a) to read "on every event where high frequency moves out of the operational frequency tolerance band or every 5 years (whichever is more frequent) and after plant change as appropriate to the technology of the relevant sub-system"
- References to technologies in the template should be reviewed to remove unintended technology bias. This review should carefully consider whether particular methods are intended to only apply to particular generation technologies and only where this is definitely the case notes to that effect should be included in table 1 of the template.
- Review those methods that rely on continued use of "plant models used to establish initial compliance", replacing the references to "the plant models used to establish initial compliance " with the latest plant models provided under clause S5.2.4."
- The AER has advised that the generator performance standards information booklet published in August 2013 and referred to in section 1.3 of the template is no longer current. GHD recommends that reference to the August 2013 guideline be deleted and a reference to the new guideline be added if it becomes available prior to finalising the amended template.
- The AER also suggested including in the template a link to the AEMO web page where generators can access the form developed to assist in advising AEMO of any non-compliance with their registered performance standards. GHD recommends incorporating this revision in the template.
- A number of stakeholders suggested that the template should provide greater detail and a more prescriptive approach to defining acceptable compliance test methods. AEMO noted that the compliance template published by Western power for the South West Interconnected System provide a greater level of detail than the compliance template published by the Reliability Panel. Powerlink suggested refinements for S5.2.5.9 method 1(b) and S5.2.5.13 methods 1 and 3. GHD notes that the template is not intended to prescribe tests, but rather provide a sufficient description of suitable test methods to assist generators to develop appropriate tests for their plant. GHD has reviewed the Western Power compliance template and does not recommend any further change be made to the template.
- A number of stakeholders suggested refinements to the template to address perceived duplication of test methods. GHD has reviewed the specific test methods cited and considered the range of feedback provided through the stakeholder survey. In many cases the survey responses indicate important but subtle difference between the existing methods and it is therefore recommended that the existing methods be retained. In a few instances a slight refinement of the method is recommended to clarify the differences between similarly worded methods.
- Feedback provided via the technical working group identified that often tests performed during the R2 generator model validation phase do not provide sufficient validation of a generator model. This could arise if significant system events did not occur during the test period resulting in incomplete model validation. Members of the working group suggested that when this occurs, it is reasonable to expect a generator to consider the need to finalise the model validation by collecting data via the initial compliance program and for the template to be revised to provide this guidance. GHD supports this recommended change to the template.
- Members of the technical working group also suggested that the reference to "plant model used to establish initial compliance" in the basis for compliance assessment in

table 1 of the template should be amended to read “the latest plant model provided in accordance with clause S5.2.4”. GHD supports this recommendation as it clarifies that compliance methods that rely on comparison of measured and modelled performance should consider the latest plant model.

Appendix B provides a marked-up version of the template with the recommended changes implemented.

This report is subject to, and must be read in conjunction with, the limitations set out in section 1.3 and the assumptions and qualifications contained throughout the Report.

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1. Introduction

1.1 Overview

GHD is assisting the Reliability Panel with the review of the template for generator compliance programs. The focus of the review is to identify refinements to the template required to reflect:

- the changes made by to generator performance standard provisions in the NER by the AEMC in its 2018 GTPS rule change, and
- stakeholder experiences with assessing compliance with their generator performance standards, including the options to apply new technology and manage compliance cost.

Further details of the review are provided on the AEMC web site [1]

GHD surveyed a representative group of 18 stakeholders to gain feedback on the application of the Generator Compliance template.

Table 1 Stakeholders surveyed

Generators	NSPs and Regulators
Goldwind	AEMO
Snowy Hydro	AER
Pacific Hydro	Powerlink
Stanwell	TransGrid
Energy Australia	TasNetworks
AGL	ElectraNet
Origin Energy	Energy Queensland
Neoen	Powercor
Hydro Tasmania	
Wirsol	

The following specific areas of feedback were sought.

- Suggested revisions to the compliance template to reflect changes introduced through the GTPS rule.
- Feedback on which of the compliance methods described in the template are most commonly used and the reason for that choice. Only generators were requested to complete this section of the survey
- Feedback on a number of potential revisions and clarifications of the template identified via a review completed by GHD

[1] https://www.aemc.gov.au/market-reviews-advice/generator-compliance-template-review-2019

GHD completed interviews with each selected stakeholder to discuss the topics covered by the survey. Stakeholders were also invited to provide written submissions to supplement the information provided during interviews.

Building on the feedback gained through the stakeholder survey, GHD developed an initial set of recommended changes to the template. Those changes were further refined considering the feedback provided by members of a technical working group convened by the AEMC. The workgroup members are listed in Appendix C. The members of the working group were invited to a workshop hosted by the AEMC on 5th July during which the initial set of recommendations were discussed.

1.2 Purpose of this report

This report presents the information and insights gained through the stakeholder survey. GHD has used that information to develop recommendations regarding changes to the template for generator compliance programs. The report presents a summary of the recommended changes with details provided in an accompanying revision-marked version of the template.

The stakeholder survey also identified a number of suggested improvements associated with the technical compliance framework in the National Electricity Rules, while those changes are outside the scope of the review of the template, they have been noted in the report to inform the AEMC.

1.3 Scope and limitations

2. Summary of Findings

The following sections summarise the key insights provided in responses to each section of the survey. The survey results provided by each stakeholder are provide in Appendix A to provide additional detail.

2.1 Suggested changed to align with GTPS rule

Prior to executing the survey GHD completed an initial review of the template for generator compliance programs against the generator performance standard provisions in in the NER. The GTPS rule change introduced significant changes to the generator performance standard provisions in October 2018 and the review sought to identify changes to the template necessary to provide adequate methods to demonstrate compliance with the performance standards as modified through the GTPS.

Our review found that the existing methods described in the template were generally suitable for assessing ongoing compliance even considering the changes introduced through the GTPS rule. The current version of the template provides methods that allow for the use of high speed monitoring to assess compliance with specific performance standards. While the GTPS rule introduced more detailed and in some case more onerous generator performance standards, compliance with those revised performance standards can generally be assessed utilising data captured by high speed monitors.

Our review identified two potential changes to the methods in the template and stakeholder feedback was sought regarding the merit of proceeding to implement the recommended changes. Figure 1 shows the level of support received from stakeholders for the recommended changes.

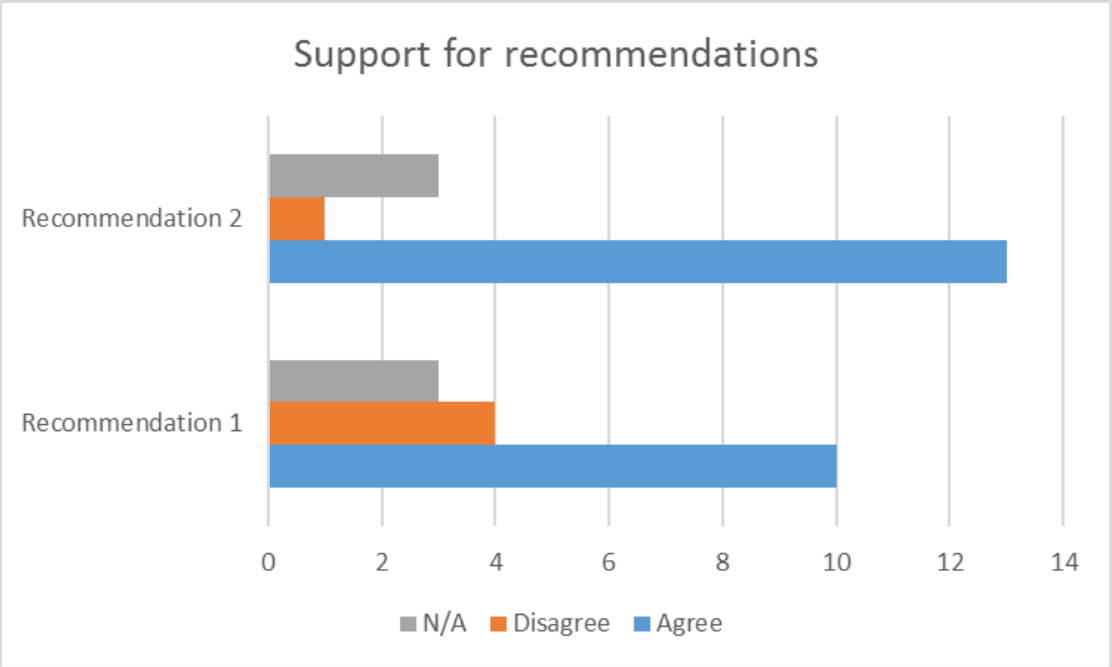

Figure 1 Suggested Change to Align with GTPS Rule

2.1.1 Recommendation 1 - assessing compliance with S5.2.5.5

S5.2.5.5 specifies the performance requirements for generating systems to ride through disturbances caused by power system faults. The template currently provides three methods for assessing compliance with Method 3 specifying the application of two approaches for assessing compliance:

a) The use of continuous monitoring using high speed recorders and

b) routine monitoring and testing and/or calibration of relevant subsystems

The template suggest that method 3(a) be applied "*on disturbances when the plant trips or at least one major event every 3 years*".

The GTPS rule changed S5.2.5.5 to including an explicit requirement to ride through multiple disturbances and requirements to inject or absorb reactive current to support power system voltages during the fault. The GTPS rule also clarified obligations for continuous uninterrupted operation. Monitoring the performance of the generating system during faults using high speed recorders should provide a suitable means of assessing compliance with the revised aspects of this performance standard and the ability to maintain continuous uninterrupted operation To demonstrate suitable performance the generating system should remain in continuous uninterrupted operation unless the disturbances are more severe than the ride through events specified in the generator performance standard.

The frequency of testing suggested for method 3(a) indicates that it would be adequate to just review performance following disturbances where the plant trips or to just test performance for one major event every 3 years or some combination of these. If compliance assessments only review performance following plant trips, this will not result in performance being reviewed for events where the generating system rides through the disturbance. Assessment of the performance where the generating system rides through the disturbance is required to confirm that the reactive current injection or absorption during the fault complies with the generator performance standard and that the generator maintains continuous uninterrupted operation as specified in its performance standard. GHD therefore recommended altering the suggest frequency of testing by changing the "or" to "and" as this would suggest that some assessments should also be performed when the generating system successfully rides through disturbances.

Furthermore, GHD recommended that all plant trips be investigated to assess compliance with multiple fault ride through requirements.

Most stakeholders supported the view that the proposed change was reasonable and that high speed recordings of events where the generator successfully rode through faults should be reviewed to assess compliance as well using high speed recordings to investigate any plant trips during relevant disturbances.

Stakeholders raised the following additional concerns with this test method:

- The term "major event" is not defined in the template, several stakeholders suggested there would be value in defining this term. One possibility might be to add a defined term into the template which defines a major event as an event on the power system that the generator considers best tests the ability of the *generating system* to meet its performance standard. A major event may include a disturbance that triggers AEMO to undertake a review of system performance, disturbances that result in voltage variations comparable with the minimum access standard specified in S5.2.5.4 or frequency variations that meet or exceed the minimum access standard in S5.2.5.3. Consideration should also be given to defining the terms significant disturbance, major disturbance and major event.

- It is difficult for generators to know when a major event has occurred by solely relying on triggers, protection operations and alarms that can be generated from quantities visible to the generator, particularly if the generator successfully rode through the fault. A number of stakeholders suggested that AEMO or the NSP may be better placed to identify when major events had occurred and if that information was published in a timely manner, it could provide effective triggers for assessing compliance.
- It is unnecessary to assess performance for all major events. If a generator has successfully demonstrated performance for a recent major event and there has been no plant change there would be little value in assessing performance for subsequent major event occurring within a reasonable period of time from the first major event.
- Method 2 specifies that plant trips that occur during or immediately following a major system event should be investigated. It was suggested that similar wording should be used to describe when method 3(a) is applied.
- Stakeholders also noted that while the recommended change may be appropriate for generators with performance standards consistent with the changes introduced by the GTPS rule, many generators with older performance standards do not face the same performance standards. The proposed wording for the test method should be reviewed to ensure it is also appropriate for generators with older performance standards.
- The suggested frequency of testing often specifies a maximum time between recurrent tests. Several stakeholders noted that there appeared to be little consistency between the maximum test periods specified in different methods. While some stakeholders suggested there would be benefit in adopting consistent maximum test periods across all test methods, other suggested that the specified test frequency should be viewed as a guide only and that generators should be free to select a shorter or longer time period than that specified in Table 1 of the template if they believed the technology employed in their generating system supported a different maximum period between tests. This later point of view is consistent with the advice provided in section 2.7 of the compliance template. GHD is of the view that the guidance provided in section 2.7 of the template is sound and represents good electricity industry practice for determining the frequency of recurrent compliance tests and should be retained. Furthermore the existing wording of section 2.7 allows each generator to consider whether adopting the same test frequency for all recurrent tests is appropriate for their generating systems. As such GHD does not recommend any change to address this stakeholder feedback. GHD notes that footnote 26 in Table 1 of the template directs reader to section 2.7 for more information on the factors to be considered when determining the actual frequency.

2.1.2 Recommendation 2 – assessing compliance with S5.2.5.13

The GTPS rule change introduced the requirement for multiple control modes with the Automatic Access Standard requiring the ability for a bump less switch between control modes at the request of AEMO. The test methods specified in Table 1 of the template do not currently contemplate a scenario where a generating system might have the ability to switch between control models. GHD recommended that the methods be amended to specify assessment of compliance should consider all active control modes and the ability to transfer between modes

Most stakeholder indicated support for an amendment to require testing of all control modes specified in the relevant generator performance standard. It is expected that the performance standard will identify any control modes which must be able to be activated at any time as agreed with AEMO and the TNSP, together with any requirement for bump less transition between control modes. It is those modes that should be verified through the compliance program. Stakeholders noted that it is quite uncommon for AEMO or the connecting NSP to require generators to be able to switch between active control modes while online and generating power.

Most generators only operate in one control mode and it is generally not practical to activate another mode without testing and reconfiguration of the generating system. If however a situation does exist where the generator through their generator performance standards has agreed that multiple control modes will be available continuously with the ability for a bump less switch between modes, then it is reasonable that each control mode be considered in the compliance program.

If a generator is expected to have an excitation control systems that is configured and commissioned to operate in the various modes, and be able to switch between these modes on line / in real time, then those requirement need to be clearly articulated in the registered generator performance standard, and commissioning and compliance testing should validate the ongoing ability to deliver this control. If on the other hand the generator was only required to demonstrate that capability exists for multiple control modes, but to operate in the single control mode agreed with AEMO and the NSP, it is reasonable for compliance assessments to only consider that single control model. By way of example one generator noted that some of their generating systems have a Generator Performance Standard that specified that the AVR have the capability for "reactive current compensation settable for boost or droop". While the capability has been provided in the design of the AVR, this mode has not been commissioned, and this is noted in the commissioning reports submitted to the NSP and AEMO. The generator does not conduct any compliance testing in these modes as they are not consider active control modes.

GHD recommends that the basis for compliance notes against the methods in Table 1 of the compliance template for S5.2.5.13 be revised to require testing of all control modes specified in the generator performance standard provided the generator is routinely operated with those control modes active. Furthermore the template should acknowledge that the frequency of testing may be reduced for a control mode that the generator is seldom if ever instructed by AEMO or the NSP to use.

2.2 Feedback on the compliance template (generators completed)

The template identifies for each generator performance standard a number of methods that could potentially be applied to provide an on-going assessment of compliance. The nine generators who took part in the survey were asked to assign a score to each of the methods in the template with the allocated score indicating the extent to which they relied on the method:

- A score of 0 indicates the method is not used to assess compliance
- A score of 1 indicates the method is used but only in a minority of cases
- A score of 2 indicates that method and other methods are used to the same extent
- A score of 3 indicates the method is used in a majority of cases

The surveyed generators were also asked for feedback on whether costs or other factors chose the choice of method.

Figure 2 and 3 show the results obtained regarding the usage of the various methods provided for each performance standard in the template. The label below each set of bars indicates the relevant performance standard with the number of methods provided in the template shown in brackets.

In Figures 2 and 3 each method is allocated a score of between 0 and 3. This score is the one most commonly allocated by the surveyed generators that make some use of that method. Any method that was allocated a score of 0 by all generators is shown with a zero height bar. Zero height bars indicate methods that no generator identified the method as being used to assess compliance with the relevant performance standard.

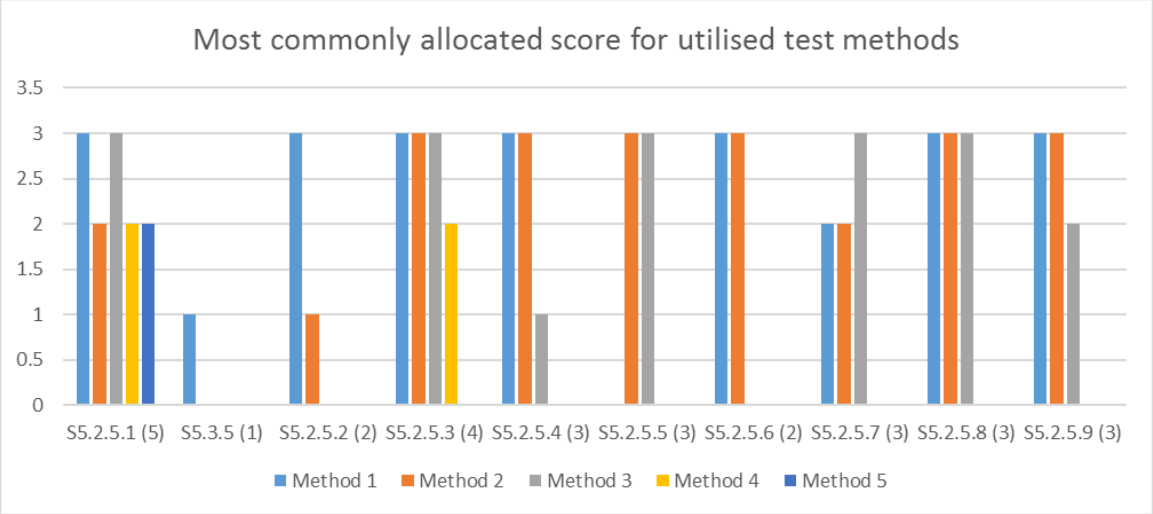

Figure 2 Use of methods in the compliance program template (S5.2.5.1 – S5.2.5.9)

Responses provided by generators for the performance standards shown in Figure 2 revealed that:

- For all standards except S5.2.5.5, each of the methods described in the template are currently used by at least one of the surveyed generators
- One of the methods for S5.2.5.5 is not used by any of the generators surveyed.

Key insights drawn from the survey responses for each of the performance standards shown in Figure 2 are provided below:

2.2.1 For S5.2.5.1 Reactive power capability

All methods are utilised so no change is suggested. Method 4 is the least used method, it calls for testing at a component level whereas the performance obligation is generally specified for the entire generating system as seen at the connection point.

2.2.2 For S5.3.5 Power factor requirements

Only one method is specified in the template.

2.2.3 For S5.2.5.2 Quality of electricity generated

All methods are utilised so no change is suggested here. Method 2 is the least used, as PQ performance requirements are specified in the generator performance standard at the connection point and apply to the entire generating system. Performance obligations at a subsystem level are generally not specified in the generator performance standard.

2.2.4 For S5.2.5.3 Generating system response to frequency disturbances

All methods utilised so no change is suggested. Method 4 is the least used, as not all generators monitor sub system performance.

2.2.5 For S5.2.5.4 Generating response to voltage disturbances

All methods are used however testing of 415 V drives as specified in Method 3 is only undertaken for thermal power stations. Feedback suggests it is appropriate to focus testing on 415 V drives as they can be more susceptible to tripping during abnormal voltage variations than higher voltage drives.

2.2.6 For S5.2.5.5 Generating system response to disturbances following contingency events

To provide an effective assessment of compliance, Method 1 would require the application of faults on the network to observe the resulting response of the generating system. All generators surveyed considered that this form of testing for recurrent compliance assessment would not be allowed due to system security concerns. Other methods are able to provide an adequate assessment of compliance and therefor Method 1 is not used. Respondents did note that in some instances a fault throw test may be included as part of the generator commission process but only at the request of the connecting NSP.

Respondents noted that Method 2 encompasses method 3 and therefore the two methods could be consolidated into a single method

2.2.7 For S5.2.5.6 Quality of electricity generated and continuous uninterrupted operation

There are two methods and both are used. So no change is suggested.

2.2.8 For S5.2.5.7 Partial load rejection

All methods used so no change is suggested.

2.2.9 For S5.2.5.8 Protection of generation systems from power disturbances

All methods are utilised. So no change is suggested.

2.2.10 For S5.2.5.9 Protection systems that impact on power system security

All methods are utilised frequently so no change is suggested.

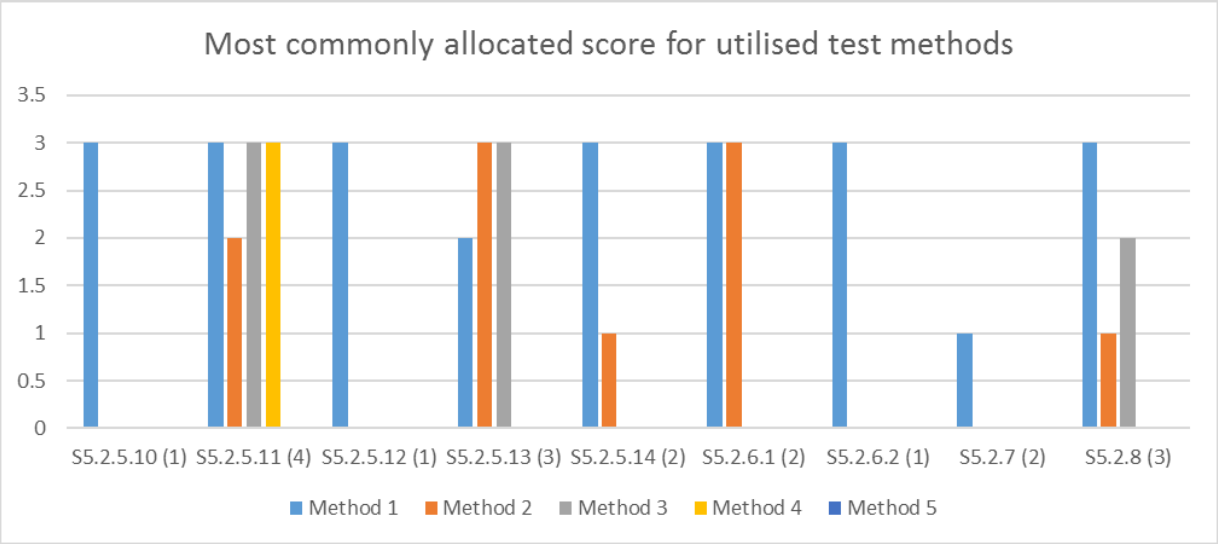

Figure 3 Use of methods in the compliance program template (S5.2.5.10 – S5.2.8)

Responses provided by generators for the performance standards shown in Figure 3 revealed that:

- For all standards except S5.2.7, each of the methods described in the template are currently used by at least one of the surveyed generators
- One of the methods for S5.2.7 is not used by any of the generators surveyed.

Key insights drawn from the survey responses for each of the performance standards shown in Figure 2 are provided below:

2.2.11 For S5.2.5.10 Protection to trip unstable operation

Only one method is specified in the template.

2.2.12 For S5.2.5.11 Frequency control

All methods utilised. Method 2 is the least used and this is because participants believe it is not applicable to their plants.

2.2.13 For S5.2.5.12 Impact on network capability

Only one method is specified in the template.

2.2.14 For S5.2.5.13 Voltage and reactive power control

All methods are utilised for this clause and therefore no change is suggested.

2.2.15 For S5.2.5.14 Active power control

Both methods are used so no change is suggested.

2.2.16 For S5.2.6.1 Remote monitoring

Both methods are used so no change is suggested.

2.2.17 For S5.2.6.2 Communication equipment

Only one method is specified in the template.

2.2.18 For S5.2.7 Power auxiliary supplies

No generators for which this performance standard applies reported using Method 2. A few respondents who expressed a preference for method 2 also stated that the configuration of their generating system mean that S5.2.7 does not apply as they do not draw auxiliary supply via a different connection point to that used to generate power.

2.2.19 For S5.2.8 Fault Current

All of the three methods are used for this clause. Method 3 relies on comparing recorded fault currents with those predicted by simulations. Generators reported that they are unlike to refresh simulations unless there is a material plant change and will instead rely on simulations completed as part of original generator performance standard compliance studies.

2.2.20 Refinement of test methods

A number for stakeholders noted that many of the different methods for a particular performance standard are very similar, but are worded slightly differently. These wording changes appear to reflect the staged reviews of the template over time, where previous methods were retained, and new methods were added because they were subtly different to the existing methods. It is suggested that by more careful and considered wording, the number of methods could be consolidated. This would potentially have an impact on the existing implementations of the template by generators, and should only be done following stakeholder consultation. Specific suggested refinements to simplify the template include:

- S5.2.5.6 the difference between methods 1 and 2 is unclear and should be clarified. GHD proposes to address this by revising method 2 to clarify that the method assumes continuous monitoring. This is consistent with the feedback received from generators currently utilising that method.
- Consolidation of methods for S5.2.5.8
    - method 1(b) and (c) and 2 appear to identical.
    - Method 3 and Method 1 are identical there is difference only in fact that method 3 mentioned one of technologies - wind farms.
    - There appears to be a case for consolidating into a single method
    - GHD recommends retaining all three methods as they are different eg method 1 allows for the use of continuous high speed monitors, while the other methods provide options which do not required continuous high speed monitors.
- Consolidation of methods for S5.2.5.9
    - Method 1, 2 and 3 are identical methods with some minor differences in descriptions. Can these be consolidated?
    - Method should include all relevant components of the monitoring and testing.
    - GHD notes that feedback from generators suggest that the test methods are sufficiently different to warrant retention, Method 1 maybe more appropriate for power stations with a few large units as it requires testing of

the protection system, while other methods may be more appropriate for generating systems with large numbers of generating units.

- Consolidation of methods for S5.2.5.11
    - There is no difference between method 1, 2 and 3. These three method should be combined into one method.
    - GHD notes that methods 1 and 3 specify high speed monitoring while method 2 does not. One survey response also identified that method 3 specified analytical simulations and is therefore different to method 1. It is therefore recommended that the three methods be retained
- Consolidation of methods for S5.2.8
    - There is need to compile all three methods into one without double or triple descriptions of the same method.
    - GHD notes that method 2 and 3 require comparison of measured fault currents and those predicted by simulation, with each method suggesting a different frequency for the tests. Method 1 places less reliance on simulation. It is recommended that the three methods be retained given the differences between the various methods.
- S5.2.5.13
    - Review methods specified for S5.2.5.1 and S5.2.5.13 to avoid unnecessary duplication
    - GHD does not recommend any additional change to the template. The differences between the tests methods for S5.2.5.1 and S5.2.5.13 are appropriate, given the different aspects of performance covered.

A number of stakeholders suggested that the template should provide greater detail and a more prescriptive approach to defining acceptable compliance test methods. AEMO noted that the compliance template published by Western power for the South West Interconnected System provide a greater level of detail than the compliance template published by the Reliability Panel. Powerlink suggested the following refinements be adopted:

- S5.2.5.9 method 1(b)
    - Acceptable monitoring methodologies need to be described in the document. Monitoring methodology need to be accurate, properly time stamped and with monitoring capability that will allow compliance to be adequately assessed.
- S5.2.5.13
    - Method 1 allows for transfer function measurement. Modern technologies are digital and transfer function measurement does not have much value. If there is value of suggested test the same measurements should be introduced for all other control systems.
    - Method 3 allows for performance assessment utilising digital protection relays. Primarily digital relays are not fault recorders. Consequently there are limitations related to this application (e.g. how this relays record and keep fault related records).

GHD notes that the template is not intended to prescribe tests, but rather provide a sufficient description of suitable test methods to assist generators to develop appropriate tests for

their plant. GHD recommends that the Western Power compliance template and the suggestions made by Powerlink be reviewed and where appropriate changes made to the template.

In addition, Powerlink noted that S5.2.5.1 method 4 (b) allows for capability to be monitored via SCADA. Powerlink considers that the SCADA minimum sampling time is not sufficient to measure the reactive power capability, especially when the plants reactive power changes in response to system disturbances and transients. GHD does not believe that this change is warranted as S5.2.5.1 states the steady state reactive capability without a contingency event, which implies that performance during disturbances and transients is not within scope for assessing compliance with this performance standard.

2.3 Feedback on revisions and clarifications of the template

GHD completed an initial review of the template and identified a number of suggested changes or clarifications that could be made to improve the template. Through the survey, stakeholder feedback was requested on each of the suggested changes or observations made by GHD. Figure 4, below summarises the feedback received with coloured bars used to identify the number of stakeholders that:

- Agree with the proposed change or need for clarification (blue bar)
- Disagreed with the proposed change or need for clarification (orange bar)
- Did not offer a view on the merit of the proposed change (grey bar).

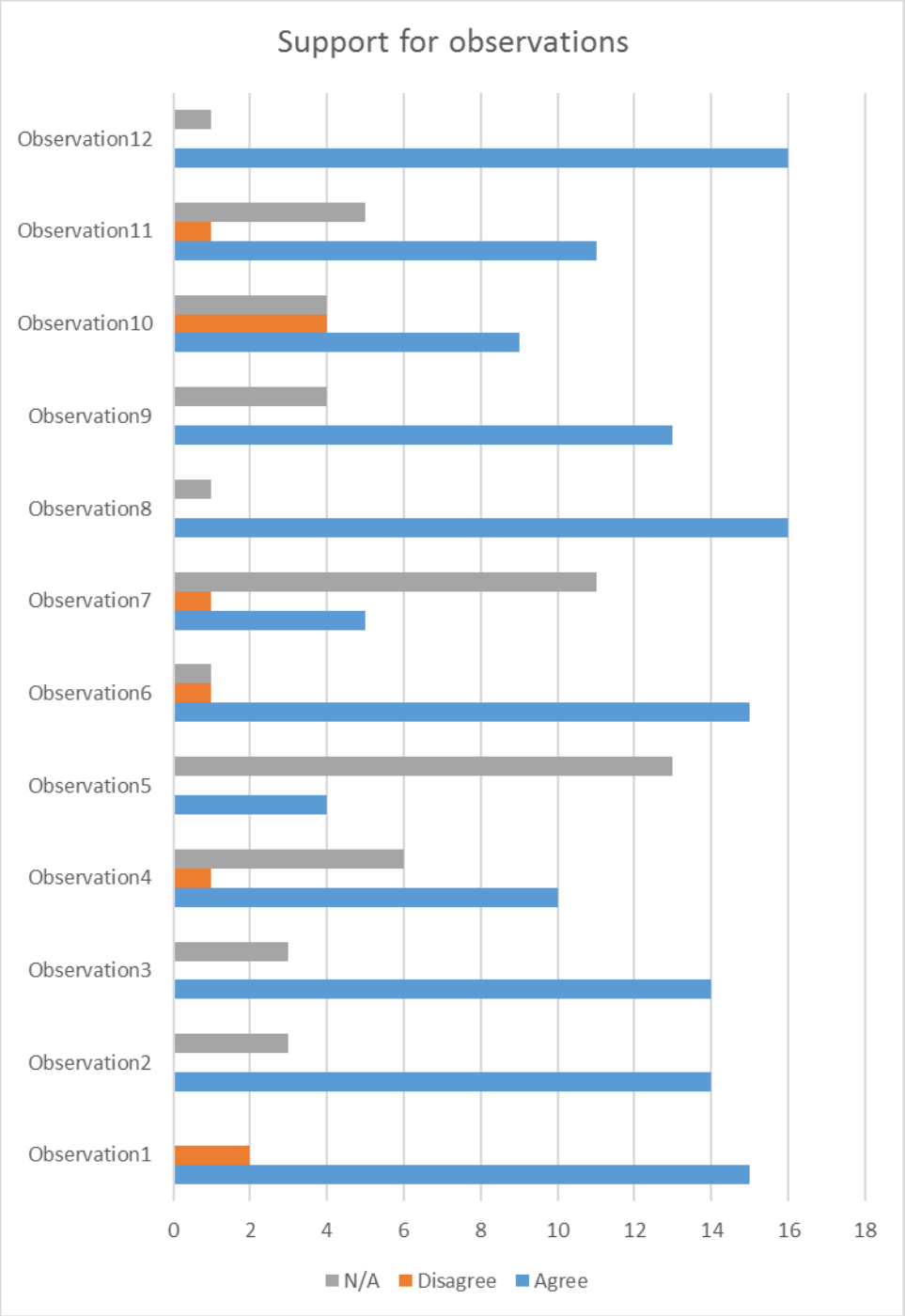

Figure 4 Stakeholder feedback on GHD observations

The following sections present each of the observations made by GHD suggesting potential opportunities to refine the template and a summary of the response provided stakeholders.

2.3.1 Observation 1 - High Speed Monitoring and compliance with S5.2.5.4 and S5.2.5.5

While high speed monitors support the assessment of compliance with generator performance standards, the NER does not appear to provide any explicit obligation on generators to install this monitoring. Stakeholder feedback was sought on whether:

- there are methods available that do not rely on high speed monitoring that can be used to assess compliance with S5.2.5.4 and S5.2.5.5 as introduced through the GTPS rule? and
- the review of data captured by high speed monitoring installed as part of the generating system and effective means of assessing compliance with these clauses?

Stakeholders reported that it is now common practice for new generators to install high speed monitors as they are not costly. Where available, Generators rely on high speed monitors to assess compliance with S5.2.5.4 and S5.2.5.5. Further, it is apparent that having high speed data that can capture transient responses from units during step changes is valuable for internal troubleshooting.

Most "older" existing generators do not have high-speed monitoring and some NSPS have their own high speed monitors installed at key generating nodes across their networks. NSPs are able to utilise the data gathered by those recorders to review system performance. In some instances data from NSP recorders is shared with generators.

The market ancillary service specification (MASS) requires FCAS service providers record their response to demonstrate performance with the MASS. High speed monitors are sometimes utilised to provide evidence of FCAS performance however these monitors are generally configured to demonstrate compliance with the MASS.

A combination of high speed monitoring with supporting plant design information (including models) is an effective means of assessing compliance with these clauses particularly considering the revisions introduced through the GTPS rule change. Generators with older generator performance standards may not face a compelling need to install high speed monitors.

Undertaking any comprehensive assessment of performance as proposed in S5.2.5.5 methods 2 and 3 for instance would prove somewhat difficult without the use of high speed monitoring at the generating unit or at the connection point (or close as possible). Whilst operation of protection relays (some high speed data may be available depending on type), design information and sequence of event data may provide some information to assist generators assess compliance, it will most likely not be sufficient without some form of high speed monitoring.

Stakeholders indicated that while High Speed Monitoring is being utilised as a standard approach for new generators there is a lack of specific guidance available to help generators configure and procure appropriate monitoring. Stakeholders suggested that there may be value in developing a high speed monitoring guideline which would include information such as appropriate performance requirements for high speed monitors, configurations arrangements including advice on the appropriate location and distribution of monitors within a generating system and appropriate configuration of alarms, triggers, the amount of pre and post trigger data recorded.

2.3.2 Observation 2 - Performance of remote equipment

S5.2.5.1 allows for performance standards to be met by reactive plant installed beyond the connection point. However the compliance template does not acknowledge this possibility. Stakeholder input was sought on experience with remote plant and whether the template should specify the need to include the performance of remote equipment when assessing the ability to meet the performance standard?

Stakeholders generally agreed that all plant that is critical for achieving the required performance should be subject to an appropriate compliance assessment process. The obligation for developing and executing the compliance program should lie with the owner and operators of the asset. The generators performance standard should specify the performance expected to be seen at the connection point and the compliance programs should assess compliance with that standard.

There was general agreement from stakeholders that in the case where remote equipment has been installed and that plant's availability impacts the ability of the generator to satisfy performance standards, arrangements should be provided to adjust the output of the generator as necessary to maintain system security should the remote plant be unavailable. The performance standard, connection agreement or operating protocol should specify obligation for the operator of the remote plant to inform the generator if the plant is not available and the control actions that the generator should take in response. The generator compliance program should confirm this control scheme continues to operate as specified.

As the compliance template already provides test methods sufficient to confirm the ongoing performance of key generator controls, no change is required to the test methods specified in the template to address remote plant. It is however recommended that a new sub-section be added to section 2 of the template to raise the potential for remote plant to impact generator performance and to articulate the preceding discussion describing the roles expected of different parties in assessing ongoing compliance of the remote plant notifying changes in availability and responding to those notifications.

Respondents noted that the Rules present a different compliance obligations for generator and NSP. A generator installing a synchronous condenser as part of a generating system would need to include the impact of the synchronous condenser in the generator performance standard and would need to test the ongoing performance of the synchronous condenser as part of it generator compliance programs. Compliance expectations for NSPs are described clause 5.7.4 (a1) of the Rules. This clause only requires compliance programs covering protection and control systems not physical plant such as Synchronous Condensers. It is outside the scope of the review of the template for generator compliance to address this perceived inconsistency. It is recommended that the AEMC note the inconsistency and consider whether it can be addressed as part of other reviews.

2.3.3 Observation 3 – Feasibility of testing full reactive power capability

S5.2.5.1 Methods 1 and 2 may not be achievable for some generators as they could introduce adverse system security impact. These methods require exercise of the entire reactive power range of the generating system or triggering of over and under excitation limits. For large power stations with a single generating unit or for wind and solar farms connected into relatively weak areas of the network, the network may not be able to accommodate the full reactive power range without breaching voltage limits. Feedback from NSPs and AEMO on this issue should be sort and the guidance notes in the template adjusted to reflect feedback obtained.

Most generators reported that they used method 1. Feedback from generators and NSPs confirmed that circumstances do exist where the network is not always able to

accommodate the full reactive power capability. Stakeholder feedback confirmed that prior approval by the NSP and AEMO would be required to enable a test exercising the full reactive power range. Such approval should be sort well in advance to have the best chance of accommodating the full range. Stakeholder feedback confirmed that even with advanced notice it may not be possible to accommodate the full reactive power range.

It is therefore recommended that the basis for compliance assessment notes for methods 1, 2 and 3 be revised to read, "be capable of achieving reactive power requirements of the performance standards subject to not exceeding network voltage limits."

One stakeholder suggest that if the network was unable to accommodate the full reactive range, testing of the full range of individual components should be viewed as an acceptable alternative. This approach could be readily applied for solar and wind farms. GHD agree that approach has merit and notes that method 4 allows for this form of compliance test.

2.3.4 Observation 4 – clarification of test frequency

S5.2.5.3 method 4(a) has a suggested test frequency of "every 3 years and after plant change". It is recommended that the test frequency be clarified to specify the test is completed at least every 3 years by reviewing the response of the relevant sub-systems to a disturbance where the frequency moves outside of the operational frequency tolerance band. What are stakeholder views on the proposed change? Is there any other feedback on this issue?

Most survey participants considered the proposed change to be reasonable.

Some stakeholders also suggested that a test every 3 years is not necessary when there is a low risk of the performance of the generator changing over time. This situation exists for synchronous generators with modern digital protection relays. While GHD considers that there is merit in allowing a risk based approach to the setting of the test frequency in compliance programs we believe this is already allowed for by the words in section 2.7 of the template and therefore no additional change in required.

2.3.5 Observation 5 – clarify simulated disturbance testing of auxiliary power supplies

S5.2.5.4 method 2(b) includes a note stating that "where possible testing of auxiliary power systems should include simulated disturbance testing". It is unclear how simulation of voltage disturbance on an auxiliary power system could be practically achieved. Insight into the application of this method is sought from stakeholders. How are stakeholders currently performing this 'simulation'?

Feedback from a number of thermal generators identified that they have interpreted this method to allow for tests that tapped the auxiliary supply transformer with the generator offline to move the auxiliary voltage and assess the ability of drives supplied from the auxiliary supplies to ride through the change in voltage. GHD is satisfied that this is a reasonable application of the method in which transformer tapping is used to simulate a voltage disturbance. We therefore do not recommend any change to the template.

2.3.6 Observation 6 – qualification of plant change

Plant change is defined in section 2.9 of the template and the definition includes changes to primary plant and changes to control and protection systems. It is unclear why S5.2.5.3 method 3 in table 1 of the template adds qualification to the term plant change by adding the clause, "which may include control system settings or protection system setting change". This qualification appear unnecessary and creates confusion that control system changes are

only relevant for some performance standards and not others. Generally control and protection system changes apply whenever the term Plant Change is used.

Consideration should be given to reviewing the definition of plant change to note that a system change should also include the implementation of new versions of digital protection and control systems. What are stakeholder views of this proposed change? Is there any other feedback on this particular issue?

Survey participants thought this was a reasonable to have this term defined once in section 2.9 and for qualifications to be removed from Table 1. Most stakeholders saw merit in reviewing the definition of plant change to clarify when compliance needs to be reassessed. A particular area of concern is to ensure plant change in corporates changes to firmware/software (including settings) changes, where these may affect a generator's performance and compliance with its registered generator performance standard.

Stakeholders noted that not all changes need reassessment of compliance. Changes that replacing a piece of equipment with an identical piece of equipment with the same performance characteristics are not expected to change generator performance should therefore not trigger a requirement for reassessing compliance.

Stakeholders suggested that any review of the definition of plant change should consider the need for consistency with the triggers that give rise to a 5.3.9 application in the Rules. The review should also consider the need to balance the timely installation of patches to ensure cyber security and the need to confirm that any such change does not impact plant performance. The guideline should raises awareness of the risk of a firmware/software change being remotely applied by an OEM changing the performance of the plant.

2.3.7 Observation 7 – justification for testing of 415 V drives

S5.2.5.4 Method 3 (a) specified tests to be performed on 415 V drives with a generators out of service. It is unclear why only 415 V drives are tested as critical auxiliary loads on large thermal generators would normally be higher voltage drives. Do stakeholders have insight into the origins of the 415V drive requirement?

Feedback provided by stakeholder confirmed that there are valid reasons for focussing attention on 415 V drives. Historically 415 V equipment at thermal power stations has been less likely to ride through voltage variations specified in the generator performance standard and it is therefore appropriate to provide addition focus on the testing of these drives. This also address the risk of 415 V drives tripping when contactors drop out if there is a temporary drop in the 415 V supply voltage.

GHD is satisfied with the feedback provided and does not recommend any change to the template

2.3.8 Observation 8 – viability of conducting a fault throw test

S5.2.5.5 Method 1 appears to require direct testing of performance by initiating a network trip. A network switching event in the absence of a fault does not appear to be a valid disturbance to establish compliance hence unless this method involved the application of a network fault (ie a fault throw test) this method would appear to be ineffective. Gaining approval for a fault through test is likely to be difficult due to potential system security issues with such a test. Stakeholders' feedback is sought on the application of method 1 being applied via a fault throw test, Do stakeholders consider the method is intended to involve reviewing the response to a network fault, with the connecting NSP co-operating to identify when such a fault has occurred?

Most stakeholders agreed that for this method to be effective in assessing compliance with S5.2.5.5 a fault trow test would be needed. None of the survey respondents support using "Fault throw test" to assess ongoing compliance. As other methods can provide an appropriate assessment of compliance with S5.2.5.5, it is recommended that this method be removed from table 1 in the template.

In Tasmania these tests are undertaken as part of the commissioning process for new generators. TasNetworks preference for some time has been for fault throw tests to be conducted during commissioning of new asynchronous generating plant. This test has been undertaken for various reasons, such as verifying its response to a network fault given the criticality of that within the Tasmanian network and being able to verify the measured response against the modelled response. The test also assists generators, to assess the robustness of their plant and rectify any issues during the commissioning process. Undertaking a "planned fault" test allows TasNetworks to minimise the "risk" and set the network up under optimal test/control conditions.

There are no preferences within TasNetworks at this stage for these tests to be undertaken for synchronous generation as part of their commissioning.

One NSP noted that fault throw tests have been conducted internationally on a 'type test' basis, as a method to establish the performance of prototype or new model wind turbines and to verify the accuracy of their software models. A process of type testing equipment as a precursor to generator performance standard negotiation may help deliver better models and provide a more practical approach to ascertain ongoing compliance for new generators. The model validated through the fault throw test could be used to confirm expected performance with routine post fault investigation as specified in Method 2 relied on the assess ongoing compliance.

The same NSP advised that rigorous fault investigations would require a generator to approach the NSP for provision of information on the network state, both pre and post fault, along with requests for any fault recordings available to supplement their own analysis. The NSP in question has no record of a generator making such an approach and this is consistent with fault throw tests not being used by generators to assess ongoing compliance.

Fault throw testing may still have a place for demonstration of compliance of older generating systems where there is significant uncertainty on the accuracy of power system models or where post fault investigation identifies performance below the required standard.

One NSP reported using a fault throw based testing system on its distribution network for the rollout of their Rapid Earth Fault Current Limiter (REFCL) system for bushfire mitigation at 22kV. While this application is not for generator testing it provides another example of performing these tests on an operating network.

2.3.9 Observation 9 – Clarification of metering required

S5.2.5.6 specifies a requirement for generating systems to remain in continuous uninterrupted operation provided the Power Quality at the connection point remains within the level specified in the system standard. Method 2 specifies the monitoring of in-service performance using appropriate metering, however the term appropriate metering is not defined. It is difficult to understand how the method is applied in the absence of power quality metering. Stakeholder feedback is sought on the application of this method and the type of metering used. What sort of metering is applied and how should the template clarify this requirement?

Stakeholder feedback indicates that appropriate metering has been interpreted to mean power quality metering. Where high speed monitors have been installed generators report that those systems can also provide continuous power quality monitoring. In addition stakeholders noted that accurate harmonic measurements also require appropriate measurement transformers. Inductive VTs for example, may not provide accurate measurement of harmonics at higher orders.

GHD therefore recommends that the test method be revised to read, "Monitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth" Guidance on the specification of appropriate monitoring and measurement equipment can be found in IEC and IEEE power quality standards.

In addition Stakeholders noted that synchronous generators do not have protection that would operate and trip the generator even if power quality was outside the standard. This means that the performance of the generator is locked in by the choice of technology and protection systems implements. If there is no material plant change then there is little risk of the generator performance changing and very little value in trying to design on-going tests to demonstrate compliance. GHD does not believe that this warrants any change to table 1 of the template as section 2.7 provides sufficient scope for a generator to use this argument to specify an appropriate time between compliance tests.

2.3.10 Observation 10 – frequency of testing of partial load rejection capability

Clarification is required regarding the manner in which the frequency of testing is specified in S5.2.5.7 method 1(a) and 3(a) and the event definition in method 3(a). For Method 1(a) the frequency of testing is specified as "on every event where the frequency moves beyond the operational frequency tolerance band or every five years whichever is more frequent". The first part of the drafting appear to require an assessment after every event where the frequency exceeds 51 Hz on the mainland and hence the second part seems unnecessary. A similar issue presents for Method 3(a). It is also recommended that the event definition in method 1(a) be applied in 3(a). What are stakeholder views on this proposed change? Is there any other feedback on this particular issue?

Some stakeholders suggested that frequency excursions that exceed 51 HZ are quite rare and may not occur within a 5 year period, therefore it remains appropriate to include a default test frequency of 5 years. GHD accepts this argument and has modified the suggested change to the template.

Most stakeholder supported the changes proposed by GHD to align the frequency of testing requirements for 1(a) and 3(a). This would change the suggested default frequency for 3(a) from 10 to 5 years. Some stakeholders expressed a concern that this change will increase the frequency of testing to be undertaken by generators should no system frequency event occur.

GHD believes that the drafting of section 2.7 of the template should allow generators to argue for the longer default test period if appropriate, however we also can see that a specific change to the default test period may create unnecessary work for generator to defend the timing in their existing compliance programs. We therefore recommend only amending the frequency of testing advice for Method 3(a) to read "on every event where high frequency moves out of the operational frequency tolerance band or every 5 years (whichever is more frequent) and after plant change as appropriate to the technology of the relevant sub-system".

Some stakeholders advised that verification of the over-frequency performance is normally achieved by tests of the relevant subsystems such as governor controls or over-frequency runback schemes. Some stakeholders are concerned that a test on every event may introduce a high test burden particularly in situations where the technology employed means that variations in performance are unlikely and where a test has already confirmed performance within the last 5 years. GHD considers that the proposed qualification of the test frequency for method 3(a) will help address this concern as every event will be qualified to only mean those events where the frequency moves outside the operational frequency tolerance band. This should occur infrequently and is probably a sufficient frequency deviation that AEMO will want generators to provide data to investigate the event.

This observation attracted a higher number of responses that disagreed with the observation. The reasons for the disagreement varied:

- One renewable energy generator disagreed with the application of partial load rejection requirements to renewable generators suggesting the compliance requirements should only apply to synchronous generators at thermal power stations and should require demonstration of a trip to house load capability
- Another generator identified that they have the ability to operate with a fast ramp in response to an over-frequency event but this needs to be enabled on instruction from AEMO. It is not normally enabled and would therefore not normally be available if a partial load rejection occurred.
- Other disagreements related to the proposed change to frequency of tests. Some of those concerns have been addressed through the modified revision proposed by GHD.

2.3.11 Observation 11 – extending compliance to consider over frequency run-back schemes

S5.2.5.8 Methods 2 and 3 do not appear to verify that the required automatic reduction in output for over frequency events will occur. It is recommended that these methods be modified to assess that aspect of compliance. What are stakeholder views on this proposed change? Is there any other feedback on this particular issue?

While most stakeholders supported the need to validate the performance of runback schemes, they advised that would normally occur as part of other compliance tests to demonstrate correct function of generator controls and protection covered by methods for other performance standards.

GHD accepts this argument and therefore does not recommend any change to the template.

2.3.12 Observation 12 – removing technology bias through use of the term turbine

S5.2.5.8, S5.2.5.9, S5.2.5.13 test methods contain notes that refer to turbine control parameters when they should apply to all control parameters, S5.2.5.11 Method 2 only applies to governor systems while Method 3 limits analytical simulations to turbine controls and governors. This use of the term turbine and governor could be interpreted as excluding active power controls on batteries and solar farms and the notes against S5.2.7 Method 2 should be reworded to consider both solar and wind farms. What are stakeholder views on this proposed change? Is there any other feedback on this particular issue?

Most stakeholder support the contention that inappropriate technology bias should be removed from the template.

One stakeholder expressed the view that S5.2.5.11 – Method 1 would appear to cover off the performance of "non-governor plant" such as batteries and solar, and Method 2 would seem to apply specifically to those generators that have a governor system for the control of frequency. The frequency of testing wording for these two methods could be reviewed as they appear to actually refer to the same thing.

In addition to this, stakeholders suggested that given the varying requirements and test methods between synchronous and asynchronous plant, there may be benefit in creating separate compliance templates for those technologies.

GHD believes that stakeholder have raised valid concerns and recommends that the template be reviewed and where necessary changes implemented to remove unintended technology bias. This review should carefully consider whether particular methods are intended to only apply to particular generation technologies and only where this is definitely the case notes to that effect should be included in the table.

As explained in section 2.6 of the template it is ultimately up to the generator to develop a compliance program that is appropriate for their generating system. GHD would expect that each generator will develop a compliance program using methods consistent with those in the table 1 of the template and will select methods most appropriate for their plant. It is therefore important that the notes included in table 1 of the template do not unnecessarily restrict methods to particular technologies.

2.3.13 Observation 13 – testing of AGC to confirm compliance with active power control requirements

S5.2.5.14 defines the requirement to provide active power control. The GTPS rule introduced a greater requirement to respond to AGC control signals. Neither of the two test methods in Table 1 of the compliance program template specify testing or monitoring of the ongoing ability to respond adequately to AGC control signals. This may not be necessary if such tests are routinely conducted by AEMO. What is current practice in this area? Are there any suggestions on how, and whether, the template should include such a requirement?.

Feedback on this observation was only requested from AEMO

AEMO advised that AGC is becoming more important and regular tuning/testing is required, especially considering the current issues with frequency and numerous changes to the NEM. Generators should expect that testing/tuning of the AGC could occur on a regular basis, but it doesn't necessarily have to occur with the regular compliance testing.

It is therefore recommended that no change be made to the template in regard to the need for inclusion of AGC testing as part of the methods for S5.2.5.14.

2.4 Additional Feedback

Through the survey process the following additional items were raised by stakeholders. This feedback did not specifically relate to any of the recommendations or observations proposed by GHD.

2.4.1 NSP Notification / Information – Powercor and other NSPs

Powercor suggests that the role of the compliance template to promote consistency in compliance programs between Generators and NSPs across the NEM. However, there is currently no formal requirement for generators to notify the NSP of compliance testing other than for operational purposes if a non-compliance is identified. A more prescriptive requirement to ensure that AEMO and the relevant NSP are explicitly informed of compliance testing in advance would create a more robust process, enabling a greater degree of

cooperation across the industry to ensure compliance and maintain system security. This would enable NSP's to better plan the use of their engineering resources and to better identify any risks to network or customers as a result of compliance testing.

Other NSPs expressed a similar desire to have greater visibility regarding the execution of compliance programs and the results achieved.

GHD notes that the compliance program provisions in the rules do not require the generators to directly engage with NSPs and AEMO as part of executing their compliance program except in the event that:

- A test might create a disturbance on the power system. This could arise for instance during tests to demonstrate the reactive power capability. The normal system security management provisions in the rules would require the generator to seek consent before undertaking such tests;
- A test raises concerns regarding whether the generator is meeting its performance standard. The rules require that a potential non-compliance be reported to AEMO.

Expect in the above circumstances, there does not appear to be any obligation in the Rules to involve NSPs in the development and execution of generator compliance programs. There may be value in including in the template notes that any test that have the potential to create system security impacts should be coordinated with AEMO and the relevant NSP. There does not appear to be scope to include any additional changes in the template that would require the generator to have any greater interaction with NSPs.

Generators may take the view that providing AEMO and NSPs greater visibility of their compliance programs will add cost and complexity to the execution of the programs. GHD recommends that the AEMC note that the request for AEMO and NSPs to have greater visibility of generator compliance cannot be solved within the scope of the review of the template

2.4.2 Alignment with Power System Models – Powercor and AEMO

Both Powercor and AEMO have asserted that a greater emphasis should be placed on ensuring that compliance testing not only acts to ensure the agreed performance standards are met, but also that the agreed generating system models used to verify those standards remain accurate. In addition to this, Powercor notes that the manufacturers of newer generating system equipment (e.g. inverter systems) are constantly updating the models of their existing equipment and those models are crucial in understanding how the generating system will responds to events on weak networks.

Revised models may often reveal non-compliance with agreed performance standards, yet existing generators are not actively seeking to update their equipment models or to highlight this to NSP's and AEMO.

A number of methods in the template for generator compliance rely on continues use of "plant models used to establish initial compliance". This approach could overlook new issues being identified with updated models.

GHD believe that this is a reasonable concern and recommends replacing the references in the template to "the plant models used to establish initial compliance " with the latest plant models provided under clause S5.2.4."

AEMO has also noted clause S5.2.4 (d) (2) requires generators to provide updated modelling information to AEMO and the relevant NSP when the generator becomes aware that the information previously provided is incomplete or out of date. AEMO suggests that a compliance program that provided for the comparison between measured and simulated performance may help identify the need to update modelling information.

GHD is of the view that the requirements to update models sit outside of the provisions in the rules that define the generator performance standard. If generators are not adhering to their obligations under S5.2.4.(d)(2) AEMO and NSP should pursue the relevant generator and if that fails the AER. Addressing the issues raised regarding the ongoing revision of models is outside the scope of the review of the compliance template.

Feedback provided via the technical working group identified that often tests performed during the R2 generator model validation phase do not provide sufficient validation of a generator model. This could arise if significant system events did not occur during the test period resulting in incomplete model validation. Members of the working group suggested that when this occurs, it is reasonable to expect a generator to consider the need to finalise the model validation by collecting data via the initial compliance program and for the template to be revised to provide this guidance. GHD supports this recommended change to the template.

Members of the technical working group also suggested that the reference to "plant model used to establish initial compliance" in the basis for compliance assessment in table 1 of the template should be amended to read "the latest plant model provided in accordance with clause S5.2.4". GHD supports this recommendation as it clarifies that compliance methods that rely on comparison of measured and modelled performance should consider the latest plant model.

2.4.3 Notification of non-compliance process – AER

The AER recommended that the generator compliance template remind generators of their obligations in rules 4.15(c) and (f) to report potential non-compliances. GHD notes that this information is already included in the template and therefore does not propose any revision. The AER also suggested including in the template a link to the AEMO web page where generators can access the form developed to assist in advising AEMO of any non-compliance with their registered performance standards. GHD recommends incorporating this revision in the template.

The AER notes that revisions to the compliance template do give rise to an obligation on generators to review their compliance programs, and through such review, potentially adjust the nature and frequency of their periodic tests. GHD believes that section 1.3 of the template provides sufficient guidance to generators of this obligation.

The AER has advised that the generator performance standards information booklet published in August 2013 and referred to in section 1.3 of the template is no longer current and is being updated. GHD recommends that reference to the August 2013 guideline be deleted and a reference to the new guideline be added if it becomes available prior to finalising the amended template.

3. Conclusions and Recommendations

The template of generator compliance programs has a specific purpose as defined in the National Electricity Rules and articulated in the current version of the template. The template also includes 10 compliance principles adopted by the Reliability Panel in developing the template. GHD recommends the Reliability Panel implement the following set of recommended changes to the template for generator compliance programs. The recommendations have been developed by considering the survey responses provided by stakeholders. We have also attempted to ensure the revisions support the purpose of the template and are consistent with the compliance principles:

- To align with the revisions introduced by the GTPS rule change the following changes should be made to the template:
    - The entry in table 1 of the template providing advice on the frequency of testing for Method 3(a) for S5.2.5.5 should be revised to read, "When the plant trips during or immediately following a significant voltage disturbance and at least one major event every 3 years where the generating system maintains *continuous uninterrupted operation*"
    - The term major event be defined as an event on the power system that the generator considers best tests the ability of the *generating system* to meet its performance standard.. A major event may include a disturbance that triggers AEMO to undertake a review of system performance, disturbances that result in voltage variations comparable with the minimum access standard specified in S5.2.5.4 or frequency variations that meet or exceed the minimum access standard in S5.2.5.3.
    - The terms significant disturbance and major disturbance should also be defined.
      A **significant disturbance** means a power system disturbance that significantly varies frequency, voltage or power quality at the connection point beyond normal system conditions. Significant disturbances provide a trigger for investigating plant trips to assess whether the trip indicates an inability of the generating system to remain in continuous uninterrupted operation as required by its performance standard.

      A **major disturbance** means a power system disturbance that the generator considers will provide a significant test of the ability of the generating system to remain in continuous uninterrupted operation as required by its performance standard.
    - The basis for compliance notes against the methods in Table 1 of the compliance template for S5.2.5.13 be revised to require testing of all control modes specified in the generator performance standard.
- The compliance template can be simplified by deleting S5.2.5.5 Method 1 as stakeholders have identified this method is not being used for compliance testing and system security concerns are unlikely to allow the method to be used.
- The compliance template can be simplified by deleting S5.2.7 Method 2 as stakeholders have identified this method is not being used for compliance testing.
- A new sub-section be added to section 2 of the template to raise the potential for remote plant to impact generator performance and to articulate the roles expected of different parties in assessing ongoing compliance of the remote plant notifying changes in availability and responding to those notifications.
- The basis for compliance assessment notes for S5.2.5.1 methods 1, 2 and 3 be revised to read, "be capable of achieving reactive power requirements of the performance standards subject to not exceeding network voltage limits."
- The test frequency specified for S5.2.5.3 method 4(a) be clarified to specify the test is completed at least every 3 years by reviewing the response of the relevant sub-systems to a disturbance where the frequency moves outside of the operational frequency tolerance band

- That the term plant change be defined in section 2.9 of the template and that any qualifications of that term to be removed from Table 1.
- The definition of the plant-change be reviewed to clarify when compliance needs to be reassessed. The definition should make it clear that changes that replacing a piece of equipment with an identical piece of equipment with the same performance characteristics are not expected to change generator performance and therefore should not trigger a requirement for reassessing compliance, while software and firmware may well trigger a requirement to reassess compliance. The definition should provide consistency with the triggers that give rise to a 5.3.9 application in the Rules
- S5.2.5.6 Method 2 be revised to read, "Monitoring in-service performance using power quality meters supplied via measurement transformers and transducers with sufficient frequency bandwidth"
- Amending the frequency of testing advice for S5.2.5.7 Method 3(a) to read "on every event where high frequency moves out of the operational frequency tolerance band or every 5 years (whichever is more frequent) and after plant change as appropriate to the technology of the relevant sub-system"
- References to technologies in the template should be reviewed to remove unintended technology bias. This review should carefully consider whether particular methods are intended to only apply to particular generation technologies and only where this is definitely the case notes to that effect should be included in table 1 of the template.
- Review those methods that rely on continued use of "plant models used to establish initial compliance", replacing the references to "the plant models used to establish initial compliance " with the latest plant models provided under clause S5.2.4."
- The AER has advised that the generator performance standards information booklet published in August 2013 and referred to in section 1.3 of the template is no longer current. GHD recommends that reference to the August 2013 guideline be deleted and a reference to the new guideline be added if it becomes available prior to finalising the amended template.
- The AER also suggested including in the template a link to the AEMO web page where generators can access the form developed to assist in advising AEMO of any non-compliance with their registered performance standards. GHD recommends incorporating this revision in the template.
- A number of stakeholders suggested that the template should provide greater detail and a more prescriptive approach to defining acceptable compliance test methods. AEMO noted that the compliance template published by Western power for the South West Interconnected System provide a greater level of detail than the compliance template published by the Reliability Panel. Powerlink suggested refinements for S5.2.5.9 method 1(b) and S5.2.5.13 methods 1 and 3. GHD notes that the template is not intended to prescribe tests, but rather provide a sufficient description of suitable test methods to assist generators to develop appropriate tests for their plant. GHD has reviewed the Western Power compliance template and does not recommend any further change be made to the template.
- A number of stakeholders suggested refinements to the template to address perceived duplication of test methods. GHD has reviewed the specific test methods cited and considered the range of feedback provided through the stakeholder survey. In many cases the survey responses indicate important but subtle difference between the existing methods and it is therefore recommended that the existing methods be

retained. In a few instances a slight refinement of the method is recommended to clarify the differences between similarly worded methods.

- Feedback provided via the technical working group identified that often tests performed during the R2 generator model validation phase do not provide sufficient validation of a generator model. This could arise if significant system events did not occur during the test period resulting in incomplete model validation. Members of the working group suggested that when this occurs, it is reasonable to expect a generator to consider the need to finalise the model validation by collecting data via the initial compliance program and for the template to be revised to provide this guidance. GHD supports this recommended change to the template.
- Members of the technical working group also suggested that the reference to "plant model used to establish initial compliance" in the basis for compliance assessment in table 1 of the template should be amended to read "the latest plant model provided in accordance with clause S5.2.4". GHD supports this recommendation as it clarifies that compliance methods that rely on comparison of measured and modelled performance should consider the latest plant model.
- Members of the technical working group noted that parties that have recently become registered generators in the NEM should derive particular value from the guidance offered by the template. GHD has specifically reviewed the introductory sections of the template from the perspective of a new generator to confirm appropriate content and language. As a result, it is recommended that a reference to the relevant Australian Standard for compliance management systems be added to section 1.3 of the template.

GHD considers that the following specific suggestions made by stakeholders are outside the scope of a review of the template for generator compliance programs but are worth of consideration by the AEMC:

- Each NSP should make information available to connected generators that identifies when major events have occurred that should be considered when assessing generator compliance. Once the information is routinely being made available consideration should be given to amending the definition of major event in the compliance template to an event or series of events consistent with those specified in the generator performance standard and notified by the relevant NSP.
- A high speed monitoring guideline should be developed by AEMO with input from NSPs and generators which includes information such as appropriate performance requirements for high speed monitors, configurations arrangements including advice on the appropriate location and distribution of monitors within a generating system and appropriate configuration of alarms, triggers and the amount of pre and post trigger data recorded
- The AEMC note the concerns raised by stakeholders regarding the perceived inconsistencies between the compliance obligations on Generators and NSP particularly with respect to plant such as synchronous condensers and consider whether they can be addressed as part of other reviews.
- NSPs and AEMO see value in having greater involvement in the execution of generator compliance programs. The existing provisions in the rules do not appear to support this outcome. GHD recommends that the AEMC note that the request for AEMO and NSPs to have greater visibility of generator compliance can not be solved within the scope of the review of the template

- The AEMC note the concern raised by AEMO and Powercor that generators don't appear to be updating models as required by clause S5.2.4 (d) (2). As the requirements to update model sit outside of the provisions in the rules that define the generator performance standard, addressing the issues raised regarding the ongoing revision of models is outside the scope of the review of the compliance template.

Appendix C – Technical Working Group

The following table list the member of the technical working group convened by the AEMC to provide feedback on an initial set of recommended revisions to the template for generator compliance programs developed by GHD.

Working Group Member	Organisation
Graham Mills, Christiaan Zuur, Julian Eggleston	AEMC
Kate Summers	Pacific Hydro
Jock Baker	Electranet
Mark Parker	Yurika
Nick Morley	First Solar
Nicholas Buckley, Phil Onions	Stanwell
Darren Hunt	AGL
Christian Green	Energy Queensland
Andrew Dinning, Adrian DeSantis	Powercor
Eric Lauro, Prasad Shan	AER
Chris Murphy	Meridian Energy
John Titchen	Goldwind Australia
Trevor Armstrong	Ausgrid
Luke Robinson, Marina Delac	AEMO

GHD

Level 18 180 Lonsdale Street
Melbourne VIC 3000
T: 61 3 8687 8000 F: 61 3 8687 8111 E: melmail@ghd.com

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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Final	David Bones	N Pahalawaththa		D Bones		7/8/2019

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