National Electricity Rules:
Generator technical performance standards
Rule change submission

1. Introduction

Lloyd's Register (LR), founded in 1760 as a marine classification society, is one of the world's leading providers of professional services for engineering and technology – improving safety and increasing the performance of critical infrastructure for clients in over 75 countries worldwide. LR's business activities fund the Lloyd's Register Foundation, a charity which supports science and engineering-related research, education and public engagement. All of this helps LR stand by its purpose of "*Working together for a safer world*".

LR's Low Carbon Power Generation consultancy is one of the foremost providers of independent professional advice in the engineering and analysis of grid connections for renewable electricity generation projects. LR has been instrumental in the grid connection of a large number of operating renewable generation projects, and continues to provide assistance to a substantial proportion of new generation projects in the Australian National Electricity Market (NEM). LR also provides dynamic modelling software and support to leading equipment suppliers worldwide including ABB, SMA, Goldwind, Vestas and Senvion.

LR welcomes the opportunity to submit its response to AEMC's Draft Rule Determination on technical performance standards for generator connections in the NEM.

LR has endeavoured in this submission to take account of AEMC's assessment framework which stresses the following considerations:

- **Maintaining system security at the lowest cost to consumers.** Where meeting a system security objective incurs costs over and above those necessary to provide a reliable and efficient supply of energy, it is appropriate that these costs be minimised as all such costs are ultimately borne by consumers.
- **Appropriate allocation of costs and risk.** In accord with this principle, LR considers it is appropriate that generator connection applicants in the NEM share in costs to the extent required to manage their pro-rata participation in the power system. They should not be subject to costs unnecessarily (that is, where there is little to no practical benefit to system security or supply quality) or where disproportionate to the effect of their connection on the power system.
- **Regulatory certainty and flexibility.** Requirements should not be imposed capriciously on NEM participants. Given the normative status of automatic access standards in the new framework, the technical content of these standards must be justifiable by reference to good industry practice and the future needs of the power system, and not simply set arbitrarily at the highest standard

conceivable. Likewise, minimum access standards must not act to restrain prospective participants or technologies which could otherwise connect without material adverse effects on system security or quality of supply. Moreover, LR considers that in the interests of certainty, requirements should be worded to avoid undue complexity and so that practical tests to establish a clear boundary between compliance and non-compliance can be formulated in a transparent manner.

- **Technology neutrality.** In certain cases it is appropriate to formulate technical requirements by reference to specific aspects of particular generator technologies. However, such requirements must not discriminate by placing more onerous obligations on some generator connections over others by virtue of the particular technology used. Wherever appropriate, requirements should be described in a way that is 'blind' to the specific technology behind the connection point.

Our submissions on specific aspects of the Draft Rule are arranged under headings mirroring those in the Draft Rule Determination by the AEMC.

2. Negotiating process for connections

The new negotiating framework in the Draft Rule establishes a new normative role for the automatic access standard under each technical requirement clause. Previously, only a few specific clauses required applicants to demonstrate performance as near as practicable to the automatic standard. This is now required across the board, but subject to practical criteria around plant damage, local power system conditions and the feasibility – both technical and commercial – of meeting the automatic standard.

LR is largely in agreement with the balance struck by the AEMC in the new framework, specifically in retaining the right of a connection applicant to propose a negotiated standard below automatic (with reasons) where meeting the automatic standard is so costly as to be commercially infeasible, and the explicit obligation on NSPs and AEMO to provide reasons for rejecting a negotiated standard. LR agrees that the technical standards for generator connections must continue to evolve in response to ongoing technology developments (in renewable energy generation and battery storage in particular) and to accommodate rapid change in the technology mix within the NEM generation portfolio.

At the same time, LR agrees that any further restrictions on the ability of applicants to propose and receive feedback on negotiated access standards would create a level of *ex ante* regulation of the power system contrary to the principles of maintaining system security at least cost, and of allocating those costs efficiently. As other submissions to this Rule Change have stressed, the relationship between applicants on the one hand and NSPs and AEMO on the other is highly asymmetric. New generator connections are also highly technically constrained already by the nature of existing networks, which historically were not developed to accommodate generation in geographically diverse locations.

2.1. Network connection principles

For consistency with the new framework, the proposed rule includes the deletion of clause 5.1A.2(d) which provides a general right to request a negotiated access standard below the automatic standard where this does not adversely affect system security or quality of supply. Given the new normative requirements of clause 5.3.4A(b1), the existing clause 5.1A.2(d) would no longer accurately reflect the principles for network connection.

LR considers that although the principle as currently worded will not stand in light of the new framework, it is not appropriate to propose wholesale deletion of this clause. This is because the underlying principle is no more than an expression of the agreed principles that *system security should be managed at least cost to consumers* and that *costs should be efficiently allocated between generators and other NEM participants*. As indicated above, these principles both imply that where additional costs must be incurred by an applicant to meet an automatic standard, and yet meeting this higher standard is not actually necessary on system security or quality of supply grounds, the lower standard ought to prevail where appropriate taking into account technical and commercial feasibility, and the circumstances of the local network (which may be read as including the reasonably foreseeable near-term evolution of the power system). This is not merely a concession to connection applicants but a fundamental expression of the NEO.

It is not unreasonably argued by AEMO and other stakeholders that the ongoing evolution of the power system makes it difficult to predict system security in the near to medium term, and this warrants holding generators to higher performance standards as a protective measure even taking into account the underlying principles above. LR considers this is adequately addressed by the new 5.3.4A(b1) requirement to consider "power system conditions at the location of the proposed connection", as in practice "power system conditions" are already read by AEMO and NSPs as including reasonably foreseeable developments. In addition, by the principle of efficient cost-sharing, NSPs themselves should be guided by the rules to favour network-level solutions to future system security challenges where (as is often the case) this can be provided much more efficiently and cost-effectively than through *ex ante* requirements on generators.

LR therefore recommends that in place of deleting clause 5.1A.2(d), this clause be reworded to be consistent with the new negotiating framework. The following wording is suggested:

- A *Registered Participant* or person intending to become a *Registered Participant* may request *connection* of a *facility*, modification of a *connection*, or alteration of *connected plant* at a standard below an *automatic access standard* if the *connection*, modification to the *connection*, or alteration of *connected plant* does not adversely affect
    - *power system security*;
    - the quality of *supply* to other *Network Users*; and
    - any previously registered *performance standard* for the *connected plant*;

  and where connection at the *automatic access standard* would not be appropriate having regard to
    - the need to protect the *plant* from damage;
    - *power system* conditions at the location of the *connection*; and
    - the commercial and technical feasibility of complying with the *automatic access standard*.

2.2. Provision of information by NSP

Based on the above principles, LR supports the parallel submission by Eneflux Pty Ltd that the reciprocal obligations by NSPs should explicitly include the provision of information relevant to assessing whether a negotiated standard is appropriate under the new clause 5.3.4A(b2).

Although a connection applicant is able to request standing system data from AEMO under clause 3.13.3(k) for the purpose of carrying out the power system analysis studies

necessary to assess the performance of a connection, LR's experience with many such connections is that additional supporting information must be requested from the NSP to ensure these studies are as accurate as required for the NSP to be able to conduct meaningful due diligence on the evidence supplied by the applicant. Under both the existing and proposed rules, connection applicants rely on the NSP supplying this additional information voluntarily. This raises a critical procedural risk for the applicant, which the proposed rule heightens by raising the standard of evidence required from connection applicants.

Accordingly, LR recommends that as an improvement to the proposed rule, an additional paragraph 5.3.4A(b3) or equivalent be inserted, stating that:

- for the purpose of preparing reasons and evidence under paragraph (b2), a *Connection Applicant* may request technical data and information from the *Network Service Provider* that, in addition to information provided under rule 5.3.3 and standing data available to the *Connection Applicant* under rule 3.13.3, the *Connection Applicant* considers is reasonably necessary to determine whether a proposed *negotiated access standard* is appropriate; and
- subject to obligations in respect of *confidential information*, a *Network Service Provider* must provide to the *Connection Applicant* either the data or information requested, or else details of the evidence that, in the *Network Service Provider's* reasonable opinion and in the absence of the requested data or information, would adequately demonstrate that the proposed *negotiated access standard* meets the requirements of paragraph (b).

2.3. The cost of analysis

It needs to be acknowledged that both the new negotiation framework, and the increased stringency of most automatic access standards, will substantially increase the 'burden of analysis' for generator connections. Much more substantial analysis effort will be demanded in future from connection applicants, equipment suppliers, NSPs, AEMO, and consultants and advisors to all the above, on tasks including:

- The assessment by connection applicants of prospective connection performance against requirements of system security and quality of supply to establish compliance as near as practicable to the more stringent automatic access standards in the amended Schedule 5.2.
- The provision by connection applicants of the required reasons and evidence for negotiated access standards against the requirements in clause 5.3.4A(b1).
- The provision by AEMO and/or NSPs of reasons for rejecting a negotiated access standard.
- The provision by AEMO and/or NSPs of requests for additional evidence from Connection Applicants where this is considered inadequate under clause 5.3.4A(b2).

These additional tasks required under the new framework do not come without cost, which will ultimately add to the cost of generation in the NEM. It is LR's experience that technical assessment and due diligence under the existing rules can easily occupy over 20 person-months of engineers' time, even in the absence of the regulatory and jurisdictional policy changes that have been seen in the NEM in the past two years. To adhere to the principle of maintaining system security at least cost, such analysis effort should always be directed toward a tangible purpose, and not reduce to multiplying up simulation cases for the sake of it or diverting effort to issues that have no material consequence for the safe and secure operation of the power system.

While LR does not recommend changes to the draft rule specifically to address this issue, it leads to the principle – when assessing specific technical clauses below – that access standards have clear assessment criteria and are justified by appeal to good industry practice and engineers' 'common sense', which should also help ensure that the reasons for defending or rejecting a standard are not too difficult to articulate.

3. Active power capability (S5.2.5.11, S5.2.5.14)

LR does not make any specific recommendations in regard to the approach to active power capability. LR considers that the frequency control requirements in S5.2.5.11 should continue to be interpreted as 'unit capability' requirements only, with actual participation in frequency control ancillary service or special control schemes to be negotiated separate to S5.2.5.11 compliance matters.

4. Remote monitoring and control (S5.2.6.1, S5.2.6.2)

LR generally agrees with the approach taken to remote monitoring and control in the Draft Rule Determination and with the inclusion of remote control capabilities to reflect what already occurs in practice for generating systems in the NEM.

LR recommends a slight revision to this clause to generalise the type of setpoint in subclause (b1)(1), which in the draft rule refers only to the "voltage control" setpoint. It is suggested that this be amended to "voltage, reactive power or power factor setpoint (as appropriate)".

See also the point made in Section 6 below regarding the specification of numerical values for a power factor setpoint.

5. Reactive power capability (S5.2.5.1)

LR agrees with the general approach taken by AEMC in the draft rule for clause S5.2.5.1, specifically the recognition that circumstances exist where the provision of reactive power capability is immaterial to system security or to quality of supply. In general, the appropriate level of reactive power capability will depend on the particular network and location within that network of the generator's connection point, as provided in clause 5.3.4A(b1). This same clause should also ensure that departures from the automatic access standard for reactive power capability for specific connections are adequately defended.

The proposed clause S5.2.5.1 does however reword the minimum access standard in a manner that may be difficult or confusing to interpret. The draft wording "must be capable of supplying or absorbing…an amount of reactive power of at least the amount equal to zero" is unwieldy, and an alternative form of words may better avoid confusion while preserving the intention of the minimum standard, which is to allow the parties (including AEMO) to agree any level of capability down to zero as appropriate for the connection and consistent with power system security, and to clarify that the minimum and automatic standards together define a range of compliance.

As a technical point, LR notes that where a generating system does not offer any level of controllable reactive power, this 'minimum position' is typically not to operate with zero reactive power at the connection point, but rather with zero reactive power at the terminals of generating units. This will lead to a reactive power at the connection point which is nonzero, but nonetheless fixed as a function of the active power production and network voltage at any given point in time.

This observation may be used as the basis for a technically more meaningful formulation of the minimum standard such as the following:

- The *minimum access standard* is a *generating system* operating at any *voltage* at the *connection point* within the limits established under clause S5.1a.4 without a *contingency event*, must supply or absorb continuously at the connection point a certain amount of *reactive power*, which may be either zero or an amount specified and agreed with the *Network Service Provider* and AEMO as a function of *active power generation* and *connection point voltage*.

Once again, the context for this standard is as the absolute minimum required for NEM connections in those cases where NSPs and AEMO agree this is appropriate.

6. Reactive power control (S5.2.5.13)

LR generally accepts the reasoning of the Draft Rule Determination in regard to voltage and reactive power control requirements, but makes the following points:

- It will not be in general practical or desirable for a generating system to automatically switch between voltage, reactive power and power factor control modes in accordance with the requirement in paragraph (2A). LR acknowledges that NSPs may desire this functionality at certain locations for operational purposes, and that a switching function is currently provided by some South Australia wind farms. However, in order for this to be properly considered as part of the connection process, the NSP should be required to advise as part of its clause 5.3.3 response that such a procedure is contemplated, and to provide reasonable assistance to the connection applicant in the formulation and design of the required procedure. Considerations of potential plant damage and of technical and commercial feasibility must continue to apply in accordance with clause 5.3.4A(b1).
- There is no equivalent in the draft rule to the existing S5.2.5.13 automatic access standard requirement for an excitation control system or voltage control system to include “reactive current compensation”. This change may have been made as a consequence of the new provisions for droop adjustment of a voltage setpoint; however it should be recognised that reactive current compensation may perform a function slightly more general than voltage droop. LR suggests that this omission be clarified.
- The new requirements for numerical accuracy of both reactive power and power factor control are specified as “within 0.5% of its setpoint” for consistency with the accuracy requirement for voltage control. However, additional clarification is required as to what this ‘0.5%’ represents, as in the voltage standard this is generally taken to represent 0.005pu, or 0.5% of nominal voltage. LR recommends that ‘0.5%’ in the case of reactive power or power factor control be interpreted as the equivalent reactive power output being accurate to within 0.5% of the nameplate capacity of the generating system.
- LR recommends that for the purpose of power factor control setpoint communication, the numerical value of a ‘power factor’ setpoint may be determined by agreement with the NSP and AEMO to be either:
    - the fixed ratio P/S of active power to apparent power (equivalently, the cosine of the power factor angle) with a separate indication of ‘leading’ (inductive) or ‘lagging’ (capacitive); or
    - the fixed ratio Q/P of reactive power to active power (equivalently, the tangent of the power factor angle).

7. Reactive current response during disturbances (S5.2.5.5)

LR agrees with the parallel submission from Eneflux Pty Ltd regarding the potential adverse consequences of a firm requirement for a specified level of reactive current injection (absorption) for events causing abnormal low (high) system voltages. As that submission sets out, the adverse consequences of mandating current injection (absorption) at a level between 2% and 6% of continuous current rating for every 1% change in voltage may include:

- Heightened shifts in grid voltage phase angles during and on recovery from disturbances, leading to instability of PLL and other controls in generating units.
- Hunting or cycling in and out of the low voltage ride-through (LVRT) or high voltage ride-through (HVRT) control mode of generating units, leading to large oscillations in power and voltage at the connection point.
- Entrapment of the generating unit controls in the LVRT or HVRT mode due to interaction of this mode with the ordinary voltage or reactive power control used for normal operation. Mandating a high current gain in the LVRT or HVRT mode can make it impossible to effectively coordinate these separate control systems for a smooth handover from one to the other.
- Incompatibility with the slowing of PLL and other controls that is deliberately applied in 'fringe of grid' locations to improve robustness to large shifts in grid voltage phase angles.

These consequences are magnified for weak grid sites, and have been observed by LR in its own connection studies for generation projects throughout the NEM.

Strict application of the required reactive current injection capability as a mandated performance standard at specific sites can for the above reasons require the addition of costly auxiliary plant such as synchronous condensors and Statcoms, that would otherwise not be required. In practice, such a strict requirement would operate in a similar way to a 'minimum system strength' access standard of the sort the AEMC has ruled against on cost grounds.

LR recommends that the draft rule S5.2.5.5 be amended as follows:

- All access standard requirements for reactive current injection or absorption should be clarified as a requirement to demonstrate 'unit capability' only, with the actual current injection settings to be negotiated with the NSP and AEMO on a site-specific basis. The actual settings for reactive current injection and absorption on site should be able to be negotiated to a minimum level of zero, without this being deemed non-compliant with the relevant access standard.
- All references to reactive current injection or absorption during a disturbance shall be deemed to apply, by agreement with the NSP and AEMO, at one or other of:
    - The generating system's connection point; or
    - The aggregate of reactive current measured at all generating unit terminals and at the terminals of all items of dynamic reactive power equipment.
- The minimum rise time and settling time requirement for reactive current injection or absorption under the minimum standard, subclause (c)(4), should be removed. In place of this, the negotiating framework will apply to ensure the automatic standard requirements are achieved where appropriate, but that a lower rise time or settling time may be negotiated where this would otherwise involve substantial cost for additional reactive plant without any material improvement in system security.

- The stipulations on the range (85% to 90% and 110% to 112%) for activation thresholds of generating unit LVRT and HVRT modes under subclause (i)(4) should be removed. These stipulations amount to *ex ante* regulations that may not be appropriate for all conceivable connection locations and local power system conditions.

Notwithstanding the above, the following additional changes are recommended to ensure internal consistency of the S5.2.5.5 requirements:

- Subclause (b)(3)(iii) should insert after "clearance of the fault" the words "and recovery of voltage to between 90% and 110% of normal voltage". The active power recovery would otherwise be limited by a requirement to inject or absorb reactive current.
- Subclause (i)(4) should replace "activation of the reactive current contribution" with "activation of any distinct mode of operation for abnormal voltage". Some generating plants (both synchronous and non-synchronous) provide the reactive current contribution as an extension of normal operation, and there is no actual threshold setting applicable.
- Subclause (i)(5) should insert "after the occurrence of a fault" the words "causing a low voltage event". It is understood this clause is only intended to apply to low voltage events.

8. Continuous uninterrupted operation (S5.2.5.3, S5.2.5.4, S5.2.5.5, S5.2.5.7)

LR generally supports the reasoning behind the more stringent definition of 'continuous uninterrupted operation' to account for prescribed active and reactive current response during the application of faults. LR however has serious concerns regarding the boundaries of compliance under the draft rule clauses, and with the feasibility of assessing compliance with certain clauses.

8.1. Minimum standards for voltage disturbances under S5.2.5.4

The draft rule proposes new minimum access standards for the voltage disturbances which all generating systems must withstand under clause S5.2.5.4. This includes overvoltage disturbances in excess of 110% of normal voltage for durations up to 0.9 seconds, and undervoltage disturbances below 90% of normal voltage for durations up to 5 seconds.

The justification given for more stringent minimum standards is to ensure that generators are able to withstand more severe voltage disturbances that may occur in future as a consequence of likely reductions in system strength (fault level) across the NEM, and to reduce the chance of cascading failures as disturbances are prolonged or worsened due to generators disconnecting.

LR does not accept the reasoning that the situation for voltage disturbances is entirely different from that regarding reactive power capability. The appropriateness of a 'zero' minimum standard for reactive capability lies in the fact that there are certain network locations where the provision of variable reactive power is immaterial due to local system conditions – specifically, the relative insensitivity of voltage to changes in reactive power flow. Similarly, there are network locations (for example, major urban areas or locations near large hydropower facilities) where large voltage excursions due to low system strength are highly unlikely and will remain so for the foreseeable future.

In addition, there is a substantial degree of arbitrariness in the proposed minimum voltage standards (why 80% for 5 seconds, and not 2 seconds or 10 seconds?). The risk again arises that the minimum standard becomes an *ex ante* regulation that cannot

adapt to local system conditions at stakeholders' discretion, and that acts as a restraint on technologies that do not meet the particular level mandated. (LR is familiar with at least one major generator supplier and active NEM participant whose plant is not designed to operate at 80% terminal voltage for 5 seconds and likely could not be redesigned to do so without incurring substantial additional cost.)

In short, LR does not believe a convincing argument has been made that imposing a more stringent *minimum* standard for voltage excursions leads to a materially lower risk of cascading failures, relative to the current approach of aligning the minimum standard with the system standard for normal operation but requiring all generators to target performance as near as practicable to a more stringent *automatic* standard.

As to current practice, LR's recent experience with NEM generator connections is that:

- virtually none have proposed to connect at the current S5.2.5.4 minimum standard;
- most or all have been above at least the proposed S5.2.5.4 minimum standard for overvoltage; but
- many are not above the proposed S5.2.5.4 minimum standard for undervoltage.

At the same time, a sizeable percentage are able to demonstrate compliance with the current S5.2.5.4 automatic standard for both overvoltage and undervoltage, and many of these would be likely to comply with the proposed S5.2.5.4 automatic standard.

LR recognises that the proposed automatic and minimum standards for overvoltage have been extensively scrutinised and adapted during the consultation process leading up to the draft determination. The same level of scrutiny is not evident for the undervoltage standards, which is perhaps understandable since the automatic standard has not changed substantially from that in the current rules, and ultimately it is the automatic standard that sets the benchmark under the new negotiating framework.

LR therefore considers that on balance, the proposed S5.2.5.4 overvoltage standards are appropriate and the minimum standard, while above the current minimum, is not so onerous as to pose a barrier to entry for any specific technology or supplier working in accordance with current industry good practice. LR however considers that the new S5.2.5.4 minimum standard for undervoltage is set at too onerous a level and poses a barrier to entry to at least some technologies. In LR's view a less onerous standard (for example, 70% to 80% for 1 second and 80% to 90% for 2 seconds) would likely address concerns about restraining particular technologies while still guaranteeing a higher degree of resilience as a floor level. (It would, for example, most likely have functioned no worse than the proposed standard in regard to the grid-separation events recently observed in South Australia.)

LR considers that the new S5.2.5.4 automatic access standards in conjunction with the new negotiating framework should fulfil the desired function of guiding industry practice toward greater resilience to large voltage disturbances. Given the review process also proposed in the draft rule, there will be opportunities in the future to strengthen the automatic and minimum standards further where appropriate.

8.2. Multiple disturbances

LR agrees with the need to put in place access standards regarding the ability of generators to operate through a sequence of successive disturbances and not just isolated faults. For most generator technologies, the capability to ride through single disturbances also implies some capability to withstand multiple disturbances close together in time, and the main technical challenge is in quantifying this multiple disturbance capability.

LR's comments here arise from our position as a consultancy with many years of experience assessing the performance of generator connections, including the establishment of compliance boundaries and the formulation of test scenarios that provide a positive indication of compliance or non-compliance at specified levels of performance.

From this perspective LR has major concerns with the proposed access standards for withstanding multiple disturbances, both with the degree of complexity (which imposes a particularly high time and cost burden for analysis effort by connection applicants), and that in our view it is difficult to impossible to establish from these standards any practical compliance boundary or to establish from study evidence whether there is a substantive risk of non-compliance. For these reasons LR does not see the proposed standards as consistent with the objectives of *regulatory certainty* or *maintaining system security at least cost*.

For most technical requirements in the rules it is possible either to enumerate and test all credible study scenarios to establish compliance, or else to articulate a relatively small set of 'most onerous scenarios' or 'boundary cases', compliance for which is reasonably expected on engineering 'common sense' grounds to imply compliance for the potentially infinite set of scenarios not actually studied. The proposed multiple disturbance standards in our view fail these criteria:

- The set of all credible study scenarios for 'qualifying' multiple disturbances is so large that to exhaustively test all would be impractical.
- There is no readily identifiable subset of 'most onerous' scenarios where a positive result would reasonably imply positive results for all 'in between' cases. In more technical terms, this is because there are so many independent dimensions to the specified standard that the study space is not 'compact' in a topological sense.

The situation posed is akin to that considered by Wolpert and Macready's celebrated paper "No Free Lunch theorems for search" (Santa Fe Institute, Technical Report SFI-TR-95-02-010, 1995). To seek out potential non-compliant cases, when there is no obvious structure to the space of possible alternatives, there is no feasible alternative to picking valid scenarios entirely at random and hoping the sample size is large enough to capture the non-compliances. Yet the possibility always remains that there are non-compliant cases among those not sampled, and it is unclear how to 'structure' the sampling in a way that these can be identified with greater probability.

The practical effect of proposing such complex standards is to transfer system security risk from system operators to individual generators and equipment suppliers who are not best placed to manage this risk. Generators, having attempted to demonstrate compliance through a vast but necessarily non-exhaustive set of studies, will operate henceforth in an environment of uncertainty in which a potential major system event can be attributed to their non-compliance with clause S5.2.5.5 despite their best efforts, and irrespective of what other system factors beyond the generator's control may have contributed to the event.

Importantly, no such transfer of risk would have been necessary to exclude the specific class of protection settings that contributed to the South Australia black system event in 2016, which involved 6 faults of varying severity within a five-minute period. AEMO confirmed in its final incident report in March 2017 that "Changes made to turbine control settings shortly after the event has [sic] removed the risk of recurrence given the same number of disturbances." The practical import of this is that the specific sequence of disturbances of the type leading up to the South Australia event, appropriately translated to different locations in the network, could furnish a reasonable minimum standard for

multiple disturbances that is both relatively straightforward to test and able to be met by most or all current generator technologies.

At the other end of the scale, some types of generators can withstand a very large number of disturbances in a short time period and/or withstand disturbances with arbitrarily short durations between events. This means there is in practice considerable latitude in formulating an automatic access standard *provided* it is within a framework where applicants may readily propose a lower negotiated standard without requiring a large and costly effort to provide the necessary supporting evidence. The existing provisions for the determination of 'plant standards' in clause 5.3.3 would likely assist in developing such a framework.

As long as the negotiating framework can accommodate the practical differences between specific technologies, the automatic standard can be substantially simplified (for example, to 6 deep faults and 9 shallow faults of a prescribed type in a five-minute period, without further qualifications) on the understanding that most applicants will put forward a negotiated standard, but the specific negotiated standard may be technology specific.

Another option, not so far considered, is to not prescribe any automatic standard for multiple disturbances, and instead rely on the minimum standard (and/or declared plant standards) to ensure a level of capability is provided. LR considers that the level of risk here may be practically acceptable, given that:

- With all generators required to meet a minimum standard involving multiple disturbances, 'loose' protection settings of the type that contributed to the South Australia black system event are already prohibited. There is a strong argument, based on the evidence provided to the AEMC to date, that ride-through of multiple disturbances is a 'threshold' phenomenon: once it is established for a smaller number of disturbances, it will work in practice for a larger number without significant additional effort.
- Clause S5.2.5.8 "Protection of generating systems from power system disturbances" already requires the documentation of all generator protection systems including the conditions for which a generating unit or system 'must trip' or 'must not trip'. There is no automatic access standard for this clause, which means the relevant protection conditions are always subject to negotiation with the NSP and AEMO and subject to the 'system security impact' test of clause 5.3.4A(b).
- The likelihood of an event leading to a more onerous sequence of disturbances than those leading up to the (already rare) September 2016 event in South Australia – and where the S5.2.5.5 performance of generators is the specific decisive factor in whether customer supplies are lost – has not been established. Notwithstanding the very high costs of such events (and given the point above that the 2016 event would have been avoided by simpler standards than currently proposed), one may legitimately question whether the cost of the additional study effort required in proving the proposed performance standard for every new generator connection in the NEM, and of additional mitigating measures by equipment suppliers, is greater than the expected loss due to such an event occurring. And should such an unfortunate event occur, there may be less costly mitigating strategies available that better protect customer supplies.

LR accordingly recommends a simplified approach to the multiple disturbance access standards as follows:

- The minimum access standard is that a generating system and its generating units must be capable of continuous uninterrupted operation for a sequence of

three hard two-phase-to-ground faults and three shallow faults within a five minute period, with fault timings and durations matching the sequence in the lead up to the September 2016 event in South Australia, and where the faults are applied at the closest point in the transmission network to the generating system connection point.

- There is either no automatic access standard, or the automatic access standard requires continuous uninterrupted operation for a sequence of six hard two-phase-to-ground faults and nine shallow faults within a five-minute period, where the hard and shallow faults may occur in any order and at arbitrary times within this period, and are applied at the closest point in the transmission network to the generating system connection point. (This would lead to a standard similar to that adopted by ESCOSA in 2017.)
- Clause 5.3.3(b3) applies where the Reliability Panel has adopted a plant standard in regard to withstanding multiple disturbances.

8.3. Partial load rejection

LR agrees with the position in the Draft Rule Determination that in light of increasing penetration of non-synchronous generation in the NEM, it is appropriate that the requirement for partial load rejection capability be extended to this category of plant. LR also agrees with views expressed by stakeholders that this requirement is within the technical capability of most or all current non-synchronous plant technology, or can be added at modest cost.

LR also notes the clarifying statement in the Draft Rule Determination that where a partial load rejection event causes voltage or frequency to exceed other relevant performance standards for the generating system, those other performance standards take priority and the generating system is permitted to disconnect.

LR has some concern however about the practicality of testing the partial load rejection capability of a non-synchronous generator in pre-connection studies. As non-synchronous generators are in general not designed to operate islanded with a passive load, load rejection can in practice only be studied where the generating system operates in parallel with a 'slack' synchronous generator or with a full NEM system model. The test would then effectively establish the joint capability of the generating system and the balance of generation. LR suggests it be clarified that where such study evidence is provided and demonstrates successful ride-through when total system load is reduced by the required amount, this will be taken as evidence of compliance.

8.4. Continuous uninterrupted operation: wording of definition

A minor change is recommended to the wording of the new definition of 'continuous uninterrupted operation' in the Glossary. LR recommends that the wording of item (d) be adjusted to insert the word "operating" before "so as not to exacerbate or prolong".

9. System strength

LR agrees with the approach taken in the Draft Rule Determination to not proceed with any new access standards in regard to 'system strength'. Such standards would be likely to substantially add to the costs of many new generator connections, while not making a readily quantifiable contribution to overall power system security.

10. Transitional arrangements

In regard to the status of existing projects that have negotiated or are negotiating connections under the existing technical requirements, LR considers that adequate

provision must be made to avoid substantial delays and risks where performance standards negotiations are otherwise well advanced.

Transitional arrangements for the new rules must consider a practical context where currently in the NEM:

- There are a very high number of generation projects currently seeking connection at various stages of development;
- These projects are proceeding relatively slowly owing to a shortage of skilled engineering resources in the Australian market and to other regulatory changes stemming from necessary due diligence requirements as the NEM transitions to new generation sources; and consequently
- Requiring existing projects to seek connection under the new requirements will place extremely heavy demands not only on project proponents, NSPs and AEMO but also on a limited number of technical consultants and advisors who will have already undertaken substantial analysis work in regard to these projects.

While LR leaves it to others to make specific recommendations on transition timescales and strategies, LR believes it is important to take account of the market context in formulating the final transitional arrangements.

11. Conclusion

LR has considered AEMC's Draft Rule Determination on technical requirements for generators and has made specific recommendations above in regard to a number of proposed clauses.

On the whole, LR supports AEMC's approach to the draft rule and the need for the technical requirements of the power system to evolve in accordance with the generation mix and new demands on distributed network resources. Some specific concerns and recommended changes have been raised, particularly in regard to the negotiating framework and generator response to voltage disturbances and faults.

LR hopes that this submission proves of value to the rule change process and will help support improvements to the final rules.