AEMO SSRM, SSISG & PSSG - SMA Response to Questions

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Table of Contents

Abbreviations & Definitions

Abbreviations

Term	Definition
AEMO	Australian Energy Market operator
AG	Aktiengesellschaft (translation: public limited company)
AU	Australia
DMAT	Dynamic Model Acceptance Test
DNSP	Distribution Network Service Provider
EMT	Electro-magnetic Transients
GW	Gigawatt
IBR	Inverter Based Resources
kV	Kilovolt
NEM	National Electricity Market
NEO	National Electricity Objective
NSP	Network Service Provider
POC	Point of Connection
R&D	Research and Development
SMA	SMA Solar Technology AG or SMA Australia Pty Ltd
SRC	Short Circuit Ratio
WSCR	Weighted Short Circuit Ratio

Definitions

Term	Definition

1 Response to consultation questions

1.1 Question 1

1.1.1 - 3.1.2 Dot point 4 – protection system operation.

Over the last 20 years, substantial role out of protection grade communications have enabled widespread use of "current comparison" style protection, which is much less dependent on fault level than traditional impedance and over current protection.

As the cost of replacing remaining legacy protection systems will often be much less than other fault level increase options, it is proposed that modernisation of protection systems to support a lower fault level power system dominated by IBRs has potential to materially reduce the cost of transitioning the NEM.

1.2 Question 2

1.2.1 - 3.1.2 Dot point 2

It is suggested that the approach of using high level metrics as opposed to technology specific plant models is the most objective approach to long term modelling of "system strength" metrics. This is because different technologies will have a wide range of characteristics and it is quite likely that a plant connecting 5-10 years into the future will have very different characteristics to a plant being deployed today. For example, it is highly likely that grid forming technologies will be mature and in serial deployment in 5 years' time.

In terms of the metric applied, SMA's experience is that the most onerous conditions on control system stability for grid following inverters is the voltage angle jump on fault inception and sensitivity of voltage angle at the POC to angle of current injection from the power station. For this reason, it is suggested that a metric around these phenomena is likely to be more effective than traditional metrics such as weighted short circuit ratio (WSCR)

1.3 Questions 4, 5 and 6

The questions focus on operation of protection systems under reduced fault level, whereas it is entirely plausible that fault level at the periphery of the transmission system may well be a limiting factor, in at least some instances, under high levels of penetration of inverter connected storage in conjunction with additional inverter connected generation and energy intensive load.

Referring to the response to question 1, it is quite possible that the issue of robustness of protection can be addressed quickly and efficiently by means of migrating to current comparison style protection as opposed to traditional impedance and over current protection.

As a first step, it may well be efficient to mandate migration to current comparison protection for voltages above, for example, 66kV, and perhaps perform some analysis to confirm whether sub 66kV impedance protection can still be adequately graded under reduced fault level conditions.

1.4 Questions 7, 8

It is considered that equipment associated with remediation of unacceptable transient voltage events is likely to be high relative to the cost of the equipment being deployed. For this reason, it is suggested that fundamental power system analysis be relied upon in determining requirements, so maximising the potential for economically efficient outcomes.

It is also noted that in several areas of the NEM, wide area transfer trip schemes are used to manage post contingent voltage profile and stability. To minimise the risk of monopoly network service providers favouring more expensive, capital-intensive solutions such as auxiliary reactive plant or new transmission lines, a mechanism should be applied to ensure that Network Service Providers must investigate transfer trips schemes in a timely and proactive manner upon request.

1.5 Questions 9, 10

Transition of the NEM to host high levels of IBR could conceivably widen the range of conditions experienced by embedded generation, and indeed inverter connected load. Experience with current following IBR is that the key survivability / stability conditions relate to the ability of current source inverters to push or pull the voltage angle as they try to follow the external grid angle. This suggests metrics around sensitivity of infault voltage angle at key busses to angle of current injection from surrounding busses could be effective in determining the potential for fast voltage angle instability.

As Distribution Network Service Providers (DNSPs) have best visibility of embedded generation, it would appear pragmatic for responsibility for assessing and managing these issues should also lie with the DNSPs.

Specific to Question 10, it is noted that a wide range of embedded connected generation, and indeed large inverter-controlled load is likely to be relevant to these considerations.

1.6 Question 11

Use of fault level as a measure of the vulnerability of the system to weak grid effects such as voltage angle instability is likely to be inaccurate due to the poor alignment between simplistic "fault level" metrics and the complex interaction between power systems elements that cause vulnerability to such stability effects. This should be avoided as it is likely to result in inefficient market outcomes such as over investment in auxiliary plant or unnecessary curtailment of low marginal cost generation.

Focus should initially be placed on arriving on more appropriate metrics such as those outlined in Questions 9 and 10 above. In the longer term, efforts should be deployed to develop advanced operational tools such as a real time EMT system analyser, noting that substantial investment would be required to arrive at an effective tool.

1.7 Question 12

The approach proposed appears pragmatic, and substantially more objective than measures associated with fault level, noting that the actual metrics should be given careful consideration in the implementation phase.

The terminology around pre-contingent and post-contingent conditions could be clarified to refer to voltage phase angle change on fault inception and fault clearance, presuming this is what is intended. A degree of detail as to how this voltage angle is calculated or measured would be necessary, given the mathematical challenges around determining the angle of a distorted wave form in time frames less than 2-3 cycles.

In addition to a maximum voltage angle shift, consideration should be given to metrics around sensitivity of voltage angle to injection of current in the d-axis, as a more representative representation of the vulnerability of the system to voltage angle instability from grid following inverters.

The question of wave form distortion in the cycles immediately following fault inception or clearance needs careful consideration, as non-fundamental components may indeed be helpful in restraining voltage angle, or indeed an un-avoidable artifact of optimised grid forming inverter design.

1.8 Questions 12,14, and 15

No considerations are offered here, as we have not assessed this proposal in detail. Refer comments in previous sections around need to arrive at metrics that correspond best to the conditions that can result in voltage angle instability.

1.9 Questions 16 to 20

In addition to the factors under consideration, it is suggested that AEMO also consider the possibility of:

- Retro-application of grid forming algorithms to existing IBR fleet.
- Retuning of IBRs which require, for example, greater than 1.6SCR to maintain stable operation

1.10 Questions 20 to 29

- No considerations are offered here, as we have not assessed this proposal in detail.

1.11 Question 30

In addition to the factors under consideration, it is suggested that AEMO consider the possibility of:

- Retrospective application of grid forming algorithms to existing IBR fleet.
- Retuning of IBRs which require, for example, greater than 1.6SCR to maintain operation

1.12 Question 31,32

Provided the SMIB tests are extensive, it should be possible to gain a high degree of certainty around the performance of the plant in advance of wide area studies.

In addition to SMIB test currently in use in connection studies and Dynamic Model Acceptance Test (DMAT), it is suggested that:

Consideration be given to expanding the range of faults for which the network impedance changes after fault clearance and;

Use of play back techniques to test for robustness to infault voltage angle slew and a range of post fault clearance voltage magnitude oscillations typical of fast voltage angle instability modes.

1.13 Questions 33, 34, and 35

It is considered that robust SMIB tuning as outlined in the proceeding section is key to achieving robust and efficient outcomes in the "Full Assessment". If this is done well, then the sensitivity of eventual outcomes to the methodology is minimised.

In recent times, it appears that AEMO and the NSPs have been very much constrained in their ability to process full assessments due to industry wide skill shortages and the often iterative nature of achieving acceptable outcomes from proponent applied tuning.

For this reason, focus should be applied to achieving a high degree of automation in processing of full assessments, including provision of results for plant point of connection voltage, power, and reactive power profiles. This will allow the connecting parties to improved tuning or rectify anomalies largely independent of the NSPs and AEMO

1.14 Question 36-38

No considerations are offered here, as we have not assessed this proposal in detail.

1.15 Question 37

Care should be taken to ensure that in pursuing this objective, Network Services Providers are not given the ability to recover inefficient costs from subsequently connecting parties based on rules or methodologies that do not align with the actual needs of the system or the connecting plant. It is noted that the National Electricity Objective (NEO) is based on efficiency, rather than any concept of fairness or avoiding "free riding". Such enabling of Network Service Providers to recover sunk costs from subsequently connecting parties would appear in-efficient and hence counter to the NEO.

1.16 Question 39, 40

No considerations are offered here, as we have not assessed this proposal in detail.

1.17 Question 41, 42

The AFL approach is considered highly inaccurate and likely to result in incorrect conclusions if used for long term planning. Refer considerations in previous sections.

1.18 Question 43, 44

The access standard of SCR 3.0 is lax and could result in plant connecting that inefficiently consumes “system strength”, either reducing the ultimate hosting capability of the network or driving up the cost of utilising the full hosting capability of the network.

For this reason, all plant should be rigorously assessed for operation at SCR 3.0 as a minimum, with a comprehensive range of tests including those outline in response to Questions 31 and 32 above.

1.19 Question 45, 46, and 47

It is considered that it would be of merit to more precisely define and include aspects of system performance that are currently referred to broadly as system strength.

Practical performance standards may relate to:

- voltage angle jump on fault inception and clearance
- in fault voltage angle rate of change
- sensitivity of voltage angle to incremental Id injection, including in faults.