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SMA RESPONSE TO AEMC RULE CHANGE ERC0222

SMA has undertaken review of AEMC'S National Electricity Rules (NER, the Rules) change as proposed by AEMO and published on 19 September 2017 (reference no. ERC0222) as well as the supplementary material published on 24 October 2017. This letter contains SMA's response on the proposed NER changes.

In summary SMA is of an opinion that the proposed changes may further hinder already difficult connection process to the National Electricity Market (NEM) for inverter connected generation. SMA's comments as well as detailed response to changes proposed are provided below.

Main difficulties emerging from the proposal

The following are the most challenging changes proposed in relation to capabilities of inverters:

- **High voltage ride through capability proposed under S5.1a.4** – to SMA's knowledge no 1500Vdc inverters currently available on the market from any manufacturer would be able to comply with the high voltage withstand capability as proposed, due to the limitations of the components used.
- **Short Circuit Ratio (SCR) requirements proposed under S5.2.5.15** – the proposed SCR of 3 at the connection point could result in SCR below 2 at inverter terminals considering common impedances of inverter based generating systems. Stable operation of generating systems is possible but cannot be guaranteed below that value.

Detailed comments and recommendations on the above and other clauses are provided in Appendix A.

Other comments

Reduction of ability to negotiate

The main tendency noted in the proposal is a shift of majority of minimum standards towards the automatic level that would reduce the scope for negotiation. As an equipment manufacturer SMA is not directly involved in the performance standards negotiations, however from the interactions with our customers and connecting parties SMA notes the already difficult position of Connection Applicants (Applicants) in the negotiation process over the last year. We have rarely observed AEMO and connecting Network Service Providers (NSPs) allowing or accepting negotiated standards. The reduction in scope for negotiating will

further weaken the Applicants position in the process. Providing a clear reason for rejecting the negotiated proposal would help the Applicants in assessing what is required and amending their proposal.

Feedback from connecting parties

New Rules increase the requirement for the Applicants to provide justification of their design and selected system parameters (e.g. under clause 5.3.4A) whilst there are no requirements for NSPs and AEMO to provide justification of their decisions, for example when rejecting proposed negotiated standards. SMA considers it would aid the negotiation process in general if the NER clause 5.3.4A (that requires the connecting NSPs as well as AEMO to negotiate with each proponent individually and in good faith) required the connecting parties to provide formal feedback to the Applicants on their negotiated proposals, related to power system security, stability or reliability and quality of supply.

Risk of retrospective application of NER

SMA considers retrospective application of NER as proposed a great risk to current projects' financial feasibility (11.X.1.1 Rule proposal). It is unclear how the applicants can design their system and obtain funding for the project when potentially dealing with two different sets of requirements. When the Rule changes are likely to be approved the projects that were in advanced phase as of 11 August 2017 are expected to be preparing for commissioning. Projects are likely to face extreme difficulties if forced to redesign their system on short notice, directly prior to commissioning, when the Rule changes are approved.

NER becomes technology specific

Changes proposed acknowledge the limitations of synchronous generation and allow it to propose lesser standards for many clauses (e.g. S5.2.5.3). The same provision is not made for asynchronous generation which is required to perform to the same and/or higher standard than synchronous generation for all of the clauses. The distinction is made only when describing the voltage control system under clause S5.2.5.13 due to the obvious lack of excitation system in inverter based generating systems. In some instances negotiated standard for asynchronous generation is not defined at all (e.g. S5.2.5.3).
The new Rules appear to favour synchronous technology over inverter connected generation and will effectively no longer be technology neutral. SMA understands the potential need to establish different standards for different technology types however the limitations of each technology should be acknowledged equally and all Applicants should have equal ability to negotiate.

Additional ambiguity

The proposal introduces additional ambiguous terms such as 'measurable', 'sufficient' or 'reasonable'. This opens the Rules up for interpretation and doesn't support the Applicant in establishing the requirements of the design. Applicants would not be able to clearly define and propose the design requirements until the negotiation process is finalised. Additionally automatic levels for some access standards (e.g. S5.2.5.11) are worded in a way that would make it difficult to establish and test the performance of the system. It should be expected that the negotiation process would be unnecessarily prolonged and complex as the connecting parties establish and agree on the interpretation of unclear sections of the Rules. SMA sug-

gests defining guidelines and processes on how the ambiguous values are to be established, providing additional clarification within the Rules or avoiding ambiguity where possible.

Setting lower system standards for network owners and operator

The responsibility to maintain certain aspects of the network such as system strength and voltage is mainly applied to the connecting generation. The network in the current form has been developed to address the needs of all participants – generators and load customers equally. Network support equipment (such as Static Var Compensators or synchronous condensers) have been installed to control and maintain the voltage and frequency within required boundaries, allowing secure operation of all generation (mainly synchronous) and protecting all connected equipment. Similarly to the network itself the Rules were developed as a two way agreement between network users and network owners and operator – the standards were set to the levels achievable by the generation and the owners and operator agreed to maintain them. Today the needs of the network are not addressed as fast as required (potentially due to complex Regulatory Investment Test process) and such network support assets are retired (for example synchronous condensers in Victoria[1]). In the similar manner the new Rules are setting low system standards (for maintenance and operation) shifting the responsibility to maintain power system security to connecting generation (e.g. low SCR requirement in S5.2.5.15, ability to withstand 15 disturbances in short timeframe specified under S.5.2.5.5, higher voltage ride though capability specified under S5.1a.4). The responsibility for maintaining good network standards should be shared.

Shortage of generating capacity

One of the underlying causes of recent system events including South Australian blackout and load shedding was the lack of available generation. To SMA's knowledge the majority of connection applications currently being processed are based or closely interlinked with inverter technologies, and all committed generation projects are utilising inverter technology (see Appendix B for extract from AEMO's presentation at the Solar Integration Workshop, Berlin October 2017). The proposed changes are likely to hinder the connection process for such applications resulting in even lower generation availability in the NEM. It should also be noted that the modern inverters can provide many functions to support the grid (such as reactive power at zero active power output, active power change in response to frequency deviation) and new abilities are constantly developed.

[1] Short Circuit Levels for the Victorian Electricity Transmission Network, Committed Projects and Closures, AEMO June 2016. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/VAPR/2016/Report-ShortCircuit-Levels-201516-to-201920_Final.pdf

APPENDIX A Detailed response to changes proposed

NER Clause	SMA comments	Suggestions/Questions
5.3.4A	Proposal reduces the scope for negotiation between automatic and minimum standard decreasing Applicant's ability to negotiate with the connecting NSP. Additional ambiguity introduced by un-defined terms such as 'practicable', e.g. in section (b)(1) 'A *negotiated access standard* must be as close as practicable to the automatic standard (...)'. Requirements for information to be provided by the Applicant are increased while no requirements are present for information to be fed back from NSPs or AEMO.	Define what is considered 'practicable' in all situations when the term is used and how such practicability will be assessed. Introduce a requirement that the NSP and/or AEMO must provide a clear reason for rejecting a proposed negotiated standard that relates to power system stability, security or reliability and quality of supply. Ensure that it is clarified that when the NSP is required to provide a different negotiated standard to the one proposed it is not necessarily to be equal to the automatic level.
S5.1a.4	It is not clear how the new over-voltage capability was established and how would the changes to the required timeframes support the system better. A general statement that the new capability would support the resilience of the power system is provided. More details on the changes proposed would be advantageous. The high voltage capability proposed may be one of the highest voltage requirements specified in international grid codes. The grid codes usually require good capability for low voltages. For example the United Kingdom's Grid Code doesn't specify similar high voltage ride through capability above 110% of nominal voltage, focussing on low voltage ride through requirements[2]. Based on SMA's knowledge of the inverter industry none of the currently available inverters will be able to comply with the increased over-voltage requirements as proposed, due to the limitations of the electronic components used, mainly transistors. New inverters would have to be designed to be capable of withstanding higher voltages. Time frames for such development are tween 2-3 years. Additionally a significantly more expensive transistors would have to be used – up to 50% transistor price increase. With transistors making up about 30% of the total inverter price	Provide details on how the new timeframes for over-voltage capability were established and if the capability of actual equipment currently available on the market was taken into account during this process. Provide examples of how the new capability will support the system better and under what conditions high long lasting voltages could be expected. Compare the proposed requirements with international standards. Consult with the industry or consider actual capability of existing power electronics equipment in establishing the new over-voltage requirements.

[2] Connection Conditions, Grid Code. Available at: http://www2.nationalgrid.com/UK/Industry-information/Electricity-codes/Grid-code/The-Grid-code/

	this would mean a substantial price increase of the equipment. See APPENDIX C for comparison of standard proposed and capability of SMA's latest generation of inverters defined at inverter terminals. The standard specifies the voltage at the connection point – considering the voltage change between the connection point and inverter terminals the inverters may not be able to provide the capability as proposed. Defining the overvoltage requirements at inverter terminals would aid in establishing the capability that can be achieved.	
S5.2.5.1	The minimum standard requires the S5.2.5.13 to be defined at automatic level preventing the Applicants from negotiating each standard separately.	Each level should be defined independently to allow Applicants to negotiate all standards. The current Rules allow negotiation of all standards. This should be maintained to avoid reducing Applicant's ability to negotiate.
S5.2.5.3	Proposal removes minimum standard for asynchronous plant. The minimum standard is only defined for synchronous plant. It is unclear how would the negotiated standard be achieved for asynchronous generation without the minimum standard being defined. The definition of negotiated standard is significantly reduced.	Define minimum standard for all generators regardless of technology. Different minimum standard for asynchronous generation can be proposed however should exist. If Rules are to become technology specific consider acknowledging the limitations of the asynchronous as well as synchronous technologies.
S5.2.5.4	Changes related to the proposed S5.1a.4 described above. Minimum standard is almost identical to the automatic. Negotiated standard introduces ambiguity by referring to a limit that AEMO and the NSP would consider 'reasonable under the circumstances'. Current AEMO's interpretation of *continuous uninterrupted operation* (noted during recent connection projects SMA was involved in) for the purpose of this clause is that the system must maintain unchanged active power output while the voltage is reducing at all active power levels including maximum. This definition is currently applied to voltages in the 90% to 110% range only. If this is to be extended to the 70% voltage level, significant oversizing of the plant would be required. For example a 100MW project utilizing 2.5MVA inverters, wishing to provide automatic level of reactive support (0.395 x maximum active power level) would require 62 inverters to meet this requirement at 70% voltage as opposed to 43 inverters to meet this requirement at 100% voltage. Increase of about 45% in system size would be necessary. See Appendix D for capability charts of latest generation of SMA inverters at different voltag-	Same suggestions as specified for changes related to S5.1a.4 above. Remove ambiguity or define what is considered 'reasonable', how should it be assessed and under what 'circumstances'. Clearly state the active power requirements that satisfy the definition of *continuous uninterrupted operation* for the purpose of this clause ensuring that unchanged active power is not requested for voltages below 90%.

	es. SMA notes the additional clarification added to the definition of *continuous uninterrupted operation* (in the supplement published on 24th of October) that in intended to remove the above uncertainty from this clause. The current definition doesn't clearly state that the unchanged active power level is required for voltages between 90% and 110% of nominal voltage. The proposed new definition doesn't full clarify that similar will not be required for lower voltage levels.	
S5.2.5.5	AEMO and connecting NSPs typically require software simulation studies to prove performance of the generating system at selected level for each access standard. This is also the case for S5.2.5.5 performance where a number of different types of disturbances must be simulated. Whilst SMA is confident the new requirement to withstand 15 disturbances within 5 minute period would not pose significant challenges to inverter connected generation it may be difficult to simulate such scenario with the currently available simulation packages that the connecting parties accept. Additionally the new wording of the automatic access standard implies that the network operator only has to ensure the resilience of the system at a level that guarantees less than 15 disturbances within a 5 minute timeframe. Similarly to the new S5.2.5.15 requirement, this is setting operational standards at a very low level. SMA advises the current contribution from inverters during faults to be moderate. High current contributions may lead to stability concerns. In general SMA suggests carefully selecting parameters for reactive current injection, especially in weak grid scenarios, and conducting EMT type studies for when the injection factors are set higher than usual (2% injection for each 1% voltage change). Additional reactive equipment may be required to comply with new reactive current injection requirements, leading to significant project cost increase. Negotiated access standard refers to a level specified in the automatic standard. It also refers to a reduction of generation in the system that AEMO and the NSP must agree on. It is unclear how this agreement would be reached and under what conditions (e.g. simulated maximum load conditions, analysis of actual operational data). Negotiated standard introduces ambiguity by referring to a limit that AEMO and the NSP would consider 'reasonable under the circumstances'. The subclause (i)(i) specifies reactive current 'may' be limited to the maximum continuous current for asynchronous generating system without details of conditions under which this would be required. Additional general requirement (j) allows the NSP to specify any level of reactive current contribution and any time for active power recovery undermining the requirements specified in the automatic standard.	SMA would like to understand if the new requirement to withstand 15 disturbances in 5 minutes would have to be simulated. If yes it would be beneficial if evidence of such studies being successfully conducted with the current NEM snapshots and with the currently accepted simulation software is provided. Clarification on the nature of the disturbances to be simulated would also be beneficial (e.g. depth, duration, distribution across the 5 minute timeframe). Consider the potential additional cost of reactive equipment necessary to comply with the increased reactive current injection requirements. Consider clarifying under which conditions the reactive current contribution is to be limited. Clarify what is understood by 'active/reactive power consumption'. Remove ambiguity or define what is considered 'reasonable' and how should it be assessed. If the reactive current contribution and active power recovery requirements are to be opened to NSP's free interpretation it should be specified under which conditions this is permissible. In general this kind of Rule wording should be avoided as it undermines the idea of specifying the automatic requirements in the first place.

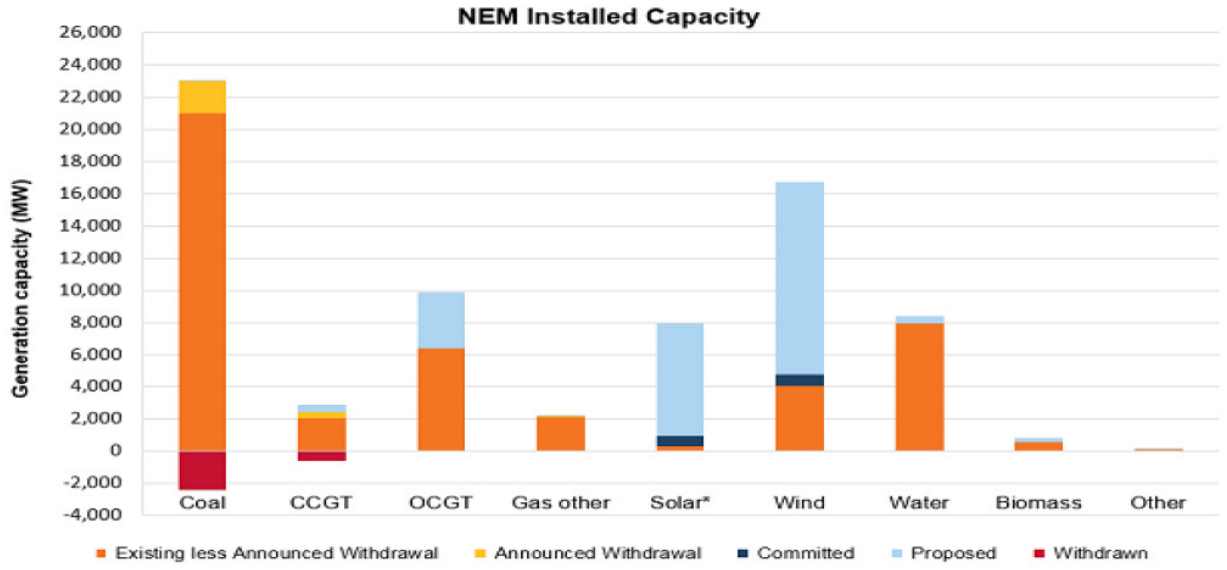
S5.2.5.11	Automatic standard under this clause removes clear requirements and introduces high number of ambiguous terms such as 'proportional', 'sufficiently rapidly', 'sufficient period', 'measurable amounts'. It is not clear how the generating systems could be designed to comply with this standard when the requirements are not clearly defined. The proposed wording is opening this standard to wide interpretation. The negotiated standard is only to be allowed when as close as 'practicable' to automatic level. This reduces the scope of negotiation drastically. It is also unclear how could the Applicant 'satisfy' AEMO and the NSP of this when the automatic level is not clearly defined. General requirement (i)(3) allows the NSP and AEMO to specify any level of frequency droop undermining the requirements specified at the automatic level. The definition of frequency droop is unclear.	Remove ambiguity and define the performance requirements clearly. If the droop requirements are to be opened to NSP's and AEMO's free interpretation it should be specified under which conditions this is permissible. In general this kind of Rule wording should be avoided as it undermines the idea of specifying the automatic requirements in the first place. Clarify the definition of frequency droop.
S5.2.5.15	SMA inverters are designed to operate at very low Short Circuit Ratio (SCR) – SMA provides assurance that the inverters will operate correctly down to SCR of 2 at inverter terminals. Based on SMA' knowledge this is one of the lowest SCRs that the inverter manufactures can provide guarantees for. AEMO acknowledges a similar limitation in the market[3]. Stable operation of inverters below this value is possible but additional EMT type studies must be conducted to confirm it. Proposed SCR of 3 at the connection point could result in SCR below 2 at inverter terminals considering common impedances of inverter based generating systems (impedance of HV transformer of up to 22% is possible[4]). It should be noted that this being the only direct SCR requirement in the Rules could permit NSPs to allow deterioration of system strength to a very low level. Up until recently AEMO used to require EMT type of studies for SCRs lower than 5.	The selection of SCR should consider capabilities of current inverter technologies as well as common impedances of HV transformers. SMA recommends increasing the SCR requirement (to e.g. 5) or defining it at inverter terminals which can be guaranteed by the manufacturers. The responsibility to maintain grid quantities including system strength should be shared between network users and network owners. If not already considered it should be proposed to apply requirements to maintain reasonable system strength to NSPs as well.
11.X.1.1	SMA would like to note that introducing retrospective application of Rule requirements is very dangerous and undermines further already vulnerable position of Generators when in negotiations with AEMO and NSPs. Some ambiguity is also introduced with wording such as 'AEMO's reasonable opinion'.	As these Rules may have significant impact on the already connected generation any ambiguity should be avoided.

[3]AEMO's modelling requirements. Available at: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Network-connections/Modelling-requirements

[4]Specification – Substation Power Transformer, Standard Number: HPC-8DC-23-0001-2015, Appendix B – STANDARD IMPEDANCE FOR TRANSFORMERS, Horizon Power 2015. Available at: https://horizonpower.com.au/media/1613/hpc-8dc-23-0001-2015-spec-substation-power-transformer.pdf

APPENDIX B Extract from AEMO's presentation at Solar Integration Workshop (Berlin, 30 October 2017)

EXISTING, COMMITTED AND PROPOSED SOLAR FARM PROJECTS ACROSS THE NEM



Status	Coal	CCGT	OCGT	Gas other	Solar*	Wind	Water	Biomass	Other	Total
Existing	22,976	2,449	6,434	2,159	274	4,070	7,941	574	139	47,016
Announced Withdrawal	2,000	379	34	30	0	0	0	0	0	2,443
Existing less Announced Withdrawal	20,976	2,071	6,400	2,129	274	4,070	7,941	574	139	44,573
Committed	0	0	0	0	692	690	4	0	0	1,387
Proposed	80	460	3,465	15	6,975	11,938	484	228	53	23,698
Withdrawn	-2,416	-624	0	0	0	0	0	0	0	-3,040

Note: Existing includes Announced Withdrawal. This data is current as at 19 May 2017.

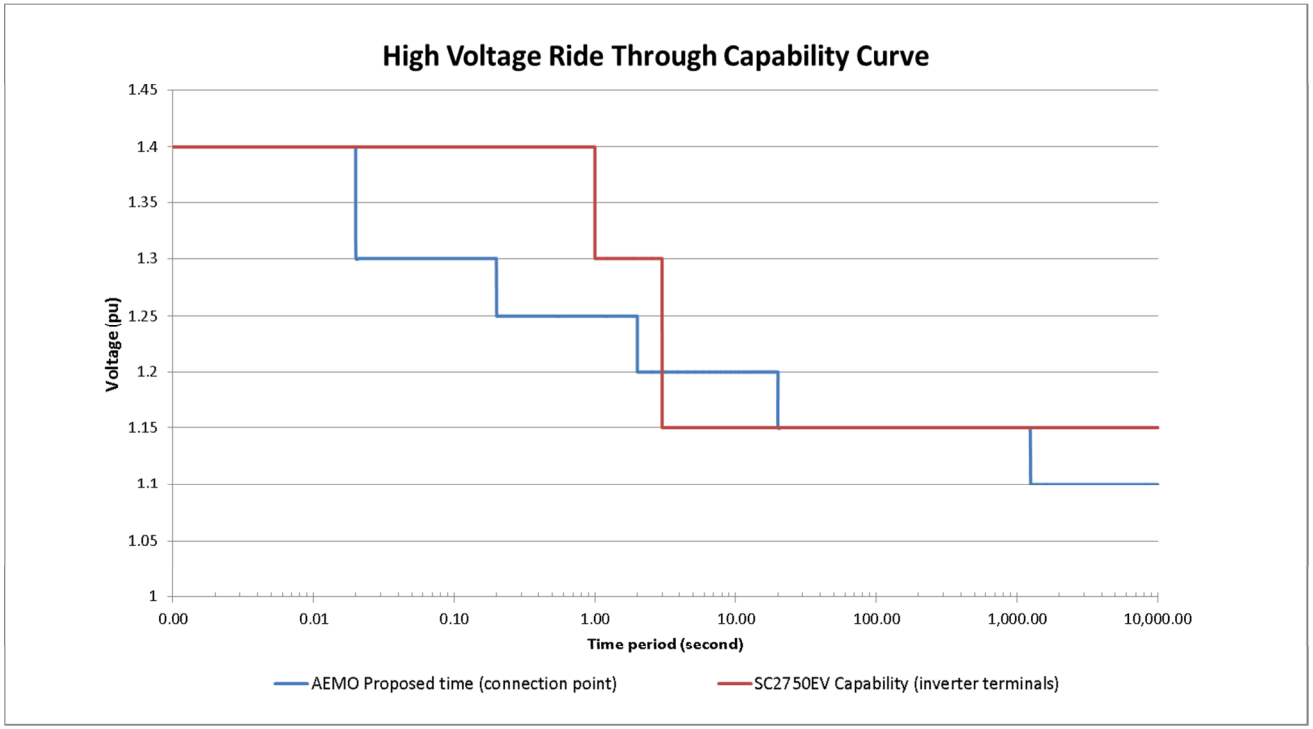
* Excludes rooftop PV installations.

More than 8 GW of solar farm projects in various stages

SLIDE 5

APPENDIX C High Voltage Ride Through Capability of SMA's Sunny Central (SC) 2750-EV inverter

Inverter capability is specified at inverter terminals.



APPENDIX D Capability chart of SMA's Sunny Central (SC) 2750-EV inverter at different voltages

Voltage is specified at inverter terminals. Capability at 25°C.