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Australian Renewable Energy Agency

ARENA

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Investigation into System Strength Frameworks in the NEM
Australian Energy Market Commission
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ARENA submission to Investigation into System Strength Frameworks in the NEM

This submission provides information from projects funded by the Australian Renewable Energy Agency (ARENA) as relevant to the AEMC's Investigation into System Strength Frameworks in the NEM discussion paper (the Investigation).

Attachment A sets out responses to some of the matters set out in the AEMC response template.

In summary -

- Demonstrating the performance of batteries and other inverter-based generation technology, in addressing system strength constraints, is a priority for ARENA. We will continue to work with the market bodies and industry participants to share detailed information and insight from relevant projects.
- ARENA's experience supports the AEMC's assessment of issues related to current frameworks and we agree that changes are required to support efficient investment in new transmission and generation capacity. In particular, a number of ARENA studies have highlighted that substantial cost savings can be achieved through better-coordinated investment in synchronous condensers, and other remediation strategies, at different system levels. Coordinated investment is not well supported by the current 'do no harm' framework.
- 'System strength' is a bundle of different concepts (For example, fault current and 'voltage stiffness') that each have different characteristics and potential treatments. We see value in a more granular analysis of the underlying services to ensure new requirements or incentives are well targeted at the underlying need.
- We draw your attention to phasor measurement-based control paradigms, and related ARENA-supported projects (described in Attachment A), that offer strategies to achieve

system safety and resilience in low fault current conditions and provide new approaches to voltage stability. Microsynchophasors can be used to map impedance (and therefore system strength) across transmission and distribution networks in real-time. Alternative approaches to managing the power system may not require the same set of services, or not to the same extent, as has been required in the past.

About ARENA

The Australian Renewable Energy Agency (ARENA) was established in 2012 by the Australian Government. ARENA's function and objectives are set out in the *Australian Renewable Energy Agency Act 2011.*

ARENA provides financial assistance to support innovation and the commercialisation of renewable energy and enabling technologies by helping to overcome technical and commercial barriers. A key part of ARENA's role is to collect, store and disseminate knowledge gained from the projects and activities it supports for use by the wider industry and Australia's energy market institutions.

Please contact Jon Sibley, Principal Policy Advisor (jon.sibley@arena.gov.au) if you would like to discuss any aspect of ARENA's submission.

Yours sincerely

Darren Miller

Chief Executive Officer, ARENA

Attachment A - Completed stakeholder submission template

SUBMITTER DETAILS

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CHAPTER 2 – key issues with the current system strength frameworks

Section 2.3 – Key issues of the minimum system strength framework	
1. Do stakeholders agree with the AEMC's assessment of the issues of the minimum system strength framework?	
2. Have stakeholders identified any other significant issues as a result of the minimum system strength framework?	
Section 2.4 – Key issues of the "do no harm" framework	
3. Do stakeholders agree with this assessment of the issues of the "do no harm" framework?	Yes - Coordinated investment is not well supported by the current 'do no harm' framework. The ARENA-funded report Development of Renewable Energy Zones in the NEM that compared the business case for a range of measures to jointly address system strength and thermal constraints. The study found that substantial cost savings can be achieved through

	better-coordinated investment in synchronous condensers, and other remediation strategies, at different system levels. It found that a coordinated approach to investment could reduce costs of synchronous condensers in the study areas by around 85%.[1]
4. Have stakeholders identified any other significant issues as a result of the "do no harm" framework?	ARENA agrees with the AEMC's concerns regarding the assessment of the 'do no harm' framework.
Section 2.7 – Conclusion	
5. What are stakeholders views on the Commission's proposal to consider evolving the framework to a more integrated approach for system strength in the NEM?	The discussion paper states that "*system strength is a critical NEM system security service that is necessary to support the transition to low emissions future*." While this is not contested, not all aspects of system strength may be required at their historic levels in all areas across the longer term. For example (discussed further below), phasor measurement can potentially be used to detect faults faster[2] and more precisely than relying on fault current and mechanical circuit breakers, and can be reliable in low system strength areas. This is already being trialled in Australian distribution networks (see below). The AEMC's assertion could be more nuanced in this regard.

CHAPTER 3 – Considerations for provision of system strength

Section 3.1 - What is system strength?	
6. Do stakeholders agree with the Commission's characterisation of system strength?	The AEMC's analysis may be enhanced by more clearly and explicitly recognising how electricity system strength is shaped by the impedance of the network. This may help stakeholders reconcile different arguments put forward regarding the role of centralised versus decentralised mitigation/remediation strategies.

[1] https://arena.gov.au/knowledge-bank/development-of-renewable-energy-zones-in-the-nem/

[2] According to industry proponents, fault can be detected 'before the conductor hits the ground'.

	The forthcoming ARENA-funded study *Managing system strength during the transition to renewables*[3] summarises these issues including highlighting the 'tyranny of distance' in relation to the propagation of system strength over high-impedance network areas. Other expert accounts[4] illustrate how the NEM could utilise high voltage network backbones, and existing thermal generator sites, to 'broadcast' system strength more globally. The topology of network impedance creates an additional layer of complexity for valuing services by requiring sources of system strength to be valued differently depending on their location. This issue of differential value could be more directly addressed through the AEMC Investigation. The Investigation would also benefit from a more dedicated consideration of alternative approaches to electricity system management. For example, there is a growing body of experience and theory regarding protection mechanisms (e.g. circuit breakers) where the control logic does not rely on the detection of fault currents. For example, the ARENA-funded Intelligent Switchgear project[5] with Noja Power is demonstrating phasor measurement and switch control at the distribution level, where reclosers have to operate in high DER (low fault current) network context. The maturity of the different use cases for real-time phasor measurement is variable in different applications, but appears rapidly evolving.[6] Dr Elizabeth Ratman from ANU, among other researchers around Australia and globally, are exploring the use of phasor measurements via micro Phasor Measurement Units (µPMUs) to map real-time impedance across the network which can be used to locate and isolate faults. This information can also be used to tune inverter settings to enhance stability (dampen oscillations) in weak parts of the grid. The AEMC's assertion that '*maintaining adequate levels of system strength is a permanent requirement*' (p.31) may therefore benefit from being tested in relation to the various services that sit underneath the 'system strength' banner, and what 'adequate' could mean in different contexts. It may also be useful to test this proposition in the context of the AEMC's stand-alone

[3] https://arena.gov.au/projects/powerlink-cost-effective-system-strength-study/
[4] E.g. https://www.linkedin.com/pulse/inertia-power-system-frequency-bruce-miller-2/
[5] https://arena.gov.au/projects/noja-power-intelligent-switchgear/
[6] Control using uPMUs: https://www.mdpi.com/1996-1073/13/1/190, See page 2929 and 2933 - fault location and impedance estimation: https://ieeexplore.ieee.org/abstract/document/7961200, NASPI white paper - more detail can be found here: https://www.naspi.org/sites/default/files/reference_documents/naspi_distt_synchrophasor_monitoring_distribution_20180109.pdf

	power systems work program which has flagged potential material changes in network topologies over the coming decade due to changes in the economics of micro-grids and network maintenance. ARENA-funded microgrid projects such as the Coober Pedy microgrid have illustrated how smaller-scale power systems have been able to operate reliably and securely on 100% inverter based generation most of the time.[7]
7. Has the Commission set out all the necessary considerations for defining a system strength service? If not, what additional considerations could be included?	As above
8. Do stakeholders consider the regulatory definition of system strength should be updated/changed? If not, why not? If so, how could this be done?	The ARENA-funded study *Managing system strength during the transition to renewables*, provides an assessment of some of the trade-offs in taking a broad or narrow definition of system strength. AEMO has noted that a more flexible approach to defining system strength will assist them as they respond to new information and evaluate prospective management strategies that are hard to anticipate in advance. The benefits of this approach needs to be balanced against the benefits of having more granular service definitions, that may reflect the current state of knowledge, where specific services lend themselves to individual regulatory treatment. For example, 'fault current' and 'voltage stiffness' can have different sources and could be subject to different policy treatment. A more granular analysis of the services that make up system strength could therefore be beneficial.
9. Do stakeholders consider that the system strength definition should recognise active and passive system strength procurement? If not, why not? If so, how could this be done?	It is important that the definition (or definitions) reflect a granular assessment of the underlying power system needs that contribute to security and resilience. The definition, along these lines, should support a technology neutral approach to remediation. The benefits of thorough investigation into alternative options are highlighted in the ARENA-funded report *Development of Renewable Energy Zones in the NEM* that compared the business case for a range of active

[7] https://reneweconomy.com.au/coober-pedy-powered-by-100-per-cent-renewables-most-of-the-time-80275/

	and passive measures and the potential to co-optimise investment to jointly address system strength and thermal constraints.[8] Options considered included: ● Synchronous condenser ● Battery with grid-following inverter ● Battery with grid-forming inverter ● VRE with grid-forming inverter ● Synchronous Static Series Compensator ● Network build
10. Do stakeholders agree that clarifying the NER system strength service definition is likely to contribute to more/broader options for the system strength provision?	
11. Are there any additional sources of fault current in the NEM that can contribute to meeting system strength needs?	
12. Are there any other technologies in the NEM that can contribute to meeting system strength needs that should be considered?	ARENA notes that various projects in its forward funding pipeline propose the use of voltage source inverters and those capable of dynamic reactive power control. It is intended that these projects will help demonstrate: ● Ability of advanced inverters to operate stably in low system strength conditions; and ● An ability to improve local system strength through i) improved voltage stiffness and ii) improved fault levels[9] Demonstrating the performance of batteries and other inverter-based generation technology, in addressing system strength constraints, is a priority for ARENA. We are working with market bodies, project proponents and network service providers to direct funding to areas of the highest demonstration need.

[8] https://arena.gov.au/assets/2020/01/development-of-renewable-energy-zones-in-the-nem.pdf
[9] Improvement in fault levels is expected to be small in the short term

Section 3.2 - Why is system strength needed?	
13. Do stakeholders agree with why system strength is needed?	
14. Are there any additional reasons for why system strength is needed in a power system?	
15. Do stakeholders agree with the characterisation of the impact of inverter-based generation on system strength?	
16. Are there any additional impacts on system strength that should be taken into account?	
Section 3.3 - The provision of system strength in the NEM	
17. Do stakeholders agree that with the characterisation of system strength thresholds?	
18. Are there any additional thresholds or alternative characterisations that might be included in the investigation?	
Section 3.4 - The provision of system strength in the NEM	
19. Do stakeholders agree with the system strength attributes?	Note the above discussion on locational attributes.

20. Are there any additional attributes of system strength that the Commission should be aware of?	Where practicable, the provision of system strength (through both active and passive measures) should be co-optimised with energy generation and other essential system services (e.g. inertia), both for investment and operational decisions. ARENA's project experience indicates that effective co-optimisation may require a more granular consideration of the system strength services, such as 'voltage stiffness' versus 'fault current', than currently detailed in the NER.

CHAPTER 4 – Evolving system strength frameworks

Section 4.1 - Approach to developing a new framework	
21. Do stakeholders agree with the approach (Plan, Procure, Price, Pay) to developing a new framework for system strength? Are there additional steps/concepts that should be explored?	
Section 4.2 - Models for delivering system strength	
22. Do stakeholders agree with the summary of the potential capabilities of each system strength model in Table 4.1?	
Section 4.3 - Model 1: Centrally Coordinated	
23. Do stakeholders agree with the characterisation and assessment of a centrally coordinated model? Are there any other advantages and/or challenges?	
Section 4.4 - Model 2: Market based decentralised	

24. Do stakeholders agree with the characterisation and assessment of a market based decentralised model? Are there any other advantages and/or challenges?	
Section 4.5 - Model 3: Mandatory service provision	
25. Do stakeholders agree with the characterisation and assessment of a mandatory service provision model? Are there any other advantages and/or challenges?	
Section 4.6 - Model 4: Access standard	
26. Do stakeholders agree with the characterisation and assessment of an access standard model? Are there any other advantages and/or challenges?	
Chapter 4 - General	
27. Are there other model(s) stakeholders think should be explored?	
28. What combination of models (i.e. hybrids) should be explored further?	
29. Do stakeholders have any suggestions as to how any/all the models set out could be implemented or modified? Please comment on any and all models possible.	Consideration should be given to how to promote dynamic efficiency under regulatory frameworks, that reflect the need for timely action while also encouraging investment in the commercial development of new technology and management approaches.

CHAPTER 5 – System strength in distribution Networks

30. What factors make system strength provision in distribution networks unique from transmission networks?	It appears the current focus on system strength in transmission networks relates to the risk of one or more large-scale generators tripping as a result of a large change in voltage, creating further voltage or frequency instability. AEMO's Renewables Integration Study identifies that similar concerns might arise in the future where distribution network areas have very high levels of inverter based generation capacity (i.e solar/ batteries/EVs). In this case, system dynamics will be determined by the interaction of many inverters with variable settings. Instability may also arise from the coincident response of many small-scale systems to centralised VPP dispatch instructions or the changeover of ToU retail tariff bands. This has been explored in some detail in the context of EV charging, which can produce oscillatory effects undermining grid stability, and which can be resolved through specific decentralised control paradigms.[10] The interaction between decentralised (self-optimising) control paradigms and voltage stability, needs to be considered at all system levels. These issues will become more pronounced in the medium term as flexible DER achieves greater scale. The ARENA-funded *Addressing Barriers to Efficient Renewable Integration* project is directly testing the response of a range of photovoltaics (PV) and storage inverters to disturbances of different kinds on the network. In addition, the installation of high-speed disturbance records on key distribution network feeders will monitor and record behaviour during power system disturbances.[11]
31. What are the key issues for system strength in distribution networks, including the magnitude and urgency of system strength issues in distribution networks?	

[10] https://www.researchgate.net/publication/273758258_Decentralized_Charging_Control_of_Large_Populations_of_Plug-in_Electric_Vehicles, https://web.eecs.umich.edu/~hiskens/publications/pscc2014_346.pdf

[11] https://arena.gov.au/projects/addressing-barriers-efficient-renewable-integration/

32. How should any system strength issues in distribution networks be addressed? Are any model(s) from Chapter 4 appropriate to address system strength provision in distribution networks?	The above mentioned ARENA-funded Intelligent Switchgear project is demonstrating how reclosers could work in low fault-current (high DER) situations using real-time phasor measurement.