12 May 2020

Mr John Pierce AO
Chair
Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

Electronic Submission – EPR0076

Discussion Paper – System strength investigation

Dear Mr Pierce

Energy Networks Australia welcomes the opportunity to provide a response to the Australian Energy Market Commission's (AEMC) Discussion Paper on System Strength Investigation.

Energy Networks Australia is the national industry body representing Australia's electricity transmission and distribution and gas distribution networks. Our members provide more than 16 million electricity and gas connections to almost every home and business across Australia.

Energy Networks Australia recognise that the AEMC has initiated this investigation alongside several related rule changes and that system strength services are also considered within the Energy Security Board's (ESB) post 2025 reform – System Services and Ahead Markets. As such, we expect that stakeholder thinking will continue to develop throughout this process as the various reforms and rule changes are explored further, and we encourage the AEMC to take an integrated approach to these issues.

Energy Networks Australia have provided a more detailed response in the Attachment. In summary:

- Energy Networks Australia broadly supports the description of issues with respect to the minimum system strength framework and the do no harm framework and would recommend an increased emphasis on medium to long term planning for system strength needs to provide holistic solutions at the least long-term cost to consumers.
- The energy mix is rapidly transforming and system strength is an issue now, but solutions require sufficient time to deliver and therefore the requirements to forecast and plan for system strength should be further emphasised.
- System strength is a necessary pre-condition for meeting a range of transmission network performance standards, including proper operation of

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protection systems and quality of supply to customers. As such it should be considered a network service.

- While the current framework has allocated responsibilities for system strength between Australian Energy Market Operator (AEMO) and Transmission Network Service Providers (TNSPs) that address the immediate security issues, a new framework is needed to more efficiently provide system strength services over the long term.
- The current short-term reactive approach to deliver a theoretical minimum system strength level is too short-sighted and does not sufficiently enable holistic planning for the long-term management of system strength and related system security requirements. The need to securely operate the power system under a wide range of operating conditions means the frameworks need to provide for a degree of headroom and Energy Networks Australia would recommend inclusion of a stronger operational overlay on the forward planning requirements.
- System strength is influenced by a number of complex and interlinked factors. It is difficult to accurately forecast requirements for system strength in localised areas. Any framework that the AEMC considers adopting should not be targeted to theoretical minimum levels or presume a high degree of accuracy in the models. The adoption of suitable margins for system strength requirements should be examined while ensuring efficient outcomes.
- Adverse interactions between distinct facilities are increasingly observed; due to the complexities involved, it is difficult to relate these interactions to simple metrics. There is no agreed definition of the system strength service that enables commoditising the service in a de-centralised market.
- Model 1 offers simplicity and certainty– a centrally planned and coordinated approach, building on the Integrated System Plan (ISP), enables a forward-looking proactive approach that can evolve with the change in generation mix/location and be implemented in a timelier manner. The TNSP could procure to meet the essential levels of system strength required in the plan with clarification that meeting these essential levels of system strength is a mandatory requirement and be recognised as such under the Regulatory Investment Test for Transmission (RIT-T).
- Model 2 is more costly, complex and will take longer to implement. As noted in the ESB System Services and Ahead Markets paper [1], there is unlikely to be a competitive market for the service. The scheduling and price forming aspect is also not favourable. While this option could be further explored it should only proceed if there is a realisable net benefit to consumers.

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[1] Energy Security Board, System Services and Ahead Market, April 2020, p20

- Models 3 and 4 do not meet the full capability required for system strength and could only be explored in conjunction with another model.

Should you have any queries on this response please feel free to contact Verity Watson, vwatson@energynetworks.com.au.

Yours sincerely,

Andrew Dillon

Chief Executive Officer

Attachment

Minimum system strength framework

Energy Networks Australia broadly agree with the AEMC key issues on the minimum system strength framework;

- The framework is reactive, solving the immediate challenge, but failing to provide a means to proactively remediate future system strength shortfalls in the most efficient manner;
- Defining the minimum system strength requirement needs to better recognise the transition in generation sources underway; and
- The framework does not efficiently allocate responsibility between AEMO and TNSPs for providing the minimum level outside of system normal.

Energy Networks Australia agree that the current short-term reactive approach to deliver a concept of a normal minimum system strength level is not workable. AEMO has had to make a number of shortfall declarations for fault level and inertia over the last few years across four states in recognition of imminent problems. However, this approach does not address the longer-term issue of the need to deliver a minimum system strength level in the most efficient manner.

Current frameworks are reactive and don't provide any clear ability for either networks or proponents to "get ahead of the curve" in terms of:

- planning and providing sufficient system strength services to proactively maintain system security in a least regrets view of the power system's transition;
- increasing the capacity to host inverter connected plant;
- accommodate necessary network outages for maintenance without severely impacting a large number of participants; and
- provide resilience in the power system to better withstand various operating conditions and non-credible events without major disruption to customers.

It is important that the essential levels of system strength are provided to meet the power systems needs under a broader range of "routine operating" conditions; recognising that the types, levels and locations of generators that are dispatched varies and both generators and transmission network can be unavailable at times for maintenance or unplanned events. There needs to be a tolerance level built into what is considered "normal" as the power system varies across the day and year. It is also noted that minimum levels of system strength are needed for the proper operation of protection systems and acceptable voltage management following switching events.

The do no harm framework

Energy Networks Australia agree that the system strength impact assessments involved in the connection of each new generator are time intensive and iterative. This impacts generation connection timeframes, increases costs and uncertainties in the connection process and investment decisions. The modelling is complex and needs to consider the interactions of other generators and control systems in the area.

This complexity is evident in north west Victoria and the time it has taken to define the issues and the remediation steps, which has caused severe constraints to parties impairing their business cases.

As the AEMC notes the physics of the power system are ultimately driving the need for these assessments and for additional remediation work. The piecemeal approach of remediating on each new connection rather than a coordinated scale efficient approach can be expected to create operational challenges in the future.

When the current frameworks were established it was seen that fault levels at a location, or a similar metric, was an adequate surrogate for the whole range of issues arising from low levels of system strength – but that premise has now been shown to be incorrect.

Early thinking was that issues for inverter connected plant in areas of low system strength were largely limited to the ability for inverters to “ride-through” or recover from a nearby fault on the system – the interaction of the inverter controller with the power system. Experience has shown that the issues are more widespread and include the interaction of the various inverter and other power electronic controllers (e.g. static var compensators) with each other across wider parts of the power system.

As multiple proponents may be negotiating connections in parallel the possible combinations to be analysed can become overwhelming. When one of these multiple parallel proponents becomes committed the analysis for the remaining parties often needs to be redone to reflect the new state of committed generation. The project by project work invariably results in inefficiencies and overall high cost solutions.

AEMC rightly identifies potential interactions and overlaps between the system strength and inertia frameworks. Energy Networks Australia agrees with the AEMC view that a more coordinated approach is necessary. This can more accurately identify and manage the full consequences of the change in the generation fleet from synchronous to non-synchronous.

It may be efficient for TNSPs to address AEMO identified system strength shortfalls in a more holistic manner that aligns with the optimal development path and meets the intent of the current do no harm remediation works. This could enable TNSPs to take advantage of scale efficiency to address both existing shortfalls as well as provide additional capability to enable the connection of additional non-synchronous generators where this is reasonably forecast (e.g. in the ISP). As noted in the South Australian experience, there are further efficiencies to be gained by recognising shortfalls in system strength and inertia to enable optimised design and implementation.

Learnings from the existing frameworks

Energy Networks Australia agrees that longer term modelling is necessary to enable investments in system strength to address the longer-term needs in a more proactive manner.

AEMC note that modelling system strength dynamically to inform dispatch decisions of generators on a real time basis would be prohibitively difficult given the scale and complexity. Experience also shows that actual performance of the power system can differ from modelled predictions due to limitations in the models themselves and the continuing increase in understanding of engineers of these complex power system phenomena. These concerns do not readily lend system strength services to a commoditised market-based approach. The ESB's recently released System Services and Ahead Markets paper in Table 3, recognises that these services are unlikely to have a favourable degree of competition or be able to be scheduled and priced adequately in dispatch[2]. The issues arising from limited depth in the market for system strength service provision would also be present in a centrally planned approach if the service was to be procured solely by AEMO, without the ability to test both network and non-network options.

System strength is influenced by a number of complex and interlinked factors. It is difficult to accurately forecast levels of system strength in localised areas. It is a false premise that the energy market can easily commoditise this service in the evolving power system as complex interactions between facilities are increasingly identified. As such, it is difficult to sufficiently define a needed system strength service at each location to the extent necessary.

Any de-centralised services market, if adopted, must be fit for purpose, practical to implement and be subject to a cost benefit analysis before proceeding, noting lack of competition in the service provision, the extensive computing power required for real time calculation of service requirements to meet dispatch times and the complexity of such arrangements.

The provision of system strength needs to be reliable, consistent, and recognised as a permanent and increasing requirement as the thermal synchronous generation fleet retires. Energy Networks Australia agrees that additional margins of system strength are beneficial to increase power system resilience and assists with manageable outcomes for non-credible contingency events. Like investment in transmission lines which is lumpy in nature, investing in scale infrastructure for system strength can be undertaken at low incremental cost.

What is system strength?

AEMO note in the Renewable Integration Study Stage 1 Report that system strength is a complex concept and definitions are continuing to evolve internationally. "AEMO see system strength as the ability of the power system to maintain and control the voltage waveform at any given location in the power system, both during steady state operation and following a disturbance".[3] The AEMC describe this capability as an important characteristic of the power system necessary for it to operate effectively.

[2] Energy Security Board, System Services and Ahead Market, April 2020, p20
[3] AEMO 2020 Renewable Integration Study Stage 1 Report, 30 May 2020, p50

The AEMC notes in the discussion paper that the AEMO definition that is evolving on system strength does not provide clarity on the system strength service and what it is and isn't. Neither the use of a three-phase fault level nor the short circuit ratio (SCR) provide a complete description of the service and fails to meet the nuances that the evolving power system needs for stable operation. The AEMC review could consider the definition of system strength more broadly and be mindful of its interactions with wider system security issues.

Energy Networks Australia agree that there are a range of proven technologies that can provide active or passive contribution to system strength whilst other technologies such as grid forming inverters remain unproven in utility scale power systems.

Energy Networks Australia agrees with the conceptual overview of the thresholds outlined in Fig 3.3[4]. However, given the rapid transformation of the power system and the need to recognise that defining system strength is not precise, it is recommended that the essential level[5] be characterised to include the system strength capability that builds power system resilience, increases hosting capacity and alleviates constraints. This would be expected to be both system and network 'design' level, which, typically, would be based on, and consistent with, the optimal interconnected power system development pathway set out in the ISP.

Energy Networks Australia consider there is a need to move away from the theoretical minimum declared shortfall levels to better plan and coordinate the system strength needs of the power system. Any new framework needs to be fit for purpose, and practical to implement, for the physics of the power system and agile enough to evolve as the generation mix and technology change. The essential level needs a degree of tolerance to operate the power system in a manner that can free up capacity on the network to allow connection of more generation capacity. This is consistent with the AEMC view that essential levels of inertia and system strength are best met in a coordinated manner as part of the TNSPs planning processes. If the service requirements don't coincide then an option value approach can also be considered to deliver efficiencies and avoid missed opportunities that result in higher costs to consumers.

Approach to developing the Framework

The Plan, Price, Procure and Pay model appears a reasonable approach to consider the development of the framework. The AEMC could also consider a number of principles in assessing the design of the framework, including:

» provision of the system strength capability needs to be forward looking both in terms of power system needs and ability of technology to deliver, and should

[4] AEMC, Discussion paper, System strength investigation, 26 March 2020, p44
[5] The AEMC Discussion paper uses the term minimum and essential levels of system strength interchangeably. Energy Networks Australia considers given the rapid transformation and the imprecise nature; the minimum level of system strength needs a level of tolerance which is some way into the market benefits level in the discussion paper.

cover related security requirements, such as inertia, in arriving at the optimal least cost solution;

- providing the greatest certainty that the essential level of service will be available for the transformation of the power system;
- enabling and improving system strength throughout the transformation; and
- the changes to the system strength framework need to be fit for purpose and efficiently meet the requirements at the lowest cost.

The models

Energy Networks Australia has provided more detailed comments on the models in Table 1, and high-level comments below.

A more centralised and coordinated approach is recommended with the TNSP procuring to meet the essential levels of system strength required in the plan. This is on the basis that system strength is a necessary pre-condition to meet a range of network performance standards and so should be considered a network service. The regulatory processes will provide transparency of the options considered to meet the essential level of system strength required and costs, with the TNSP ultimately making the investment decision.

Consideration of system strength in central planning needs to consider a longer-term outlook, building on the ISP, and define an essential level of system strength with the requirement being considered a prescribed transmission service. Ideally the improved planning would align to the 10-year outlook in the TNSPs Transmission Annual Planning Report (TAPR) or the 20-year outlook in the ISP. This will support the efficient entry and exit of generation as the power system transforms, in line with other transmission investment supporting the transition. Further, the cost of providing the needed levels of system strength needs to align with the optimised power system development path (ISP) and is minor in the scheme of the generation and point to point transmission requirements. In the case of the South Australia main grid system strength project the incremental capital cost of $166m[6] for the synchronous condensers compares to large transmission backbone projects in the order of $1-3b.

It's also important to have replacement system strength services operable in time so that we aren't paying inefficient generators to stay in the market for too long. It will also avoid the piecemeal complexity created by each generator seeking to meet the do no harm requirement.

A stable power system allows energy to flow to meet demand as the energy mix transitions, as such, meeting the essential levels of system strength can evolve under this central planning approach as both learnings and technology evolve. Costs associated with meeting the essential system strength requirements in the plan will be recovered ultimately from consumers, recognising that generators could pay in the

[6] AER, Final Decision, ElectraNet Contingent Project, Main Grid System Strength, August 2019, p35

first instance as part of signalling the costs of their locational decisions, provided there is a practical and workable framework for doing so.

A recent report by GHD Advisory noted scale benefits of synchronous condensers

"From our lifecycle cost analysis we have found that synchronous condenser exhibit significant economies of scale, predominantly as a consequence of the largely-fixed capital costs related to civil works, network connection, and cooling control systems, and the largely fixed operating cost from "no load" energy losses. Thus, there is economic merit in exploring the possibility of a shared solution to system strength that supports multiple projects. A centralised approach to developing and operating this shared solution could also simplify, accelerate and de-risk the connection process for developers, as well as streamlining the ongoing operation of the synchronous condenser. "[7]

Where AEMO considers a TNSP is not procuring sufficient system strength services to meet the prescribed essential system strength level, AEMO as a last resort, or where planning assumptions have significantly changed, should be able to declare a gap to ensure system security is maintained.

There is no simple metric to define system strength, there is no agreed definition of the system strength service internationally, and the need or understanding of the service required is continuing to evolve. A clear definition of the system strength service is needed that meets the operational requirements of the power system as a precursor to creating and implementing a decentralised market. Any decentralised market created needs to realise a net benefit for consumers.

While there may be some benefit in utilising market-based approaches to co-optimise the dispatch of system strength resources with other services, it is highly unlikely a market can deliver investment at efficient levels of system strength in the localised areas where and when it is needed.

There may be benefit in recasting the system strength service level along the following lines:

- TNSPs proactively provide bulk fault level at nodes based on criteria to maximise the overall efficiency of provision;
- TNSPs and AEMO have the ability to work with parties to re-tune equipment on the power system (e.g. in NW VIC re-tuning of generator equipment improved the interaction of generators in a localised area and allowed constraints to be lifted, there is benefits if this could be undertaken in a more timely and efficient manner);
- Generators have to be able to operate stably, and make sure others can still operate stably, when they connect; and

[7] GHD Advisory report for ARENA, Managing system strength during the transition to renewable, May 2020, p 64

- TNSPs can consider other aspects of system security while developing solutions for system strength, using a holistic approach to address multiple challenges emerging in the evolving power system.

Table 1 – Comments on the Models

Model	Description	Comments
Centrally coordinated	Builds on ISP and TNSP planning, central buyer (AEMO or TNSP) procures volumes to meet a central plan, either contract with existing generators or build network assets Could be procured by TNSPs as a regulated approach, least cost procurement or via AEMO procurement.	This option builds on the ISP and the forecast needs of the power system that have been subject to robust stakeholder engagement. It allows a proactive coordinated planning approach by AEMO (with TNSPs) and avoids the short-term reactive nature of the current minimum system strength arrangements. TNSPs could issue tenders for and procure system strength to satisfy the modelled power system needs. This option provides adequate time to consider the least cost suite of options for system strength provisions and potentially optimise with other emerging system needs e.g. inertia, enabling a longer-term view. TNSPs have an obligation to progress regulatory processes to meet the anticipated power system needs and to continually assess these needs through the regulatory investment process to manage costs and risks borne by both under investment and over investment. The framework should clarify that meeting these essential levels of system strength is a mandatory requirement and be recognised as such under the RIT-T. TNSP procurement via a regulatory approach would enable transparent consideration of network options and non-network options to meet the system strength needs. The economic regulatory framework could provide a discipline on the economic costs and has oversight by the Australian Energy Regulator (AER). This option could offer economies of scale with coordinated provision of system strength with other services, which can reduce upfront costs for generators and streamline connection processes and provides certainty that the needed essential levels will be provided. AEMO procurement does not have this optionality, and AEMO procurement would suffer from the same problems as an open market approach, where market power and limited competition could lead to consumers significantly overpaying for the service. As a service essential for secure network operation, it is also important to preserve the policy principle of TNSPs remaining the single party accountable for shared network service outcomes.

		This centralised procurement approach alleviates the un-coordinated nature of new connections, inefficient long-term outcomes and the risks of unpredictable interactions between generator control systems which are increasingly likely to result in system instability and becoming harder to predict. Payment via Transmission Use of System (TUOS) could simplify connection processes compared to an apportioned generator fee which could delay connections. However, the payment by generators is more consistent with the do no harm framework and provides a locational signal, and while preferable in principle may be complex to implement in the short term. A range of payment models should be explored as part of this investigation. AEMO as a last resort, or where planning assumptions have significantly changed, should be able to declare a gap to ensure system security is maintained. It is likely that there may be some short-term gaps in system strength needs that AEMO may need to fill using short term constraints on non-synchronous generators or other market interventions. This model does not necessarily preclude the need for generators to have a given level of system capability e.g. demonstrate as part of connection process they could operate stably down to given levels of SCR, however further tuning and response to specific SCR levels would sit with the TNSP and AEMO.
Market based decentralised	System strength assets are dispatched according to bids to provide system strength in the market with the least cost combination being	The essential service the power system needs may not be available where and when it is needed in dispatch if market signals are not effective to drive scale investment and keep the cost down. The ESB paper also notes there is likely to be limited competition in the provision of services.[8] This complexity suggests that procurement is more likely to need to be based on longer term commitments and not short-term deals or spot markets. Complex system strength issues are emerging now, and this option will take time to design and implement, this is time the NEM doesn't have available. It is appropriate that such approaches be

[8] Energy Security Board, System Services and Ahead Market, April 2020, p20

	dispatched – price set by marginal provider or some form of price regulation/cap, customers and/or generators pay	considered in the ESB's post-2025 work program, however it should not be considered further to address the immediate system strength issues facing the NEM. This approach would not realise the many benefits from co-optimising investment in system strength capacity with other network services (for example, thermal network capacity that may improve/reduce the need for system strength, inertia, frequency control or voltage control provision). Again, because of the complexity of control system interactions it may be that one source of system strength is not always substitutable with a different source – even if they deliver the same fault level contribution at a nominated point in the network. Under this model it is not clear that the capability needed can necessarily be clearly defined to commoditise a service. It should be recognised that the power system is sourcing most of the current levels of system strength as a by-product of participation in the energy market by synchronous generators. If this system strength is being relied upon then, which it is, it should be recognised as being procured and paid accordingly. However, Energy Networks Australia notes that, whilst this model may be able to value these generators better than model 1, it comes at significant additional cost/complexity. The same cost/timing issues were noted with the primary frequency response rule change which is not going to renumerate the service for a number of years. In theory this could allow optimised dispatch to drive productive efficiency gains, enable value stacking of system services and allow participation of existing and new players. However, the technical nature of system strength makes it difficult to formulate constraints and gain visibility in NEM dispatch to enable optimised dispatch. The ESB paper suggests that this is unlikely to be favourable for system strength services in terms of optimising scheduling and marginal pricing. The AEMC recognise that it is computationally intensive to calculate near real time, dynamic constraint equations. In addition, costs to design and implement the ahead market and registration categories etc would need to be carefully considered to ensure that the decentralised approach is fit for purpose and realises a net benefit for consumers, particularly when the costs of delivering system strength as a prescribed transmission service do not on their face appear to be prohibitive. There are a number of complexities with the model which may not meet minimum system strength

		needs at all locations and, simultaneously, could still lead to over specifying the service and increasing costs to consumers. Subject to the reservations above, this option could enable AEMO to fine tune system strength in operational timeframes and provides a risk cost trade-off. This option could combine a regulatory approach for essential levels and market-based arrangements for the optimal dispatch of the additional service, without being the principal signal for new investment in the service. For example, market power may be less of a concern when the essential levels are provided via model 1. This option may also provide opportunities for other than synchronous generators to provide a service in the medium to long term.
Mandatory service provision- generator provision obligation	Centralised approach imposing active system strength provision obligations on generators- generators acquire from a third party or build to meet the specified technical performance standard	If the level is set sufficiently high for active system strength provision, this option could theoretically provide sufficient system strength levels and allow the power system to operate in a less constrained manner, increasing wholesale market benefits. However, imposing obligations for a certain level of system strength placed on generators up front at the time of connection will contribute to investment uncertainty and delays to connection processes and will also need to constantly change over time. Imposing obligations on existing generators also has a number of complexities. This option is likely to lead to duplication of investment in system strength services, similar to what is occurring under the current do-no-harm framework.
Access standard – generator performance obligation	Impose obligation on generators to install equipment that is capable of operating stably	This model can be implemented with any of the other three models to slow the decline of available system strength on the grid, possibly as a centrally coordinated approach moves to higher levels of system strength.

	during low system strength	This standard could reduce the overall system strength requirements, it does not increase the total system strength provision which the power system needs.
	New generators to connect with requirement to maintain continuous uninterrupted operation down to SCR of 3	This option does not facilitate active supply of fault current, nor will it provide the necessary investment in system strength for unconstrained output of non-synchronous generation. This option does enable inverter connected generators to better manage obligations to withstand power system disturbances. This option reduces future risks of generators being constrained due to system strength and enhances wholesale competition benefits. This option also reduces negative impact of non-synchronous generators on system and enhances hosting capacity. A high-level assessment of the costs and benefits of this options should be conducted in order to determine whether it should be implemented as a complement to other options.