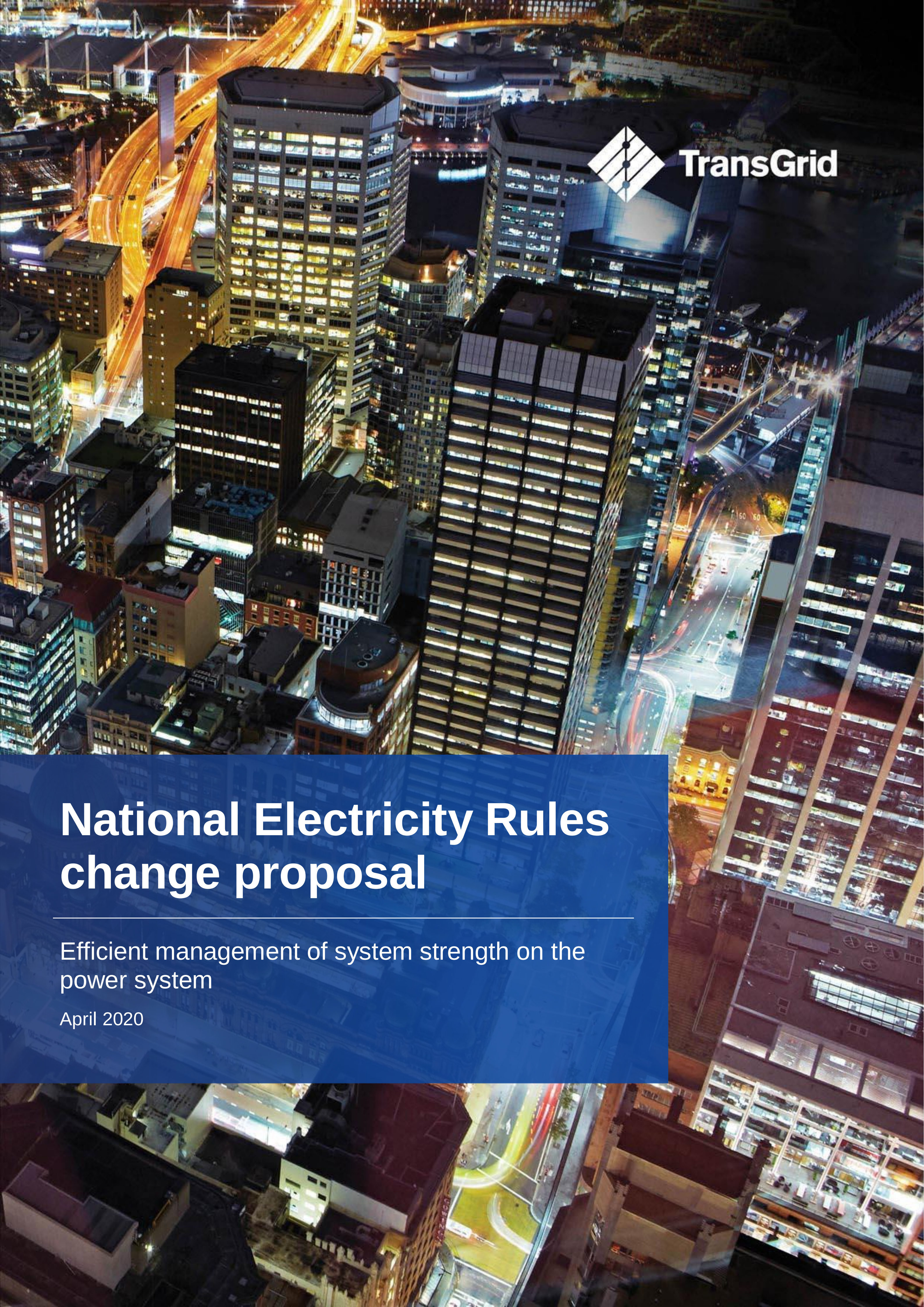


National Electricity Rules change proposal

Efficient management of system strength on the power system

April 2020

Contents

1. Summary

TransGrid is the operator and manager of the high voltage transmission network connecting electricity generators, distributors and major end users in New South Wales (**NSW**) and the Australian Capital Territory. Our network is also interconnected to Queensland and Victoria, and is instrumental to an electricity system that allows for interstate energy trading.

Our responsibility is to operate and manage the transmission network safely, securely and efficiently in the long-term interests of consumers. We continually seek to identify changes in the regulatory environment that promote this objective. We are therefore proposing amendments to the National Electricity Rules (**NER**) to allow for a more efficient management of system strength on the transmission system.

The current framework for managing system strength on the power system is costly for consumers and leads to increased risks in operating the power system. This increases whole-of-system costs and, in turn, final prices for consumers.

The current framework shares responsibility for addressing system strength issues between different participants. The Australian Energy Market Operator (**AEMO**) is tasked with setting minimum fault levels at nodes across the national electricity market (**NEM**). AEMO then forecasts emerging shortfalls and may direct transmission network service providers (**TNSP**s) to procure system strength services to address any shortfalls. When directed, TNSPs must address those shortfalls by procuring system strength services. Separately, new connecting generators must “do no harm” to the security of the power system caused by their connection, including remediating any adverse impact on system strength. This framework was introduced by the Australian Energy Market Commission (**AEMC**) in September 2017.

These arrangements are creating inefficient investment in system strength services, increasing the cost of generator connections, and increasing risks and costs of operating the power system securely. The three principal issues are caused by the “do no harm” arrangements as well as the reactive nature of the overall framework. More specifically, these issues are:

- the inability to coordinate the procurement of system strength services, due to new connecting generators investing in “ad hoc” solutions while TNSPs are unable to effectively coordinate the procurement of services because they can only do so when reacting to a notice from AEMO
- the additional time and cost for connection of new generation to the power system, because new connecting generators must model system strength impacts, propose and negotiate system strength remediation schemes, and implement system strength remediation schemes (which can include long lead times to install additional equipment), and
- increased risks of costly interventions in the operation of energy markets and the power system caused by the reactive nature of the framework.

TransGrid considers a more proactive approach would facilitate the installation of fewer more scale efficient system strength solutions that are better coordinated and thereby reduce total costs. TransGrid is therefore proposing a package of changes to the NER to achieve this outcome, with the key changes being:

- introducing a fault level standard (a probabilistic standard akin to the Reliability Standard), reflecting an efficient balance between the risks and costs of over-investment in system strength services against the risks and costs of under-investment
- requiring TNSPs to meet the fault level standard at each fault level node in the power system, effectively incorporating this new obligation on TNSPs into existing planning, investment and regulatory processes for the provision of prescribed transmission services
- removing the “do no harm” obligations for generator connections, instead TNSPs would take new connections into account when procuring services to meet the fault level standard

- increasing the options available for TNSPs to address system strength issues, and
- suggesting transitional arrangements from the current framework to a new approach.

These changes would address the three key problems with the current arrangements identified above. The changes would:

- provide the ability to manage system strength issues in a well-coordinated and considered manner, utilising scale efficient solutions where possible and improving the efficient operation of the transmission network over the longer term
- allow generators to connect to the power system more quickly and at lower cost, significantly reducing the commercial risks they are exposed to, and
- reduce the risk of overuse of costly market interventions as emerging issues would be addressed in a more proactive manner.

Collectively these benefits would provide significant savings for end use customers, which are likely to be in the order of hundreds of millions of dollars over the medium term. This would also represent a significant reduction in total system costs, which would contribute to meeting the national electricity objective.

2. Relevant background

2.1 System strength

System strength is a term used to describe a number of factors that together contribute to power system stability, particularly as it relates to the control of voltage. Specifically, it relates to the ability of the system to return to stable operating conditions following a disturbance, such as a physical fault on the power system.

System strength in the NEM has predominantly been provided as a by-product of synchronous generation. In contrast, present inverter-based asynchronous generation (largely made up of wind and solar generating units) requires a certain level of system strength from the grid for stable operation. Accordingly, as the power system transitions away from synchronous generation, and towards asynchronous generation, some areas of the power system are experiencing lower levels of system strength. Declining system strength can affect the stability and dynamics of generating systems' control systems. This can inhibit the ability of the power system to remain stable under normal conditions and return to steady-state following a disturbance.

System strength indicates inherent local system robustness to disturbances. When considered as a service, system strength represents a complex interaction of electrical and mechanical elements, including, but not limited to, fault levels and synchronising torque.

There are a range of measures that have a relationship to system strength, including fault level, short circuit ratio (**SCR**) and the ratio of reactance to resistance (**X/R ratio**). The connection of inverter based generating units to the power system can impact some of these measures, for example by eroding fault level or SCR.

2.2 Current framework

The current framework for managing system strength in the power system was introduced by the AEMC in the *Managing power system fault levels rule* in September 2017.

Under this framework AEMO is required to determine fault level nodes in each region of the NEM and for each node set minimum fault levels that are necessary for the power system to be maintained in a secure operating state. Depending on the circumstances, different parties may be responsible for procuring/providing system strength services to address any emerging or emergent issues.

Following the determination of system strength requirements for each region, AEMO must undertake an assessment of any fault level shortfall. If AEMO assesses that there is, or is likely to be, a shortfall, it is required to publish a notice and give it to the relevant TNSP. This notice must specify:

- the extent of the fault level shortfall, and
- the date by which the TNSP must provide services to address the shortfall (the services to address the fault level shortfall are "system strength services"), which must not be earlier than 12 months after the notice is published (unless otherwise agreed).

After receiving a notice from AEMO declaring a shortfall, a TNSP must make system strength services available to AEMO in accordance with the specification in the notice. These services must cover the system strength requirements for the region and must be provided by the date specified by AEMO. When procuring these services, a TNSP is required to identify and implement the least cost option or combination of alternatives.

Once the additional system strength services have been supplied, AEMO is able to enable these services to maintain the secure operation of the power system in that region.

Separately, new connecting generators must “do no harm” to the level of system strength necessary to maintain the security of the power system.

When a new generator is negotiating its connection with the relevant network service provider (**NSP**), the generator is required to undertake a system strength impact assessment to assess the impact of the connection of the generating system on the ability of the power system (including other generating systems) to maintain stable operation including following any credible contingency event or protected event.

Where it is determined that the connection of the new generating system would have an adverse impact on the stability of the power system (i.e. would “do harm”), the connecting generator and NSP agree:

> the NSP will undertake system strength connection works, or
> the generator will implement a system strength remediation scheme.

The system strength connection works or remediation scheme effectively mitigate the incremental impact of the connection on the security of the power system. The connecting generator is required to fund the costs associated with providing system strength services.

2.3 Related projects

TransGrid is aware of a number of review and rule change proposals either already underway or being contemplated that relate to the management of system strength on the power system.

> The Energy Security Board’s (**ESB**’s) *post-2025 market design project*, which is among other things considering arrangements to ensure system security and resilience in the power system in the long term. The ESB has also been asked to provide the COAG Energy Council with advice on immediate measures to ensure reliability and security of the electricity system in March 2020.
> Following on from its *Investigation into intervention mechanisms and system strength in the NEM*, the AEMC is progressing a review into system strength issues on the power system, which is considering the operation and effectiveness of the system strength framework in the NEM.
> A rule change proposal to the AEMC from Hydro Tasmania for the creation of synchronous services markets that would operate alongside dispatch of the NEM wholesale market, which would include inertia and system strength services.
> The ESB’s consultation on draft integrated system plan (**ISP**) rules, which will embed AEMO’s ISP into the rules framework. This appears likely to include processes for AEMO to conduct whole of system planning related to power system needs over a 20-year planning horizon, including needs related to power system security such as system strength.

These projects vary in scope and in the role they would play in the development of rules governing the operation of the NEM. For example:

> the ESB’s consideration of system security arrangements, and the AEMC’s investigation of system strength issues, are unlikely to result in immediate changes to the arrangements for ensuring sufficient levels of system strength on the power system, and
> the rule change proposed by Hydro Tasmania relates principally to the efficient provision of existing inertia and system strength services on the power system, and does address the full scope of issues related to system strength, detailed below.

More generally, none of these processes represents an appropriate avenue to quickly implement changes to improve the management of system strength on the power system. This rule change proposal is required as a matter of some urgency to address the rapidly emerging issues with the current framework (described below).

3. Issues with current arrangements

3.1 Issues with current framework

The current arrangements for managing system strength on the power system are creating inefficient investment in system strength services, increasing the cost of generator connections, and increasing risks and costs of secure power system operation.

While there is limited experience with the current framework, given it has only been in operation for a short period, TransGrid is well positioned to observe that a range of poor outcomes for consumers are emerging. These poor outcomes are serving to increase whole-of-system costs and, in turn, final prices. The three principal issues are:

- the inability to coordinate the procurement of system strength services
- the additional time and cost for connection of new generation to the power system, and
- increased risks of costly interventions in the operation of energy markets and the power system.

The “do no harm” aspects of the current framework mean that connecting generators are required to address their impact on the power system by implementing system strength remediation schemes. We have observed that the system strength remediation schemes currently being implemented are not well coordinated or optimised, with little incentive for competing generators to work together. Assets that provide system strength services are being overbuilt by subsequent connecting generators as they cannot rely on the assets built by earlier generators being in operation. Each time this occurs tens of millions of dollars in unnecessary costs are passed on to consumers (see further detail on these costs in **Section 5.1** below). We expect this impact to broaden as system strength remediation schemes proliferate across the power system.

This issue extends beyond coordination between concurrently connecting generators. System strength can be provided by changing network conditions, such as reducing impedance on the network. The current arrangements do not allow for an efficient coordination of the provision of system strength services between network and non-network elements. The arrangements also do not allow for efficient procurement of system strength services together with other services that TNSPs are required to provide, such as inertia or voltage control.

Additionally the “do no harm” aspects of the framework are increasing the cost of generator connections, including at times through significant delays in connection. Determining appropriate system strength remediation schemes can be time consuming and costly. Ordering and commissioning equipment to provide system strength services can significantly delay connection and energisation of new generators. This results in significant added risks and costs for connecting generators, passed on to consumers through wholesale market costs (see further detail on these costs in **Section 5.1** below).

The current framework is reactive, not proactive. When considering whether to declare a system strength shortfall, AEMO is not able to take into account anticipated new generator connections. TNSPs can only procure system strength services in reaction to receiving a shortfall notice from AEMO. Further, new connecting generators must address their own impact on the system in an *ad hoc* fashion, reacting to what the TNSP determines is appropriate for their connection to “do no harm”.

This reactive nature of the framework has led to system strength shortfalls arising with little warning, in some areas causing an extended and inefficient reliance on market interventions to maintain power system security. These interventions are costly for consumers because the system strength constraint must be managed by:

- requiring consumers to pay compensation for higher cost synchronous resources to be dispatched (such as has occurred in south Australia), or

> removing a portion of lower cost generation from the system (such as has occurred in North West Victoria and South West NSW).

The impact of operating the power system under these constraints is considerable. The additional costs consumers face can include both compensation to generators directed to operate when they otherwise would not, as well as costs faced through broader impacts in the wholesale market. In aggregate these costs can amount to hundreds of millions of dollars per year (see further detail on these costs in **Section 5.1** below).

While these three issues are of greatest concern, **Table 3.1** below explores a broader range of issues and their drivers in more detail.

Table 3.1 Issues with current arrangements

Outcome	Cause	Details
Inefficient investment in equipment and system strength solutions	"Do no harm" obligations	• Implementation of multiple smaller system strength management solutions (such as installation of synchronous condensers), driven by uncoordinated generator led investments are, are more costly the implementation of fewer scale efficient solutions • The location and operation of synchronous condensers is not optimised for the shared network as there is no effective coordination between connecting generators on system strength remediation works • When a generator begins the connection process it does not know if it will be the generator that pushes the system below the minimum system strength level, requiring expensive remediation works. This risk is outside the connecting generator's control, does not provide a good locational signal for investment, and adds a premium to the returns expected by investors on such projects • There is little ability to gain efficiencies from coordinating the procurement of system strength services with the procurement of other related services that the jurisdictional planner must provide, such as inertia and voltage control • It is unclear whether planning and investment frameworks for the provision of prescribed transmission services allow for system strength services to be included as part of a renewable energy zone
	Minimum system strength levels set by AEMO, with AEMO forecast shortfalls to be addressed by TNSPs	• The minimum fault level required to be set by AEMO is sufficient to ensure system security at a point in time. Due to the reactive nature of the current framework, rapid changes in the power system, together with inherent difficulties in forecasting changes in system strength, make it unlikely there will be sufficient time for networks to conduct appropriate cost-benefit analyses to support the procurement of the most efficient overall solution to address a shortfall (without relying for an extended period on expensive market interventions) • The current arrangements may not provide the most efficient ability or incentives to invest in and utilise emerging technologies to address system strength issues
	System strength	• Requirements for initial and detailed system strength assessments are onerous and add to existing modelling challenges for connections

Inefficient connections	modelling requirements	(which include the need to update modelling each time a competing generator is committed). This adds both time and cost to connections • The process for initial and detailed system strength assessments is not workable because generators do not have ready access to detailed power system models in order to perform the wide area PSCAD studies necessary to be able to develop and propose system strength remediation approaches
	"Do no harm" obligations	• There are significant lead-times for ordering, delivery and connection of synchronous condensers. This can add significant time and cost to connections when this equipment is required as part of a system strength remediation scheme • The rules do not contemplate the registration of synchronous condensers that are not located behind the connection point for a connecting generator, however this is relatively common in practice. Without such arrangements it is difficult to negotiate performance of equipment and there may be gaps in compliance arrangements for the power system if work-arounds are used for registration
Increased risks and costs in power system operation	Minimum system strength levels set by AEMO and obligation on AEMO to forecast	• As noted above, the minimum level of system strength set by AEMO is sufficient to ensure system security at a point in time, with no buffer. Rapid changes in the power system (e.g. due to unanticipated generator entry or exit), together with the difficulty in accurately forecasting system strength levels, are likely to result in periods of time where costly market interventions (directions or constraints) are needed to ensure security is maintained

	"Do no harm" obligations	• Proliferation of system strength remediation schemes (including synchronous condensers owned by third parties as well as tripping schemes):
		  ○ creates additional risk of adverse interactions
		  ○ adds to the complexity of modelling the system, which adds costs to new connections as well as power system operations
		  ○ adds complexity to conducting maintenance works on network elements in the power system, which also adds cost
		• Where generators are procuring system strength services, there are significant barriers to the coordination of this investment with the ability to provide other services, such as voltage control or inertia

	No existing arrangements	• There are many existing generators on the power system with equipment performance and tuning that may be contributing to the high cost of system strength remediation. There is currently no clear process to facilitate the re-negotiation of the tuning of existing equipment on the power system (thereby avoiding investment in the provision of new system strength services) where such re-negotiation would be a more efficient approach

4. Proposed changes and rationale

4.1 Proposed changes

To address the problems described above, TransGrid proposes several changes to the framework for management of system strength on the power system. While we considered a range of options, including market driven methodologies and approaches to better coordinate investments in system strength services by connecting generators, we considered that none of those alternative approaches solved the three key problems with the current rules.

The changes proposed would require TNSPs to plan and operate their networks to meet an independently set fault level standard at nodes defined by AEMO. The fault level standard would be a probabilistic standard (like the Reliability Standard) taking into account the relative costs and risks of over- versus under-investment in system strength services. This framework would allow TNSPs to coordinate the provision of system strength services to meet the fault level standard. This would avoid generators investing incrementally in isolation or TNSPs having to react to a system strength shortfall notice, losing some of the benefits of coordination.

Generators would largely be freed from requirements to remediate their impact on the system strength of the power system, being able to rely on the TNSP meeting the fault level standard at the relevant node. However, the generator must still negotiate and meet its performance standards where they connect. Generators are therefore incentivised to locate where they can be sure the fault level will support their connection, which is likely as AEMO must take into account future generator connections when determining where to locate fault level nodes and the minimum fault level at each node. There is a disincentive for generators to locate remote from a node, as there may be costs to provide their own system strength in those locations in order to be able to meet their generator performance standards.

If implemented, the proposed changes would deliver a more proactive and long-term approach that should address the key problems with the current arrangements quickly and effectively. Specifically, they would result in:

> fewer, more scale efficient, system strength solutions that are better coordinated because TNSPs are well placed to coordinate the procurement of system strength services
> improved efficiency of and less costly generator connections because generators would be freed from obligations to negotiate, design and deliver bespoke system strength remediation schemes prior to connection, and
> reduced risk that costly market interventions are required for extended periods as the arrangements would allow more proactive management of system strength as well as be flexible to address rapidly emerging system strength issues.

The changed framework would operate broadly as follows:

Primary obligation to maintain system strength

> AEMO would be required to identify system strength nodes in each region of the power system, taking into account the forecast entry and exit of generation on the power system
> AEMO would be required to define and set a minimum fault level for each node
> The AEMC's Reliability Panel would be required to define a fault level standard for the NEM (or for each region or node, whichever is the most appropriate), which would form a system standard in Schedule 5.1 of the NER. The fault level standard would be a probabilistic standard requiring the fault level at the relevant node to be maintained above the minimum fault level for most of the time (analogous to the existing probabilistic reliability standard). The Reliability Panel would set the standard taking into account the relative respective costs of over and under-investment, namely:

  - specifying a stricter standard would require additional upfront expenditure on the procurement of system strength services, which would be passed on to consumers as higher prices, whereas
  - specifying a looser standard would require less upfront expenditure on the procurement of system strength services, but would give rise to additional costs associated with lower levels of system strength (such as risks of market interventions and costs of new generator connections)
- TNSPs would be required to plan and operate their networks to meet the fault level standard, taking into account typical dispatch patterns of current generation, as well as the ISP scenarios forecasting exit and entry of generation. This obligation would be included as a network performance requirement in Schedule 5.1 of the NER
- TNSPs would procure system strength services in accordance with ordinary network planning and investment processes, disciplined by the economic regulatory framework. A fast-tracked regulatory investment process may be required to address rapidly emerging system strength issues in the event that generation entry and exit occurs outside of the scenarios forecast in the ISP, or where new generation commits to connecting in a location that is remote from a system strength node and the level of system strength is not sufficient to facilitate the connection

Secondary obligation to maintain system strength

- AEMO would retain a reserve obligation to declare a system strength shortfall as a Network Support and Control Ancillary Services (NSCAS) gap and, as a last resort, would procure system strength services to fulfil the NSCAS gap if it remained unmet

Obligations on generators

- Generators would be required to conduct system stability assessments as part of the negotiation of their performance standards on connection.

Further changes may be considered

In addition to these proposed arrangements, there may be merit in the AEMC considering further changes that could improve the effectiveness of the system strength framework, including:

- approaches to ensure technology neutrality in the provision of system strength services, including:
  - changing the definition of *system strength service* in Chapter 10 of the NER, and
  - arrangements to incentivise the development and use of emerging technologies to address system strength issues, such as batteries and grid forming inverter technologies
- introducing a new system strength performance standard in Schedule 5.2 of the NER, requiring a connecting generating system to be capable of stable operation down to at an SCR of 2 at its connection point
- arrangements to best facilitate the efficient procurement of system strength, where required, in the distribution network
- introducing a clear process for a TNSP to require existing and prospective generators to negotiate, in good faith, changes of performance to existing generating systems (and other relevant plant connected to the power system) to reduce the impact of low system strength conditions or adverse interactions between generating systems, where the costs of doing so would benefit consumers. The AEMC should consider whether these costs should be paid by TNSPs and passed through to consumers, or paid by the connecting generator(s)
- requiring TNSPs to charge connecting generators for the provision of system strength services, rather than passing the costs of that service directly through to consumers through transmission use of service charges, and
- appropriate mechanisms (such as market based mechanisms) to best facilitate and potentially value the utilisation of existing sources of system strength on the power system.

Transitional arrangements

Transitional arrangements would need to be carefully considered. Two critical issues that arise are:

> the process within a current regulatory period for a TNSP to begin planning, investment and for the AER to test efficient expenditure to meet the minimum fault level standard, while meeting the need to act quickly to address emerging system strength needs on the power system, and
> the arrangements that apply to existing equipment that has been installed on the power system by connecting generators to remediate their impact on system strength, including whether ownership and operation of this equipment could be transferred to the TNSP by mutual agreement (e.g. for a depreciated value).

As set out in more detail below, TransGrid considers these changes would address the issues noted above and would contribute to the national electricity objective (**NEO**) because the identifiable benefits would appear to outweigh comfortably the likely incremental costs.

TransGrid has not provided a draft rule to implement these proposed changes because this detailed rule drafting is likely to be best conducted by the AEMC once it has formed its views on the appropriate policy response to the issues raised above.

4.2 Rationale for the proposed changes

The changes TransGrid has proposed would address the problems associated with the current arrangements by enabling system strength issues to be managed in a well-coordinated and considered manner that reduces whole-of-system costs. Specifically, the proposed changes would:

> require TNSPs to identify and address emerging system strength issues in advance of their becoming a material security issue
> provide more scope for scale efficient and well-coordinated solutions to be put in place, and
> provide new tools and incentives for efficient overall provision of system strength services.

Moreover, the proposed changes represent a logical extension of the existing regulatory framework. This approach would integrate the obligation to address system strength issues within TNSPs' ordinary planning and regulatory frameworks that apply whenever they provide other "backbone" power system services, such as thermal capacity and voltage control services.

4.2.1 Coordinating system strength services and investments

TransGrid considered a range of alternative options for the procurement of system strength services for the power system. This included market driven approaches to drive merchant investment in system strength services, as well as changes to facilitate generators coordinating investments in system strength remediation. Neither alternative addressed adequately the need to coordinate the procurement of system strength services, because:

> market driven approaches for providing system strength services are unlikely to deliver a well-coordinated mix of solutions and may suffer from a fundamental lack of liquidity, due to the physical characteristics of system strength, and
> the divergent commercial imperatives of connecting generators are likely to be insurmountable, even with new regulatory obligations to 'negotiate in good faith' to coordinate the procurement of system strength services.

The lack of the ability to effectively coordinate solutions to address system strength issues is the most problematic aspect of the current arrangements. It is the biggest source of inefficiency and the principal reason that consumers are bearing unnecessary costs in the form of higher prices. The proposed changes address this problem by placing the obligation to address system strength issues in a prudent and efficient manner (just like any other expenditure item) squarely upon the jurisdictional planner (usually the TNSP and hereafter referred to as such).

TNSPs are the logical candidate to coordinate the planning and procurement of system strength services because they:

> are well placed to forecast emerging system strength issues across their networks, since already they use similar forecasting processes to monitor and address emerging thermal and voltage constraints
> have detailed information on generator connection enquiries within their own networks, as well as those forecast in other NSPs' networks through joint planning with DNSPs and other TNSPs, which would enable system strength solutions to be coordinated and optimised across regions
> are well positioned to determine the appropriate scale, location and timing of any investments in assets to provide system strength services to optimise the value they provide to the shared network
> can operate any assets that provide system strength services on behalf of the shared network, as opposed to third parties that are driven by separate commercial imperatives unconstrained by network reliability standards
> can rigorously test the appropriateness of network and non-network options to procure efficient and appropriate system strength services, and
> can consider the coordination of procurement of system strength services with other network services that can be technically interrelated (such as inertia, voltage control and thermal capacity).

TNSPs are well placed to forecast system strength needs using generator entry and exit assumptions built through the scenario planning conducted under the ISP. However, as noted above, TNSPs are also best placed to understand when and how the physical power system is departing from those assumptions, and to react accordingly.

It is important that TNSPs are able to forecast emerging system strength needs so that the procurement of those services can be considered together with other aspects of their ongoing work programme. This would make the overall approach to addressing system strength issues more proactive and would facilitate the efficient procurement of system strength services together with other activities, such as network augmentation, maintenance and the procurement of related services (such as inertia and voltage control).

4.2.2 Promoting efficient procurement of system strength services

The proposed changes would promote efficient investment in system strength services through:

> independently setting the fault level standard
> applying existing network planning and investment frameworks
> applying existing economic regulatory frameworks, and
> leaving open the possibility of introducing further tools and mechanisms (including market based mechanisms) where they would promote efficient procurement of system strength services.

Setting the fault level standard

TransGrid suggests that the fault level standard be set independently by the Reliability Panel (as occurs already for the Reliability Standard). The AEMC should also consider how critical information from AEMO should feed into the process of setting the fault level standard.

The probabilistic standard defined for the NEM (or alternatively for each region or node) would be set so as to balance the respective risks and costs of over-investment versus under-investment in system strength services. As indicated earlier:

> specifying a stricter standard would require additional upfront expenditure on system security measures which, ultimately, would be passed on to final customers in the form of higher prices, whereas

- specifying a looser standard would require less upfront expenditure, but would give rise to additional costs associated with lower levels of system strength (such as risks of market interventions and costs of new generator connections).

These respective costs and risks may vary – potentially substantially – depending on the location of the relevant fault level node. The implications of falling below the minimum fault level will be different depending on the location. For example:

- in one location, falling below the minimum fault level may require AEMO to direct on synchronous generation, whereas
- in another location, AEMO may be required to constrain the output of asynchronous generation as there is no synchronous generation to provide system strength services in the region.

The cost outcomes for consumers of each of these scenarios will vary. This will likely change the balance between the costs and risks of over versus under-investment in system strength services. Consequently, the AEMC should consider whether it would be most appropriate to set a single fault level standard across the NEM, or whether it would be more sensible to define separate fault level standards for each region or even each fault level node. The former option would be simpler and cheaper to implement, while the latter options would allow the locational variances in the relative costs of over- and under-investment to be taken into account.

Applying existing frameworks to promote efficient procurement of services

The proposed rule change represents a logical extension of the existing regulatory framework for TNSPs. Under the proposed arrangements, TNSPs would plan and procure system strength services in much the same way that they provide other prescribed transmission services. Namely, they would identify the most cost efficient means of meeting the applicable fault level standard by:

- identifying emerging system strength needs
- weighing the costs and benefits of a range of options, including non-network options
- consulting at each stage with stakeholders, and
- obtaining the endorsement of the AER that the cost benefit analysis has been conducted appropriately, and the approval of the AER of efficient expenditure to meet the identified need.

TNSPs are uniquely placed to plan and procure efficient system strength solutions. Strategic inter-regional system strength needs would be signalled through AEMO's ISP and joint planning between TNSPs. TNSPs would plan to address the system strength needs arising from the entry and exit of generation as forecast in ISP scenario planning, noting also that AEMO's obligations in preparing the ISP may need to evolve to better support this function. The ISP would play an important role in providing consistency across jurisdictions in the forecasts that TNSPs use for their jurisdictional planning. Specific emerging system strength needs would be flagged in TNSPs' annual planning reports, which would also signal opportunities for providers of non-network system strength services (such as operators of synchronous generators or grid scale batteries).

Planning for system strength shares common activities with those already undertaken by Jurisdictional Planning Bodies in the annual planning review process. These include forecasting generation and demand at a locational level, and calculating fault levels to inform equipment ratings.

The existing economic regulatory frameworks for TNSPs can be easily adapted to encompass the provision of system strength services. The strong incentive properties – and numerous regulatory safeguards – contained within those frameworks would be expected to result in efficient investments in such services. The arrangement would function broadly as follows:

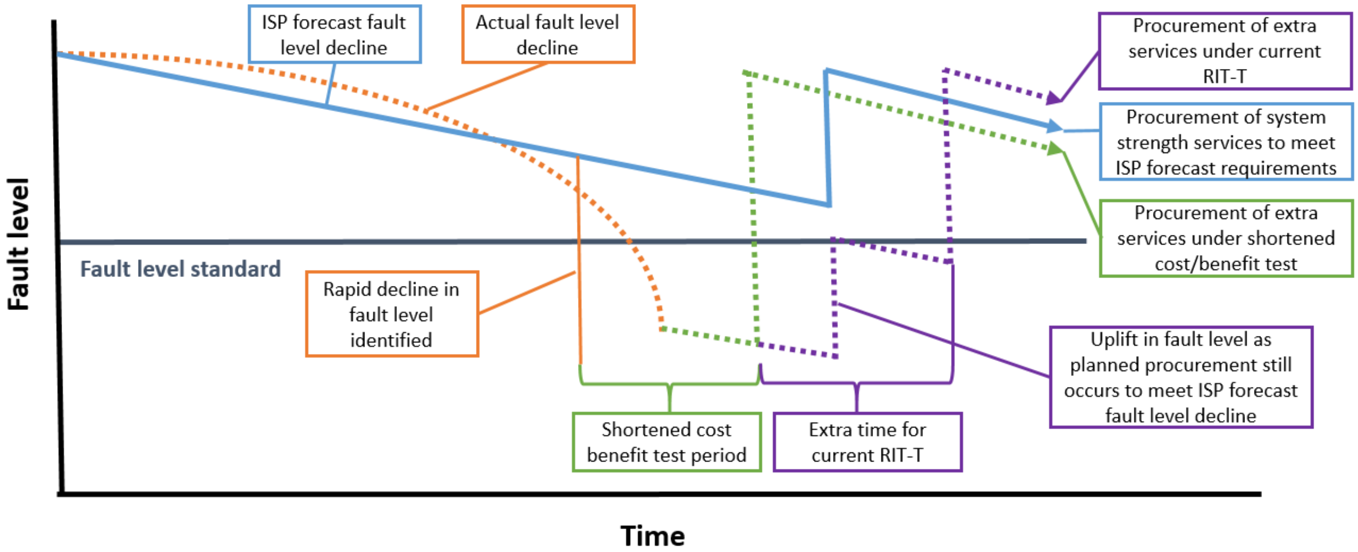
- projections of system strength needs would be forecast consistent with ISP scenarios and considered within the regulatory determination cycle as part of the regular periodic regulatory determination process

> if a need arises out of cycle (as could occur where the power system develops ways not forecast in ISP scenarios), it would be included as a contingent project in a regulatory determination
> regardless of whether an expenditure need crystallises within a TNSP's regulatory determination, or out of cycle, the options would be required to be carefully considered through the regulatory investment test for transmission (**RIT-T**) process, and
> the RIT-T process would expose the options to stakeholder and AER scrutiny and involve explicit consideration of the costs and benefits of the preferred option against non-network alternatives.

It is likely that some system strength needs will arise rapidly, including potentially arising due to a rapid increase in generator connections or specific generator connections that are more remote from a system strength node. In these circumstances it is likely that an alternative and shorter cost-benefit analysis process would be appropriate. The AEMC should consider what arrangements should be in place to test efficient expenditure and options to address these rapidly emerging system strength needs that may occur.

Figure 4.1 below illustrates the potential benefits of implementing a shorter cost-benefit analysis to address system strength that declines more rapidly than forecast in the ISP. Such arrangements may shorten the period where the power system is at risk of operation under costly market interventions (i.e. the time spent below the fault level standard). It may also allow better coordination of the procurement of services. Note the shortened cost benefit assessment illustrated below could allow better coordinated procurement (the dotted vertical green line), whereas the current longer cost-benefit test could result in more piecemeal procurement of services (the dotted vertical purple lines).

Figure 4.1 – options to address rapidly declining system strength beyond forecast declines



The AEMC should also consider any interactions between the investment process for urgently procuring system strength services and the potential for system strength remediation projects to be specified by AEMO as actionable ISP projects.

The proposed changes would also expose any expenditure to meet system strength needs to the existing expenditure efficiency schemes. These include the efficiency benefit sharing scheme and the capital efficiency sharing scheme. These mechanisms augment the existing incentive properties of the regulatory framework by providing additional motivation for TNSPs to pursue efficiency gains, the benefits of which are shared with customers in the form of lower prices.

Further tools and mechanisms to promote efficient procurement of system strength services

The AEMC should consider whether the efficient procurement of system strength services can be incentivised through changes to the Service Target Performance Incentive Scheme (**STPIS**) that applies to TNSPs. TransGrid has not fully considered whether this is feasible. However, it may be appropriate for the AEMC to investigate this option to see whether it has the potential to enable a more efficient delivery of system strength services.

The AEMC may also wish to consider the introduction of new tools to enable system strength issues to be dealt with more efficiently. For example, it may be more cost effective to address certain system strength issues if TNSPs were able to require the re-negotiation in good faith of the performance and tuning of existing equipment on the power system. This should only occur where the long-term benefits to consumers of such an exercise were to outweigh the incremental costs.

4.2.3 Locational signals for investment in new generation

The current arrangements sought to implement a causer pays framework for generator connections that impact the security of the power system, sending efficient locational price signals to generators. In principle, recovering incremental costs from causers can lead to efficient outcomes. However, that has not proved to be the case in practice. The complex interactions between equipment connected to the power system means that it is difficult for many generators to model with certainty the impacts of their connections or remediation schemes on system security – particularly when conditions are developing rapidly (e.g. if other competing generators are connecting as well). The "do no harm" framework has consequently – and inadvertently – added time, cost and risk to the connection process and muddied locational investment signals.

Nevertheless, there are sometimes clear-cut cases where the potential for adverse effects upon system security is relatively obvious. It is clear that there are some areas of the power system where it is reasonably evident that a new connection will contribute to the need for additional system strength services in light of the current system conditions and known interest in connection. Given this, there may be merit in considering approaches that socialise the cost of procurement of system strength services among multiple generators in a region. However, a number of difficulties would need to be overcome to implement such an approach, including the difficulty of:

- introducing a new charging framework for generators to pay for incremental transmission investment – which would inevitably prove complex and controversial
- determining which assets or services are contributing to the provision of system strength services (noting that network impedance also contributes to system strength)
- determining which generators (and in which proportions) are causing the need to procure system strength services, including the challenges associated with distinguishing (or not, as the case may be) between new versus existing generation, and
- determining the proportion of system strength services that are remediating system strength issues caused by connecting generators as opposed to issues caused by the exit or changed dispatch patterns of synchronous generation.

These matters would not be straightforward to address, particularly in the near term.

For these reasons we consider that, on balance, the costs of implementing a causer pays approach to the procurement of system strength services are likely to materially outweigh the benefits - at least in the short term. Due to the imperative to quickly make significant improvements to the current framework, we suggest the AEMC move to implement the changes we are proposing in the immediate term and return to consider this issue in more depth at a later stage.

Regardless, there are some aspects of the proposed framework that promote appropriate locational decisions from generators. Under the proposed arrangements generators would be required to negotiate and meet performance standards. If a generator chooses to locate far from a fault level node it may be difficult or costly to meet the performance standards required for their connection to operate stably. Accordingly, they may need to invest in equipment that provides system strength locally (such as a synchronous condenser) to facilitate stable operation. Generators that locate closer to a fault level node, on the other hand, should be able to meet required performance standards without investing in equipment that provides system strength, because their connection should be factored into the procurement of system strength services by the TNSP.

4.2.4 Removing barriers to efficient connection of generation

The changes we are proposing would remove the positive obligation on connecting generators to "do no harm" to power system security. They would also require TNSP planning and procurement of system strength services to take into account the anticipated impact on the power system of exit and entry of generation. These changes should significantly reduce the costs of connection for new generation, including by:

- removing the requirement for the proposal and negotiation of a system strength remediation scheme and its attendant costs (which is a very time consuming and complex exercise – particularly for generators)
- removing the risk of incurring substantial costs associated with a resulting obligation to implement a system strength remediation scheme on connection (and associated financing costs), and
- ultimately, making it less likely that they will be denied access due to low system strength conditions.

Under the proposed rule, generators would still be required to conduct a system stability assessment and meet the levels of performance required under their agreed performance standards. However, that assessment would be significantly more practicable and manageable than the exercise required currently because its entry would have been already anticipated and accounted for in a TNSPs investment programme.

We consider the TNSPs provision of system strength services would be analogous to the provision of other services that relate to the stability of the power system. As such, generators will be entitled to expect that the fault level standard is met at the relevant node, in the same way they expect other system security parameters to stay within defined limits (voltage) or standards (frequency). As with other constraints (such as thermal capacity or voltage control capability), it is possible that dispatch constraints could be applied to generators until procurement of system strength services is justified and implemented by the TNSP.

4.2.5 Appropriate roles and responsibilities

The changes we are proposing seek to allocate roles and responsibilities appropriately and consistently with current arrangements and future developments. Namely, under the proposed arrangements:

- AEMO's role would be determine the location of fault level nodes and the minimum fault level at each node required to keep the power system secure. This is consistent with AEMO's responsibility to maintain power system security.
- The Reliability Panel's role would be to determine the level of the fault level standard. This is consistent with the Panel's role in providing independent oversight of a range of functions for the NEM, including the analogous function of setting the Reliability Standard.
- TNSPs' roles would be to plan and procure system strength services to meet the fault level standard. This is consistent with, other than in Victoria which may require special attention, TNSPs' roles as jurisdictional planners and incumbent transmission license holders entrusted with the efficient development of the transmission system in each jurisdiction.
- Generators would be required to meet their performance standards and would choose where to connect taking into account the risks of being constrained (whether due to thermal, system strength, or other constraint). This is consistent with the current access regime in the NEM.

More broadly the proposed arrangements are consistent with AEMO's role as system planner, through its ISP, which informs jurisdictional planning and coordination of investments. This would bring arrangements for the planning and investment to provide system strength services into line with arrangements to provide other backbone power system services, such as thermal capacity and voltage control.

5. Costs and benefits and NEO contribution

5.1 Costs and benefits of the proposed rule

TransGrid considers the long-term benefits of the proposed rule would significantly outweigh the costs. Although the benefits and the costs are difficult to quantify with precision, the information available suggests that addressing the key problems with the current arrangements in the manner proposed would yield a significant overall net benefit.

Benefits

The proposed rule change would allow system strength issues to be managed in a well-coordinated and considered manner that reduces whole-of-system costs and, consequently, prices for final customers. The chief benefits of the proposal – many of which take the form of avoided costs – would be the following:

- the facilitation of more coordinated, scale-efficient delivery of system strength services because TNSPs would be better placed to deliver efficient system strength solutions than multiple generators acting in an uncoordinated fashion
- a more efficient balance would be achieved between the cost of solutions to deliver system strength services and the costs of market interventions to manage the power system securely for short periods
- more efficient generator connections to the power system would be achieved through the removal of the impracticable requirement to design and deliver bespoke remediation schemes and the various other adverse attendant impacts of the “do no harm” requirement, and
- an improved overall ability to operate transmission networks efficiently due to more flexible arrangements to respond to rapid changes in system strength on the power system – including potentially by providing new tools and incentives for efficient operation.

The cost inefficiencies that can arise from the current, uncoordinated way in which generators invest in bespoke remediation schemes are undoubtedly considerable. Consider the following recent real world example:[1]

- Generator A was required to install a 50 MVAr synchronous condenser to address the impact of its connection, i.e., in order to “do no harm”
- Generator B connected subsequently and, to address its incremental impact, theoretically only needed to install an additional 15 MVAr synchronous condenser, however
- because Generator B could not rely on the 50 MVAr installed by Generator A being available to it when needed (and no commercial arrangement could be struck), it was required instead to install a 65 MVAr condenser in the same substation as the existing asset, needlessly duplicating the earlier investment.

The assets are not sized efficiently, not located appropriately and not operated to support the most efficient ongoing use of the shared network. The unnecessary expense resulting from this one case study run into the tens of millions of dollars. This is an early example of the unnecessary additional costs that would be

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[1] Note, these figures have been changed slightly to further de-identify the example to ensure confidential information is not disclosed. The case study remains accurate and representative of the real world example. More generally, recent work by Baringa and DIGSilent Pacific for the Australian Renewable Energy Agency has found that coordinated approaches to addressing system strength issues can be significantly cheaper than uncoordinated approaches to achieve the same ends. The research was conducted in the context of considering the system strength needs in the development of renewable energy zones. The findings noted the scale of the benefits of coordination also appear to depend on the geographical location and technology used to address system strength issues. See Baringa and DIGSilent Pacific, *Development of Renewable Energy Zones in the NEM: key findings, Report for ARENA*, January 2020.

increasingly faced across the NEM as the current arrangements continue. As system strength remediation schemes proliferate across the power system, the unnecessary duplication of investment in system strength remediation works could add to hundreds of millions of dollars in the medium term. These duplicated costs (that are paid for ultimately by final customers in the form of higher prices) would be avoided under the proposed changes.

The benefits that would flow from improving the efficiency and timeliness of generator connections on the power system are similarly difficult to quantify. Nevertheless, here again the likely sources of benefits are relatively easy to conceive and can be expected to be significant. For example, the proposed changes would reduce the time and expense for most generators to connect, because, as noted above, they would:

> reduce the likelihood of a generator being denied access (absent a remediation scheme) due to low system strength, since the relevant TNSP is more likely to have planned for that entry and factored it into its investment programme in advance, and
> remove the "do no harm" requirement and the attendant complications and costs associated with proposing, negotiating and implementing system strength remediation schemes (including significant project delays and equipment costs).

This would result in quicker, cheaper connection and energisation, which should translate into clear benefits for final customers because the upshot is reduced delivered energy costs. The cost efficiencies here is directly passed through to consumers through the lower cost energy purchased by retailers and large customers in the long-term financial arrangements (such as PPAs) that ordinarily underpin the development of new generation projects. It is difficult to measure with precision these benefits, however again it would likely be in the order of hundreds of millions of dollars in the medium term.

Considerable benefits would also flow from the likely reduction in the use of costly market interventions. The costs of such interventions in South Australia and in the Western Murray region of NSW and Victoria have been significant. For example, in February 2019, ElectraNet estimated the costs of interventions to manage system strength in South Australia at around $34 million per annum.[2] However, the rate of interventions has subsequently turned out to be higher than anticipated in that analysis. Across the whole of the NEM, the total annual costs of such interventions would almost certainly measure in hundreds of millions of dollars – almost all of which would be avoided under our proposed rule change.

Further benefits from the proposed arrangements are also likely to flow from improved coordination between investment in system strength services and network augmentation and replacement. Advantages may also stem from the significant reduction in the complexity and difficulty in operating the power system over the long term. In summary, we consider that the potential benefits of the proposed rule change are substantial – potentially amounting to hundreds of millions of dollars of avoided costs per year.

Costs

Implementing the proposed changes would give rise to several material additional costs.

For example, AEMO would incur costs when setting minimum fault levels at defined nodes across the power system. However, those costs are likely to be low, since the work has largely already been done. There are also likely to be moderate costs involved in the development of a new fault level standard – which would be performed by the Reliability Panel. This is likely to involve time for AEMC and AEMO staff, consultant input and industry consultation.

There would also likely be material costs for TNSPs to implement the proposed arrangements. The most significant of these would be the procurement of system strength services. However, as we indicated above, one of the fundamental ideas underpinning the proposal is that these *incremental* costs are likely to be far

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2 ElectraNet, *Addressing the system strength gap in SA*, February 2019, p.4.

lower than the costs associated with the uncoordinated *ad hoc* procurement of system strength services that would be *avoided* by implementing the rule change.

TNSPs would also be likely to incur moderate additional costs developing the internal processes and frameworks required to implement the changes. However, they would not be starting from a "blank sheet of paper". Rather, TNSPs already have many existing processes for planning, investment and procurement that are likely to be readily adapted to apply to the provision of system security services. Consequently, these additional costs are also unlikely to be substantial.

For those reasons, although the proposal would give rise to several categories of additional costs, none is likely to be substantial and, in aggregate, those outlays would be comfortably outweighed by the benefits described in the previous section.

5.2 How the proposed rule promotes the NEO

When considering whether to accept the rule change proposal the AEMC must determine whether the proposed changes contribute to the achievement of the national electricity objective (**NEO**). The NEO is to promote efficient investment in, and efficient operation and use of, electricity services for the longer term interests of consumers of electricity with respect to:

> price, quality, safety, reliability and security of supply of electricity, and
> the reliability, safety and security of the national electricity system.

The proposed rule change relates to the efficient investment in, operation and use of, system strength services in the long-term interests of consumers. It relates specifically to achieving an appropriate balance between the security of the power system and the price consumers pay for that security. The proposed changes seek to explicitly achieve this balance through:

> setting the fault level standard, which guides the level of investment in system strength services toward an appropriate balance between the risks and costs of over- versus under-investment, and
> consolidating the planning and procurement of system strength services with the TNSP to maximise the efficiencies that can be achieved from effective coordination of scale efficient solutions and effective economic regulation to discipline expenditure.

The proposed rule change would contribute to the NEO by promoting all three elements of efficiency. Firstly, it would promote **productive efficiency** by enabling system security services to be provided at a reduced total cost, using facilities of more optimal scale, over the longer-term. This would achieved by avoiding the relatively inefficient costs that are expected under current arrangements, described in detail above. For example, the proposed arrangements would:

> facilitating more coordinated, scale-efficient solutions, avoiding situations such as that highlighted above where generators that were unable to coordinate instead duplicated investment
> providing for more efficient generator connections to the power system, avoiding costly delays to investment in new generation (and its attendant benefits for consumers)
> providing a more proactive approach to the management of system strength on the power system, lessening the risk of relying on costly market interventions beyond a level that would be efficient for consumers, and
> improving TNPSs' ability to operate their transmission networks efficiently, avoiding the higher costs of operating transmission networks that would be expected to occur under current arrangements.

Secondly, because the rule change would reduce the cost of providing system security services and, in many cases, result in cheaper sources of wholesale electricity coming on-line sooner, this would decrease the total cost of delivered energy. That would, in turn, result in lower prices for final customers. This would promote **allocative efficiency**. That is because, currently, demand that could have been served at prices that generate positive economic profits goes unmet, producing "deadweight loss". Specifically, by changing the current arrangements it would be possible to:

> make consumers better off, i.e., by enabling them to consume an additional quantity of electricity at the lower prices that they would not have demanded at the existing, higher prices (i.e., to increase "consumer surplus); without
> making suppliers worse off, i.e., the increased volume of electricity would be sold at price that still enabled those producers to recover their (now lower) total costs (i.e., there would be no equal-and-offsetting reduction to "producer surplus").

Third, the rule change would promote **dynamic efficiency** by better enabling the right investments to be made in system security services at the right times. The potential for inefficiently duplicative investments to occur under the status quo has been well documented hitherto. The proposed rule change would address this problem by allowing TNSPs to design and implement more optimally scaled solutions. The timing of those investments would also be superior in many instances. As we noted earlier, instead of investing in *ad hoc* remediation schemes in a *reactive* manner, the rule change would see TNSPs investing *proactively* – principally in advance of anticipated connections and/or exits.

Because investments by TNSPs would be made within the auspices of the existing incentive framework they would be strongly motivated to continue pursuing efficiencies over the longer term; most notably:

> TNSPs would be required to consider the costs and benefits of network and non-network solutions to any system security issues that they identify;
> investment proposals would be subjected to scrutiny by both stakeholders and the AER;
> the efficiency carryover mechanisms contained within the existing rules would further strengthen the incentives to invest efficiently over time; and
> the fault level target that TNSPs would be endeavouring to meet would be set independently by the Reliability Panel.

More generally, the proposed change would make the NER more flexible and enable market participants to respond more swiftly to any rapid changes in system strength on the power system – including by providing new tools and incentives for efficient operation and investment. In summary, the changes would allow system strength issues to be managed in a more economical manner, promoting productive, allocative and dynamic efficiency, thereby contributing to the NEO.

6. Contact details

This rule change proposal is submitted by TransGrid Electricity Networks Operations Pty Ltd (in this rule change proposal referred to as “TransGrid”). TransGrid’s address is 180 Thomas Street, Sydney, NSW, 2000.

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