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Australian Energy Market Commission
60 Castlereagh St
Sydney, NSW, 2000

RE: ERC0375 - Calculation of System Strength Quantity Draft Determination

About Shell Energy in Australia

Shell Energy is Shell's renewables and energy solutions business in Australia, helping its customers to decarbonise and reduce their environmental footprint. Shell Energy delivers business energy solutions and innovation across a portfolio of electricity, gas, environmental products and energy productivity for commercial and industrial customers, while our residential energy retailing business Powershop, acquired in 2022, serves households and small business customers in Australia.

As the second largest electricity provider to commercial and industrial businesses in Australia[1], Shell Energy offers integrated solutions and market-leading[2] customer satisfaction, built on industry expertise and personalised relationships. The company's generation assets include 662 megawatts of gas-fired peaking power stations in Western Australia and Queensland, supporting the transition to renewables, and the 120 megawatt Gangarri solar energy development in Queensland. Shell Energy also operates the 60MW Riverina Storage System 1 in NSW.

Shell Energy Australia Pty Ltd and its subsidiaries trade as Shell Energy, while Powershop Australia Pty Ltd trades as Powershop. Further information about Shell Energy and our operations can be found on our website here.

General Comments

Shell Energy supports the proposal contained in the draft determination to bring greater alignment between the two options for system strength remediation when connecting new generation to the grid. Equivalent calculations applied for generators who elect to pay the system strength charge and those electing self-remediation have the potential to enhance the efficiency of the market.

We agree with the assessment that the calculation of the System Strength Quantity (SSQ), as currently defined in the National Electricity Rules (NER 6A.23.5(j)), overstates the quantity of system strength consumed. This leads to inappropriately high charges for generators electing to pay the TNSP to remediate their system strength impact. This is because the current calculation does not provide the ability to utilise the stability coefficient of 1.2 as set out in AEMO's System Strength Impact Assessment Guidelines (SSAIG). The Rules therefore currently do not consider the superior capability of inverter based resources (IBRs) to operate at very low levels of system strength. Shell Energy considers that requiring AEMO to determine an appropriate SSQ methodology that is equivalent to the methodology applied to self-remediation requirements will assist TNSPs and help support efficient investment in lower-carbon technologies.

However, Shell Energy considers that aligning the calculation methodologies by updating the calculation of the SSQ does not address many of the fundamental difficulties introduced by the system strength rule change. Our

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[1] By load, based on Shell Energy analysis of publicly available data.

[2] Utility Market Intelligence (UMI) survey of large commercial and industrial electricity customers of major electricity retailers, including ERM Power (now known as Shell Energy) by independent research company NTF Group in 2011-2021.

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view is that the demand side system strength rule is a suboptimal policy initiative for the NEM. We believe that the rule that commenced on the 15th March 2023, and the proposed fast track amendments outlined in this draft determination, do not address the system needs and act as a strong disincentive for investment in solar, wind, large scale electric vehicle charging, HVDC transmission and hydrogen projects which are reliant on various forms of inverter technology to interface to the grid.

So whilst we support this draft determination and agree that it improves the current rules, we see an opportunity to significantly improve system outcomes through a re-examination of the system strength approach used in the NEM. This should be founded on a robust understanding of the technical definitions and system physics relevant to system strength.

Currently, the Rules conflate system strength with system fault level, which in turn is not correctly accounted for. The Rules also assign a cost penalty to projects according to transmission network location in a non-transparent manner which does not necessarily coincide with the physical needs of the network. A better understanding and an agreed definition of system strength requirements across the industry would lead to more effective rules and ultimately more efficient investment and lower costs to consumers.

The following discussion outlines why Shell Energy considers it necessary to revise the system strength Rule requirements to an approach which encourages the optimum mix of technologies. The revised approach should be fully transparent with respect to technical information to allow the industry to devise solutions to the voltage waveform stability issue. We would welcome the opportunity to discuss these issues with the AEMC.

Key points from the discussion include:

- The variety of technical solutions that may be required to solve system strength issues at a generation facility mean that a one size fits all approach, as is currently implemented in the Rules, is inappropriate.
- The available fault level (AFL) calculation definition has the effect of subtracting fault level contributions from grid following inverters which is inappropriate.
- The concept of AFL is inconsistent with mandating an appropriate minimum fault level.
- System strength rules should target the efficient delivery of an optimum mix of grid following, grid forming and traditional synchronous generation, all of which is appropriately tuned to avoid oscillation events due to their interactions with each other.
- Transparency and robust governance of the NSP system strength assessment process is necessary to ensure that the most appropriate control system settings can be delivered in partnership with project developers.

System Strength Discussion

The Rules refer to the obligations of a System Strength Service Provider to maintain:

- Minimum three phase fault levels; and
- Stable Voltage Waveform

Whilst there is no strict definition of System Strength in the NER or the system strength requirements methodology (SSRM), the original intent of the rule appears to have been mainly aimed at addressing convertor driven stability and/or control interactions associated with inverter-based resources (IBRs).

Minimum three phase fault levels

Refers to the minimum fault requirements to ensure devices such as protection system and voltage control equipment function correctly.

The SSRM (Section 4) lists a 7-step process for determining Minimum Fault Level requirements which includes consideration of existing requirements, protection systems, voltage control equipment needs, planned outages and adjustments for operational needs.

Stable Voltage Waveform

The Stable Voltage Waveform definition is captured within the SSRM (Section 5) and refers to four key criteria to be addressed as part of any assessment:

- Voltage magnitude
- Change in voltage phase angle
- Voltage waveform distortion
- Voltage oscillations

The equipment needed to address these issues is typically different in each case. For example:

- Control of voltage magnitude typically requires the installation of reactive plant such as STATCOM's, SVCs or capacitor banks.
- Limiting the change in voltage phase angle may require transmission augmentations or constraints on power flow changes.
- Waveform distortion may require harmonic filtering.
- Voltage oscillations are typically resolved using control system settings

It is not appropriate to apply a one-size-fits-all approach, which is currently inherent in the rules, given the diversity of responses that may be required for each of these issues.

Minimum fault level issue

The addition of generation plant to a network never results in a reduction in power system fault level. When wind and solar plant is installed in remote locations which previously had no local generation, they are necessarily increasing the fault level contribution in that local region. This is directly contrary to the effect of ΔAFL (available fault level) calculation defined in the system strength rule.

The AFL calculation definition has the effect of subtracting fault level contributions from grid following inverters. The concept of AFL (available fault level) is therefore inconsistent with mandating an appropriate minimum fault level. If applied without due consideration to any of the following power system issues, AFL may lead to dangerous outcomes for the power system. These issues include ensuring:

- the correct operation of protection systems,
- voltage control equipment operates correctly,
- that equipment remains within its fault rupture ratings,
- that the power system accelerates during faults in a manner which can be predicted and designed for, and
- that the system remains in a safe and secure state for various outage conditions.

Reductions in fault level across the power system only become an issue when significant amounts of existing generation are switched off, and accordingly it is necessary to model and plan for the impacts of decommissioning plant with a similar degree of rigour to that currently applied to the connection of new plant.

The argument that the introduction of inverter connected plant displaces traditional synchronous plant and leads to an overall reduction in fault level is weak. Inverter connected plant fault level contribution offsets the loss of traditional plant fault level in an approximate one to three ratio but this is balanced by the necessity to overbuild renewable plant in a rough ratio of three to one to account for resource capacity factors.

Accordingly, although individual scenarios need to be studied and planned for, there is not expected to be a significant change in overall system fault levels as the energy transition proceeds. We therefore believe that the concerns regarding protection operation, voltage control, equipment rupture ratings etc are overstated and can easily be dealt with using good engineering design and planning. The design overview and checking processes that are applied during project registration provide sufficient scrutiny.

Stable Voltage waveform

It is observed that the introduction of grid following inverters into regions which have pre-existing low fault levels, and which may also have other grid following inverter plant connected nearby sometimes experience control system instabilities leading to sub-synchronous or super-synchronous oscillations. This is an undesirable phenomenon which is normally a power quality concern but can sometimes also result in supply interruptions.

The rule on system strength seems to be designed specifically to address this issue.

Shell Energy is aware of:

- issues in the West Murray region for which AEMO have set up a webpage[3]
- incidents at Lincoln Gap Windfarm during commissioning activities
- incidents within the Queensland Grid generally

Shell Energy is collaborating with various market participants and inverter manufacturers to determine causes and potential solutions to all of these oscillation events.

Shell Energy has discovered that many of the oscillation events associated with Grid following inverters that have occurred on the network in recent years are ultimately due to control settings being set to be too aggressive with respect to speed of response. The West Murray is the most public of these instances, which was widely reported in the industry press to be largely resolved by re-tuning of solar farm control system parameters. This shows the original settings were incorrect.

It is commonly believed that a grid which has installed only grid following inverter plant would not be able to operate stably. In a strict theoretical sense this is a false belief. It is theoretically possible to operate a grid reliant solely on grid following inverters if the requirement for constant voltage magnitudes is relaxed as has been shown in simulation and in laboratory setups by various researchers.

In practice, to create a smooth transition from the existing grid dominated by synchronous generation to one dominated by power electronic interfaces, we ultimately need a grid which has an optimum mixture of grid following, grid forming and traditional synchronous generation, all of which is appropriately tuned to avoid

[3] https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/power-system-oscillations

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oscillation events due to their interactions with each other. The degree to which any system strength rules encourage this desirable outcome should be the primary consideration.

Connection Governance

The existing Rules rely on a non-physical measure (AFL) to assess the degree to which grid forming inverters consume available fault level which is then multiplied by a nodal factor to estimate system strength charges. With the proposed rule change, if a grid following (or forming) inverter can ride through a system fault with a short circuit ratio as low as 1.2 – then the project should not be exposed to system strength charges.

However, the final control system parameters which are used are informed by wide area network studies which are exclusively carried out by the TNSPs and AEMO. Project developers do not receive any documentation relating to these studies – and do not provide any input other than the models provided by manufacturers. Ultimately the results of these studies determine the final parameters that are used in the inverter control systems, which determines their behaviour in response to grid disturbances.

Project developers in conjunction with inverter suppliers do not have complete freedom to choose appropriate control system parameters to ensure fault ride through. Rather this is determined by negotiation with the TNSP and AEMO who are not transparent in providing reasons for their choices. Accordingly, prior to the completion of R0 studies it is not possible for a developer to predict whether they can ride through a fault with a short circuit ratio of 1.2 with a grid <u>following</u> inverter, or indeed if a grid <u>forming</u> inverter will be stable under all credible system scenarios – particularly scenarios which have a high fault level.

We observe that it is easier to tune grid following inverters connected to systems of low short circuit ratio to ride through a ratio of 1.2 than it is to tune for connections which have high fault levels. In the latter case, the response will often be too slow and non-compliant according to current rule requirements. The existing rule will have the unwanted effect of encouraging connection of IBR plant to regions of lower fault level to more easily meet the 1.2 threshold requirement.

These issues with the connection process highlight the potential governance issues arising when the interests of consumers and project developers may not align with those of NSPs. Without transparency and consistent assumptions and scenarios, or clear guidelines for making assumptions, the financial risk of inappropriate settings is borne by the connecting generators and ultimately consumers. The risk is compounded by the fact that it is the project developers that are exposed to the physical plant damage risk which could arise from incorrect control system parameters being applied.

The existing system strength rule does not provide adequate safeguards to prevent governance issues from arising. By mandating an overly simplistic approach to voltage waveform stability issues the rules risks poorly targeted approaches to the issue, effectively resulting in higher costs to market participants and consumers. This is further exacerbated by the lack of transparency associated with the allocation of system costs to different locational nodes.

In our view, the desirable end point of encouraging the optimal mix of grid following, grid forming, and synchronous machines will not be achieved by the system strength rule in its current form.

Conclusion

The system strength rule in its current form will distort the market and will not encourage the optimum outcomes which address the minimum fault level or waveform stability concerns.

The minimum fault level concerns can be addressed using good engineering design and practices and do not need a specific demand side system strength rule to be coordinated.

The waveform stability concern is potentially more serious given its potential to cause power quality, system reliability issues and equipment damage. The demand side system strength rule currently prioritises grid forming over grid following inverter designs which in weak areas of the network is desirable for improving voltage waveform stability. However, in strong regions of the network, grid forming inverters (and synchronous machines) are more likely to exhibit oscillatory instability than grid following inverters. Accordingly, the desired outcome is an optimum mix of grid forming, grid following and synchronous machines which create a high-performance grid with minimum capital investment.

Achieving the optimum design requires a coordinated approach which will require sharing of technical information and models across the industry and appropriate rules within the NER which allow for sensible tuning of inverter controls.

The existing demand side system strength rule does not achieve these aims and should be revised to an approach which encourages the optimum mix of technologies.

The revised approach should be fully transparent with respect to technical information to allow the industry to devise solutions to the voltage waveform stability issue.

For more information on this submission please contact Peter Wormald (peter.wormald@shellenergy.com.au)

Yours sincerely

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