Study Committee C5

Electricity markets and regulation

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Evolving system strength frameworks in the NEM

J Hyatt, V Mollard, D Bones and J O'Brien

james.hyatt@enel.com, Victoria.Mollard@aemc.gov.au, david.bones@ghd.com, jack.obrien@ghd.com

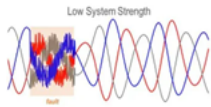
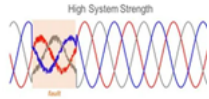
Motivation

- The transition from fossil fuelled synchronous generators to inverter based resources (IBR) such as wind, solar and batteries risk system strength falling to unacceptable levels.
- In the Australian National Electricity Market (NEM), measures were first introduced in 2017 to manage system strength, comprising the minimum system strength framework and the do no harm framework:

Minimum system strength framework	Do no harm framework
Required AEMO to identify gaps and TNSPs to provide system strength services to address gaps and maintain the system strength for a secure power system. Generally, the intent was to address declining system strength as synchronous generators retired or were dispatched less.	Designed to deliver any additional, incremental system strength services needed to support new IBR connecting to the power system. Obligations imposed on new generators through the connection process to address their specific system strength impact.

- The 2020 review of the system strength framework completed by the Australian Energy Market Commission (AEMC) identified the need for revisions to address emerging issues .

Why is system strength important?

Low system strength	High system strength
Unreliable fault clearing	Sufficient fault level providing reliable fault clearing
Malleable / distorted 	Robust voltage 
Unstable operation of grid following inverters, inability to ride through disturbances	Stable operation of IBR

Emerging Issues

- The existing framework was delivering system strength levels below the efficient level when considering total system costs:
  - IBR experiencing significant levels of curtailment (with system strength limits creating significant impacts across 2020 - see table below)
  - Delays in connection of new IBR
  - Generators exposed to uncertain remediation costs assessed through Full Impact Assessments using complex wide area EMT model only available to AEMO and TNSP
  - Minimum system strength framework was reactive and did not encourage proactive investment

Constrain Equation ID	2020 Summated Marginal Value ($/MW/DI)	2020 Binding Hours	Region
Q_NIL_STRGTH_MEWF	17,924,238.3	1,507.9	Qld
S_WIND_1200_AUTO & S_NIL_STRENGTH_1	11,147,928.7	942.2	SA
Q_NIL_STRGTH_HAUSF	10,412,278.6	858.6	Qld

Note: In the NEM the dispatch interval (DI) is 5 minutes. One measure of the impact of binding constraints is the summated marginal value across periods where the constraint is binding. This measure expressed in $/MW/DI can be used as a relative comparator of binding constraints. The measure can be expressed in $/MWh by dividing by 12. It provides an indication of the potential value of relaxing the constraint by 1MW.

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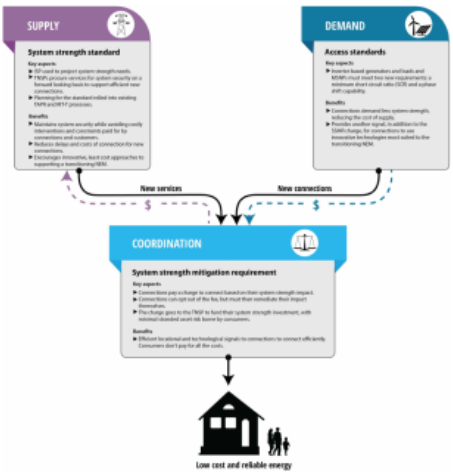
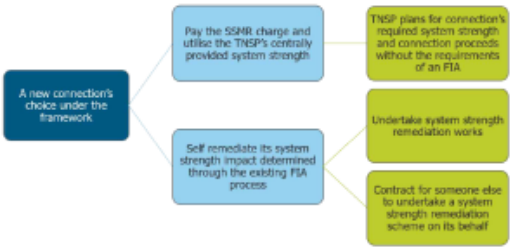
Revised Framework

- Evolved framework developed across 2020 and 2021.
- Culminating in revisions to the National Electricity Rules published on 21 October 2021.
- The evolved framework encourages efficient and timely investment that balances supply of system strength and demand for system strength by providing efficient signals to connecting parties.



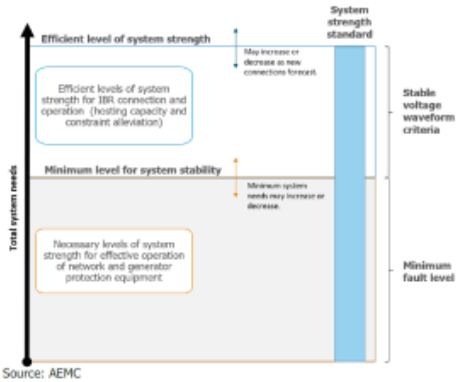
More efficient connection process

- Connecting parties can either:
  - elect to pay a system strength mitigation requirement (SSMR) charge and make the SSSP responsible for the required investments, or
  - elect to remediate any assessed system strength impacts as determined through a full impact assessment.



Supply side elements

- System Strength Service Provider (SSSP) required to invest to meet the system strength standard at system strength nodes, allowing for expected connection of IBR
- Standard has two components:
  - Minimum three phase fault level and
  - System strength to provide stable voltage waveform for expected connection of IBR



Source: AEMC

Demand side elements

- Minimum technical standards for new IBR, large inverter connected loads and market HVDC links:
  - Equipment required to maintain stable operation for short circuit ratio = 3 at the connection point
  - IBR generators must remain connected for voltage phase angle change of up to 20 degrees.

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Balancing self-remediation vs centralised solution

- The SSMR charge includes a locational factor. The factor means that the charge increases with the electrical distance between the connection point and the system strength node.
- The increase in charge with distance from the system strength node encourages self remediation where this is likely to be more cost effective than sharing a centralised solution.

Reduced costs for consumers

- The revised framework delivers reduced costs for consumers by:
  - Adopting technology neutral definitions of system strength allowing broadest range of solutions.
  - Leveraging economies of scale through centralised solutions where more cost effective.
  - Reducing the risk of system strength constraints
  - Defining the system strength standard in a way that can cater for evolving market conditions.
  - Utilising the existing framework governing regulated transmission investments to encourage the SSSP to efficiently procure system strength services.

Implementation

- The changes to the NER allow a timetable to transition to the revised framework.
- The supply side measures are phased in from 1 December 2022, with the SSSP required to achieve the new standard by 2 December 2025.
- The demand side measures, and coordination arrangement commence on 15 March 2023, from which time a party seeking to connect can elect to pay the SSMR charge or self-remediate.

Conclusion

- The enhanced NEM system strength framework combines measures that seek to:
  - increase the supply of system strength by encouraging forward-looking efficient investment to meet system strength requirements,
  - minimise the demand that connecting parties place on system strength services, and
  - provide efficient locational and technological signals to connecting parties to better coordinate supply and demand measures. This aspect of the enhanced framework ensures that the costs are shared and the risks are appropriately allocated.
- The experience from the NEM may be relevant for other power systems that are faced with the challenge of managing system strength while enabling the rapid increase in renewable generation.