NEED/OPPORTUNITY STATEMENT (NOS)

Strategic Dynamic Reactive Support Investment for Renewables Uptake

NOS- 000000001650 revision 1.0

Ellipse project description: Various Locations Dynamic Voltage Support
TRIM file: [TRIM No]

Project reason: Reliability - To maintain system voltage stability due to renewable generation uptake
Project category:

Approvals

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Date submitted for approval	12 December 2016	

1. BACKGROUND

The NSW government, other state governments and the federal government are committed to increasing energy supply via renewable sources (renewables) rather than from non-renewable sources. The degree to which renewables are being pursued varies from state to state. For example;

- Victoria has committed 40% uptake by 2025 [1],
- The federal government targets at least 33,000 GWh[2],
- Queensland is targeting 50% by 2030[3]
- NSW is aiming for 20% by 2020[4].

Irrespective of the targets, it is apparent that renewable energy generation project development is progressing at a rapid rate. For instance, ARENA funding has resulted in an increased number of applications to AEMO and various Network Service Providers (NSPs), for a significant number of PV solar generation connections[5].

1.1 Increasing renewables penetration

TransGrid has recently received over 30 connection enquiries (amounting to a total capacity of 5,292 MW[6]), many of which have progressed into Connection Applications currently under review. Table 1 below presents the number of enquiries and their potential capacity, in MW.

Table 1: Connection Enquiries for Renewable Generation

Area	Locations considered	No. of Inquiries	MW
South West	Balranald 220 kV and 22 kV Broken Hill 220 kV and 22 kV Buronga 220 kV Darlington Point 330 kV and 132 kV Griffith 132 kV and 33 kV	17	2719 MW
Central West	Parkes 132 kV and 66 kV Wellington 330 kV and 132 kV	9	1323 MW
North	Tamworth 330 kV and 66 kV	5	1250 MW

AEMO's 2016 National Electricity Forecasting Report (NEFR)[7] indicates that grid supply is expected to remain reasonably flat, reaching 184,467 GWh in 2035/36[8]. This is a total rise of only 1209 GWh over the next 20 years.[9] Furthermore, the NEFR states that:

> *"Over this 20-year period, improvement in the energy efficiency of consumer electrical appliances is forecast to reduce growth in annual consumption by 0.7% per annum, and increasing generation from rooftop PV is forecast to reduce growth by another 0.5% per annum."* (AEMO 2016 NEFR, p.5).

[1] http://www.energyandresources.vic.gov.au/energy/sustainable-energy/victorias-renewable-energy-targets

[2] https://www.cleanenergycouncil.org.au/policy-advocacy/renewable-energy-target.html

[3] https://www.dews.qld.gov.au/electricity/solar/solar-future

[4] http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0010/475318/nsw-renewable-energy-action-plan.pdf

[5] https://www.cleanenergycouncil.org.au/policy-advocacy/renewable-energy-target.html

[6] The MW proposed if all developed will achieve NSW government target of 20% renewables in 2020.

[7] Figure 1 Operational consumption 2008–09 to 2035–36

[8] http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/-/media/080A47DA86C04BE0AF93812A548F722E.ashx

[9] The 2015/16 energy consumption from the grid was 183,258 GWh.

Energy efficiency reductions between now and 2035/36 are forecast to total 27,082 GWh over the period, while the effective capacity of rooftop PV over the same period is expected to reduce grid consumption by 25,400 GWh.[10]

Australia's Renewable Energy Target (RET) is a Federal Government policy designed to ensure that at least 33,000 GWh of Australia's electricity comes from renewable sources by 2020. As at the end of 2015, achieving this target will require approximately 6,000 MW of new renewable energy capacity to be commissioned by 2020.

According to the Clean Energy Council's Clean Energy Australia Report 2015:

> *"More than 35,000 GWh of renewable energy was generated in [Australia in] 2015, of which 15,200 GWh of large-scale renewable energy generation counts towards the large-scale target [LRET] of 33,000 GWh. This means the industry is just under halfway [46%] towards meeting the LRET. More than 8000 megawatts (MW) of wind power and 2500 MW of solar power projects are either under construction or have planning approval. This is more than enough to meet the 2020 RET.[11]"*
> (Clean Energy Council 2015, p.4)

The RET is due for review by the federal government no earlier than 2020. Assuming that the RET will increase to 30% renewables by 2035/36, the commissioning of renewable generation will have to continue apace for the next 20 years.

1.2 Probable Limitations

This scenario is likely to displace some of the conventional high inertia, synchronous machine thermal units with renewable generation connected to the weak parts of the transmission system at the "edge of the grid". This would significantly reduce the short circuit ratio levels of the system, causing significant voltage management issues in the network, including maintaining power quality to customer supplies, and potential voltage collapse.

The recent CIGRÉ working group publication[12] summarises the potential issues to grid security, the reliability of connecting renewable energy sources and potential mitigation solutions.

This Need and Opportunity Statement (NOS) addresses the possible grid reinforcement requirements to facilitate new renewable generation. The key issues that need to be addressed are:

- lower short circuit ratios (SCR); and
- the potential voltage stability issues across the NSW network due to increased large scale renewable generation.
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1.2.1 Low SCR

SCR is an indication of the "strength" of the network (measured in terms of the short circuit level at a given connection point), relative to the connected generation capacity.

An assessment of connection opportunities at various locations has been completed[13].

- There are areas where the SCR is low even with all conventional generation connected.
- With significant renewables connected, it is likely the SCR will further reduce in the next few years.

The CIGRÉ working group publication[14] has identified the minimum SCR required to facilitate renewable generation for operation is in the range of 3-5, however some of the connection opportunity locations have much lower values.

[10] Projections assume more west-facing PV panels, market saturation by the 2030s, and battery storage becoming economic to the mass market in the 2020s.

[11] "The 33,000 GWh target can be met by approximately 6000 MW of wind energy or 12,000 MW of solar power." (Clean Energy Council 2015, p.8).

[12] TB WGB4.62 Final Draft for Review 02 Jul 2016.pdf

[13] https://www.transgrid.com.au/NSWconnectionopportunities

[14] See footnote 12.

1.2.2 Voltage Stability

Low SCR, coupled with significant renewable generation will lead to network loadings at a level where small changes in load and generation may lead to large voltage changes and voltage instability. Hence the network may be vulnerable to small changes in generation and demand.

1.2.3 Thermal chain limitations

The identified connection opportunity locations note a number of substation assets that will limit the capacity of generation that can be connected. These include current transformer (CT), voltage transformer (VT), disconnector and earth switch ratings that would inhibit, physically, the amount of generation that could be connected at these sites.

1.2.4 Customer Limitations

Renewable generator customers may also be constrained due to voltage stability and capacity limitations of their own equipment.

1.2.5 Source Documentation

The following documents were used to develop this Need and Opportunity statement.

- https://www.transgrid.com.au/NSWconnectionopportunities
- CIGRÉ WG B4.62 Connection Wind Farms to Weak AC Systems – Draft Technical Brochure report – Connection of Wind Farms to Weak AC Networks
- TransGrid's 2016 Transmission Annual Planning Report (TAPR 2016)
- 2015 AEMO Electricity Statement of Opportunities(ESOO)
- https://www.cleanenergycouncil.org.au/policy-advocacy/renewable-energy-target.html
- http://www.energyandresources.vic.gov.au/energy/sustainable-energy/victorias-renewable-energy-targets
- https://www.cleanenergycouncil.org.au/policy-advocacy/renewable-energy-target.html
- http://www.resourcesandenergy.nsw.gov.au/__data/assets/pdf_file/0010/475318/nsw-renewable-energy-action-plan.pdf

2. NEED/OPPORTUNITY

A significant increase in renewable generation may potentially displace existing thermal units to be dispatched during times of high wind and high sun resource. This would result in lowering the SCR. The combination of generator location, network capacity and lowering SCR will lead to voltage stability limiting the transfer capability.

As more renewable generators are connected to the system there will be a requirement for some action to be taken to address the voltage stability and SCR issues.

2.1 Need Date

There is an emerging need for corrective action to address the forecast voltage stability/capacity issues at potential connection opportunity locations. Given the uncertainty of specific timing and triggers at these exact locations it is proposed that probability-weighted projects will be required to facilitate the renewable uptake in NSW to meet the NSW government target of 20% renewables by 2020.

The following events would trigger the Need if they occur:

- Commitment to the connection of new renewable generation to one or more of the locations identified in Table 1.
- The level of committed renewable generation is such that voltage and control stability considerations will impede the ability of the generators to be connected and operated at full capacity.

- Positive net benefits of removing the potential constraints are confirmed through a cost-benefit analysis as outlined in the RIT-T guidelines.

Table 2 estimates possible trigger levels at the locations identified in Table 1.

Table 2: Connection Opportunities – Locations and trigger points

Area	Locations considered	Generation Level Triggering the Need for Reactive Support[15]
South West	Balranald 220 kV and 22 kV Broken Hill 220 kV and 22 kV Buronga 220 kV Darlington Point 330 kV and 132 kV Griffith 132 kV and 33 kV	617 MVA (Darlington Pt 330 kV)
Central West	Parkes 132 kV and 66 kV Wellington 330 kV and 132 kV	1234 MVA (Wellington 330 kV)
North	Tamworth 330 kV and 66 kV	1649 MVA (Tamworth 330 kV)

2.2 Risks

The identified risk(s) of not undertaking actions to address this need, should the above triggers occur, are:

- Ongoing technical barriers to achieving the renewable generation target in NSW (regulatory risk)
- Significant cost to the market due to constraining off renewable generation
- Under voltage load shedding to occur as a result of connecting renewables, to maintain system security

2.2.1 Risk Costs

The main risk cost of this option is estimated to be the market cost of unserved energy caused by a trip of a reasonable number of renewable generators in 2020, when renewables are assumed to supply 20% of peak demand in NSW.

A reasonable assessment of the risk cost has been carried out using the following assumptions and calculations, based on the total number and capacity of renewable generator connection inquiries.

Due to the anticipated stability and power quality issues mentioned above, it is reasonable to assume that at least 300 MW[16] of the renewable generation capacity will not be built, or will be constrained off at two or more areas identified for potential connection opportunities.

Considering the following assumptions:

- The renewable energy source most likely to connect will be solar PV;
- The price of gas-fired generation is approximately $98/MWh in 2020[17] and replaces 300 MW of solar PV generation shortfall;
- The price of solar PV generation is approximately $133/MWh in 2020[17]; and
- There is a solar PV generation capacity factor of 0.3, and a gas-fired generation capacity factor of 0.83.[17]

We find that the approximate cost of constraining the renewable generation from the NEM will be:

[15] These generation levels are based on the highest fault level in the considered area and the load at each substation.

[16] This is estimated to be around 5% of the proposed renewable generation.

[17] Australian Government Bureau of Resources and Energy Economics 2012, *Australian Energy Technology Assessment 2012.* Assuming that natural gas will replace the renewable sources if they are not commissioned or are constrained off.

$$[(\$98 * 0.83) - (\$133 * 0.3)]/MWh * 300\,MW * 24hrs * 365\,days = \$108.9\,million / year$$

Considering additional risks such as TransGrid's reputation, the total risk cost of this option is $108.97 million per annum, based on the lost generation as shown in Attachment 1.

3. RELATED NEEDS/OPPORTUNITIES

Nil.

4. RECOMMENDATION

Based on the need identified and the risk cost of not addressing the Need, the recommendation is to proceed to develop options with sufficient analysis to support the project category costs for inclusion in TransGrid's 2018-23 revenue reset.

ATTACHMENT 1 – Investment Risk Tool Output

Current Option Assessment - Risk Summary

Project Name: Strategic Investment for Renewables uptake

Option Name: Base Case

Option Assessment Name: Base Case

Rev Reset Period: Next (2018-23)

Major Component	No.	Minor Component	Sel. Hazardous Event	LoC x CoF ($M)	Failure Mechanism	NoxLoC xCoF ($M)	PoF (Yr 1)	Total Risk ($M)	Risk ($M) (Rel)	Risk ($M) (Op)	Risk ($M) (Fin)	Risk ($M) (Peo)	Risk ($M) (Env)	Risk ($M) (Rep)
Undervoltage LSS	1	Bay Controller	Unplanned Outage - HV (Undervoltage LSS)	$108.97	Failure	$108.97	100.00%	$108.97	$108.92		$0.01			$0.03
				$108.97		$108.97		$108.97	$108.92		$0.01			$0.03

Total VCR Risk: $108.90 Total ENS Risk: $0.00

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