NATIONAL TRANSMISSION NETWORK DEVELOPMENT PLAN

FOR THE NATIONAL ELECTRICITY MARKET

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared the 2015 National Transmission Network Development Plan under clause 5.20.2 of the National Electricity Rules. This report is based on information available to AEMO up to 31 August 2015.

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EXECUTIVE SUMMARY

The National Transmission Network Development Plan (NTNDP) is an independent, strategic view of the development of the national transmission grid in the National Electricity Market (NEM) over the next 20 years.

Key insights of the 2015 NTNDP

The role of the transmission grid is evolving, from the secure transportation of bulk power generation, to include the secure integration of renewable generation and emerging technologies. This reflects a changing paradigm characterised by declining electricity consumption from the grid, an increasing focus on renewable and embedded generation, and withdrawal of thermal synchronous generation (such as coal and gas-fired generation).

- Continuing the trend observed in recent years, expenditure to replace ageing transmission network infrastructure currently outweighs investment in new network capacity. This is expected to continue for the next 20 years.
- Based on the current Large-scale Renewable Energy Target (LRET), the NTNDP modelled up to 6,700 megawatts (MW) of additional large-scale renewable generation investment across the NEM by 2020. Minimal new transmission network infrastructure is required to deliver this generation to consumers, provided generation is located to balance fuel source availability and network costs. There is a risk that concentration of this generation in the same location will cause local transmission congestion due to network limitations.
- New power system infrastructure may be required to provide frequency control and network support services. Currently, regions with high renewable penetration rely heavily on interconnection to provide these services. In future, alternative solutions may need to be explored if higher penetrations of renewable and embedded generation are to be integrated across the NEM.
- As the proportion of behind-the-meter[1] generation increases, detailed information on the location, extent and operation of embedded technologies (including rooftop photovoltaics (PV), battery storage or electric vehicles) will be needed to accurately forecast operational consumption and manage the supply demand balance on the system.

A scenario-based assessment of efficient network development

Each year the NTNDP uses a range of scenarios to examine the efficient development of the national transmission grid. This year, the scenarios reflect the changing use of transmission networks, and take account of current carbon policy incentives, as follows:

- **Gradual Evolution scenario:** assumes operational consumption continues to increase in line with the 2015 National Electricity Forecasting Report (NEFR)[2] medium scenario, and there is a gradual penetration of residential electricity storage to 8 Gigawatt hours (GWh) installed by 2035 as forecast in AEMO's 2015 Emerging Technologies Information Paper.[3]

[1] Behind-the-meter refers to generation, storage and other technologies on consumers' premises, for on-site use.
[2] AEMO, 2015 National Electricity Forecasting Report. Available: http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report. Viewed: 19 October 2015.
[3] AEMO, 2015 Emerging Technologies Information Paper. Available: http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report/NEFR-Supplementary-Information. Viewed: 19 October 2015.

- **Rapid Transformation scenario:** assumes that operational consumption follows the 2015 NEFR low scenario, and is lowered further by greater rooftop PV uptake (33.3 GW installed capacity by 2034–35, compared to 20.9 GW in the Gradual Evolution scenario) and a 40% penetration of residential battery storage (19.1 GWh installed capacity) by 2035. This scenario also assumes 20% of households own an electric vehicle (over 2 million electric vehicles) by 2035.

A sensitivity assuming lower large-scale PV costs is applied to both scenarios, to reflect the possibility of large-scale PV becoming more cost-competitive with wind generation. The Rapid Transformation sensitivity also includes a higher penetration of large-scale renewable generation.

Emerging challenges in managing the power system

As wind and PV generation increases (possibly combined with battery storage), and withdrawal of thermal synchronous generation continues, secure operation of the grid will become more challenging, particularly when demand is low and output from renewable generation is high. These challenges include:

- **Less dispatchable generation:** Increasing rooftop PV in the generation mix will reduce the proportion of total generation controllable through the central dispatch process. For example, under the Gradual Evolution scenario, for 10% of the time, less than 2,030 MW of South Australian generation is expected to be controllable in 2016 (that is, about 60% of total local generation supply, including rooftop PV). By 2025, this is forecast to drop to about 1,540 MW (38% of total local generation supply). Decreasing levels of controllable generation, combined with limited information on the location, extent and operation of embedded technologies (such as battery storage or electric vehicles), will make it increasingly difficult to:
  - Forecast demand, supply and the behaviour of the power system.
  - Balance supply and demand in real time.
  - Control the flows on the grid to remain within secure limits.
- **Inertia and frequency control requirements:** Regions with high proportions of large-scale renewable and embedded generation become dependent on interconnection to other regions for inertia and network support services that maintain power system security.

  Inertia, produced by synchronous generators, dampens the impact of changes in power system frequency, resulting in a more stable system. Power systems with low inertia experience faster changes in system frequency following a disturbance, such as the trip of a generator.

  Through interconnection, inertia and network support services from other regions are currently available to manage unexpected and sudden power system disturbances. As more thermal synchronous generators withdraw from the NEM, there is a risk that there may be insufficient inertia and network support services available to be shared across all regions.
- **Voltage stability during faults:** Synchronous generators provide dynamic voltage support to the power system, particularly during and immediately following network faults. Withdrawal of these generators reduces voltage stability in the surrounding area, meaning there are larger voltage fluctuations during network faults. Most wind and large-scale PV generators in areas with poor voltage stability will struggle to remain connected to the network during network faults, and their power output may need to be restricted to manage this risk.

Proposed work

A program of work is ongoing to evaluate the current and future impact of these challenges on power system operation. This work will also identify feasible solutions to assist in maintaining power system security and reliability. In December 2015, AEMO will publish a joint report with ElectraNet on the power system implications of a changing generation mix, focusing on South Australia. Further studies will be completed in 2016.

New power system infrastructure may be part of the solution. Developments that may be required to manage system security will be factored into future NTNDPs. The 2016 NTNDP will present potential network and non-network options to address the emerging challenges identified in this 2015 NTNDP, and in the forthcoming renewable integration studies.

Minimum demand – Network Support and Control Ancillary Services requirements

At times of minimum demand drawn from the grid, managing high voltage in the transmission network becomes an operational risk in maintaining system security.

The 2015 NEFR, for the first time, included a forecast for minimum demand in South Australia. It projected the growth of rooftop PV would continue to reduce minimum demand levels, and that rooftop PV generation could exceed demand in South Australia during some midday periods from 2023–24.

Within five years, Network Support and Control Ancillary Services (NSCAS) may be required to address high voltage in both South Australia and New South Wales.

NSCAS are non-market ancillary service contracts designed to maintain power system security and reliability, and to maintain or increase the power transfer capability of the transmission network. These services are procured by Transmission Network Service Providers (TNSPs), or AEMO as a last resort, to maintain power system security and reliability where operational measures, such as switching lines out of service, are no longer feasible.