energy networks association

APRIL 2014

ENABLING EMBEDDED **GENERATION**

Turning Australian electricity on its head

WHAT IS EMBEDDED GENERATION?

Energy supply systems around the world are being transformed by embedded (or distributed) generation.

Australia's distribution networks, 800,000 kilometres in length, have been designed to deliver electricity one-way from centralised generators to consumers, maintaining safety, reliability and security of supply. Significant technology breakthroughs and government subsidies have changed the economics of onsite generation and in just five years, over one million new generators have connected to the Grid. Many household are now 'Prosumers' - market participants who may export energy to the grid in real time.

Embedded Generation is upending our traditional supply system, providing significant benefits along with new challenges to ensuring a safe, reliable and efficient service to consumers.

Distributed or embedded generation is any form of generation which is connected to (or embedded in) an electrical distribution network. Types of embedded generation may include:

» open and closed cycle gas turbines
» reciprocating engines (diesel, oil)
» hydro and mini-hydro schemes
» wind turbines
» photovoltaic generation (solar)
» fuel cells and
» cogeneration or 'polygeneration' (combined cooling, heat and power).

Generation sources such as fuel cells and photovoltaic installations generate DC (direct current) electricity and are therefore required to be connected to the distribution network via an inverter. The inverter converts the DC generated output to alternating current (AC) so that the generated energy can be exported into the network.

FIGURE 1 **THE SHARED BENEFITS BETWEEN THE GRID AND EMBEDDED GENERATION**

EMBEDDED GENERATION BENEFITS TO THE GRID

» Reduced Transmission and Distribution losses
» Potential to defer network augmentation depending on geographic location and performance during peak periods.
» Voltage support
» Improve power system resilience
» Potential emissions reduction

GRID BENEFITS TO EMBEDDED GENERATION

» Provides access to upstream markets
» Supports maintenance of reliability for intermittent embedded generation
» Supports voltage quality important for end-use devices
» Supports operating efficiency of embedded generation as output need not reflect local load
» Supports startup power requirements of the customer, when peak current may increase significantly.

HOW EMBEDDED GENERATION SUPPORTS THE GRID

Australia's energy networks are embracing embedded generation both in the direct support of network operations and through the connection of customer-initiated embedded generation on the electricity distribution system. Embedded generation is actively assessed along with other Non-Network Solutions prior to undertaking significant network augmentation investment.

For instance, in 2012 approximately 645MW of installed embedded and co-generation capacity was connected to Ergon Energy's distribution network, in addition to 91,633 Solar PV connections with a total capacity of 279MW. Ergon actively 'prospects' for embedded generation capacity to inform network planning. It has identified 209 locations with potential to provide embedded generation support with diesel generation - potentially, a reliable and timely demand response tool.

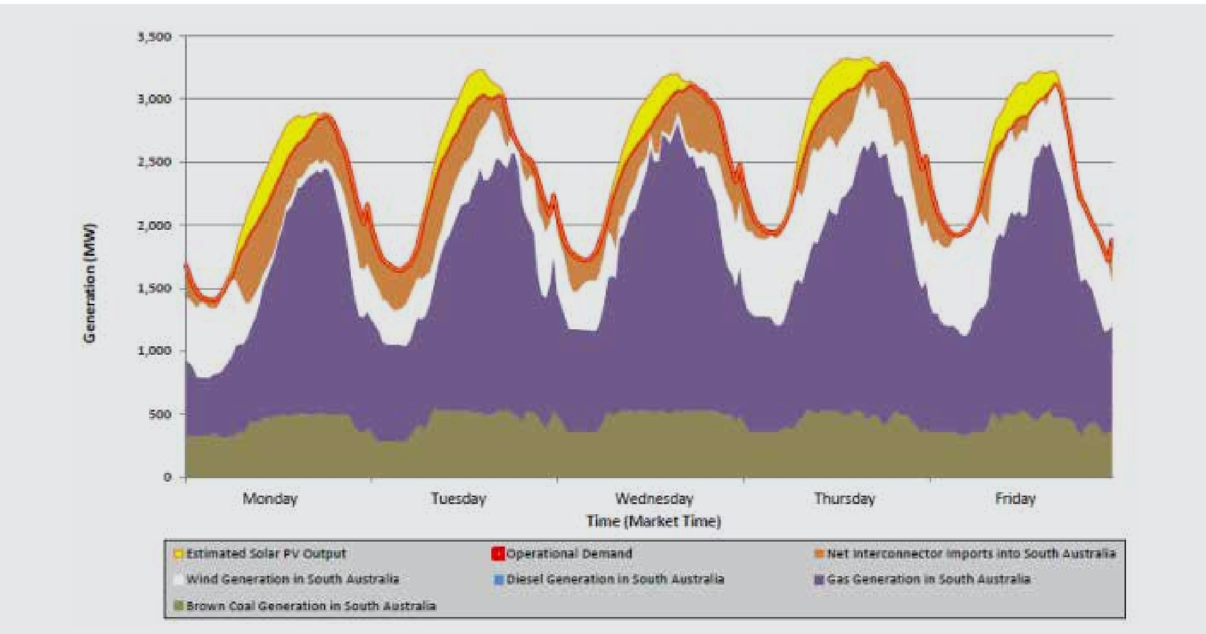
Similarly, Ausgrid's distribution network in New South Wales identifies approximately 300 MW of connected embedded generation including known diesel, landfill biogas, coal seam methane, natural gas, tri-generation and co-generation, hydro and mini hydro, coal washery, and waste heat recovery generating units, noting that not all will be used to export to the grid.

Embedded generation has been transformed by the rapid increase in Solar PV panels, with installed capacity increasing to over 3,200 MW by April 2014. Solar PV systems directly support network performance where constraints exist and provide voltage support in long feeders. There has been significant interest in examining the extent to which installed Solar PV is assisting in mitigating peak demand and thereby reducing pressure for network augmentation.

The recent South Eastern Australia heatwave event of 13-17 January 2014 provided insights on the effect of Solar PV during the traditional peak demand period. In South Australia, where 25% of homes have installed Solar PV, AEMO analysis indicates the systems contributed to meeting up to 6% of peak demand and helped 'shift' the operational peak later in the day. By contrast in Victoria, where 10.5% of households have Solar PV, the contribution of Solar PV to peak demand was less than 1.5% during the event.

Solar PVs contributions to 'shaving' peak demand have been limited by current tariff structures, which provide no incentive for customers to install panels facing west, to maximise their contribution at peak times. For instance, Ausgrid analysed the output from 26,744 Solar PV units in the peak demand period of February 2011 and found that the demand peak was significantly different to the solar peak output, such that these units operated at only 32 percent of their capacity at the time of the demand peak.[1]

FIGURE 2 **CONTRIBUTION OF SOLAR PV DURING SOUTH AUSTRALIAN HEATWAVE**



Source: AEMO (2014) *Heatwave 13-17 January 2014*

1 Productivity Commission (2012) *Regulation of Electricity Networks*, p. 514

INTEGRATION CHALLENGES

In addition to its benefits, embedded generation provides new challenges to distribution networks enabling integration.

DEMAND UNCERTAINTY

Embedded generation which is intermittent increases demand forecasting uncertainty on a short-term and long-term basis. For instance, studies indicate short-term fluctuations of 60% due to passing clouds.[2] In the long term, AEMO's National Electricity Forecasting Report (2013) includes a 2,700 MW range between the high and low estimates of Solar PV capacity in 2020. This uncertainty is increased by changing government policy measures.

NETWORK MANAGEMENT

ENA studies[2] demonstrate the integration of embedded generation requires careful management of a range of power reliability, quality and safety risks:

» **Voltage Fluctuations and Balance**: embedded generation may cause over-voltage; the reversal of feeder power flows; the need for changes to feeder tap settings; manage impacts on reactive power; and upgrade network voltage monitoring.

» **Network losses**: At lower levels of penetration, embedded generation will usually decrease network line losses, however studies indicate potential increases in line losses if single large embedded generation units represent major portions of the feeder load.

» **Power quality**: power fluctuations may result from intermittent generation such as Solar PV and wind and there is the potential for additional harmonic currents.

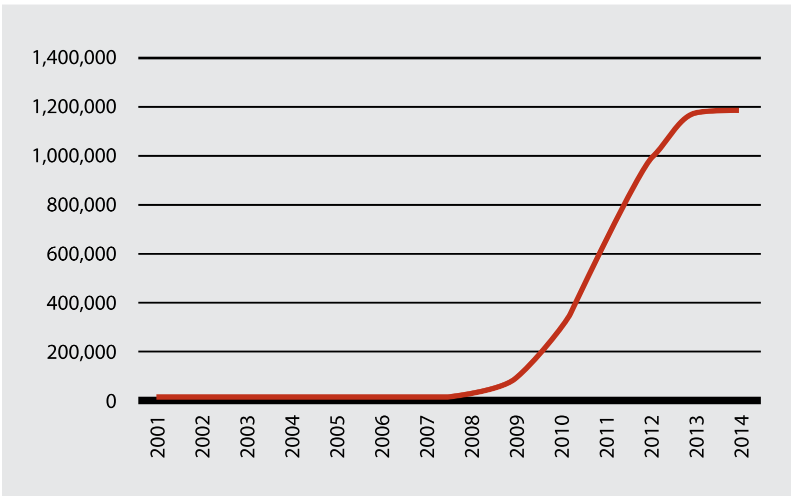
» **Network Protection and Safety**: networks use sophisticated protection systems to minimise risk to network infrastructure and consumer equipment. As they usually assume feeders are 'radial', supplied from a single source, they may need reconfiguration.

» **Fault management**: including the potential for embedded generation to impact on the fault level ratings of existing protection equipment.

In many cases, these and other issues may be manageable with simple or low cost responses, however in all cases, the risks will require a situation-specific analysis. The risk and response usually depend on the size and location of the embedded generation; the characteristics of the network environment and loading; and the existing penetration of embedded generation. These issues require networks to undertake robust connection assessments to ensure connections do not risk safety, quality and reliability of supply.

Some Australian distribution networks are already experiencing significant local voltage rise due to embedded generation, in particular Solar PV arrays. At times, local voltage rise has initiated automatic disconnection of the inverter connected generation unit, causing an impact on the environmental and financial performance expectations for these customers. Fault level considerations, particularly in city centres and other areas of high load density, may also affect the permitted output from embedded generation, and may require additional customer expenditure to manage the contribution of their generator.

FIGURE 3 NUMBERS OF SMALL SCALE SOLAR PV PANEL SYSTEMS



Source: Clean Energy Regulator

2 ENA (2011) Impacts and Benefits of Embedded Generation in Australian Electricity Distribution Networks, p.26.

THE CONNECTION PROCESS

Networks are required to allow, as far as technically and economically practicable, a person to connect to a network on fair and reasonable terms. Networks are also required to operate, maintain and protect their supply network to ensure the adequate, economic, reliable and safe connection and supply of electricity to its customers. The need to meet both requirements can sometimes cause frustration for embedded generation proponents seeking to connect to the distribution network, particularly if proponents are unfamiliar with legitimate network connection issues.

CONNECTING LARGE AND MEDIUM EMBEDDED GENERATION

Embedded generation proponents of large (over 30 MW) or Medium (10-30 MW) units make a connection application with the relevant electricity distributor, according to a connection process and technical requirements set out under Chapter 5 of the National Electricity Rules. Units less than 30MW may apply for an exemption, in which case a State or Territory provision would apply.

The connection process has recently been reviewed by the AEMC and network companies are working closely with the Clean Energy Council, Standards Australia and other stakeholders to improve the transparency of the connection process and identify common issues.

The initial enquiry stage of the connection process is a key opportunity to clearly address the applicant's needs and the potential network issues and minimise delays.

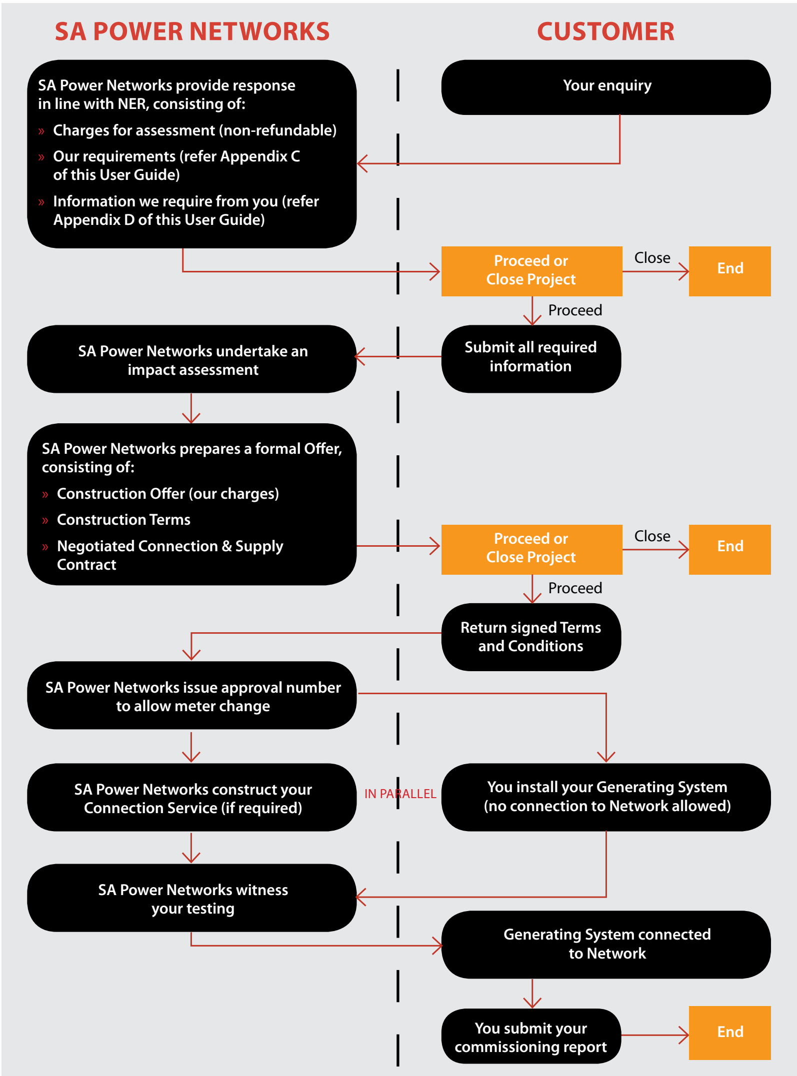
The timeframe for an application assessment will depend on the quality and completeness of the proponent's initial information. If applicants are still in the process of defining the project this can limit their ability to provide information required. Equally, the potential for network upgrading to facilitate a connection may cause delays. If the proposed connection location is in an already constrained area of the network, network reinforcement may be required to connect the customer. This may require detailed technical assessments.

CONNECTING SMALL SCALE EMBEDDED GENERATION

Networks support the connection of small (household) sized embedded generation, including the connection of nearly 1.2 million rooftops around Australia in recent years. Generally the connection process for these systems is a simple form and installation by a qualified electrician. These connections are usually organised through the seller of the PV system.

However, Networks still require the ability to assess proposed Solar PV connections, to avoid compromising network efficiency and impacting on voltage levels outside statutory ranges. The Network may need to downsize or decline an application if it presents risks to the network or to individual premises.

FIGURE 4 EXAMPLE OF CONNECTION PROCESS



Source: SA Power Networks Connection Guide A

EFFICIENT INTEGRATION

NEED FOR TARIFF REFORM

The rapid take up of embedded generation by households and businesses highlights the need to improve Australia's electricity network tariffs to ensure fairness and efficient investment.

Currently, most small customers pay network tariffs which don't reflect the key driver of network costs – peak demand. Capacity tariffs and critical peak pricing reward consumers for reducing their contribution to the system peak demand – but they require smart meters to measure the time of use. With the right electricity tariff environment, embedded generation has the potential to play an important role in mitigating peak demand. Frontier Economics has estimated that peak demand reduction in the NEM had the potential to save up to $11.8 billion over ten years in network and generation infrastructure.[3]

Embedded generation could respond to more efficient tariffs. For instance, at present Solar PV systems are installed and operated to maximise the *volume* of output, with panels facing north, rather than maximising their performance at the *peak* time, which would see panels installed to face west.

Current tariffs can also result in cross subsidies. United Energy recently estimated an average customer with Solar PV may receive a $60 per year subsidy from an average customer without Solar PV, despite both requiring the same network service.[4] A capacity tariff is one way to restore fairness.

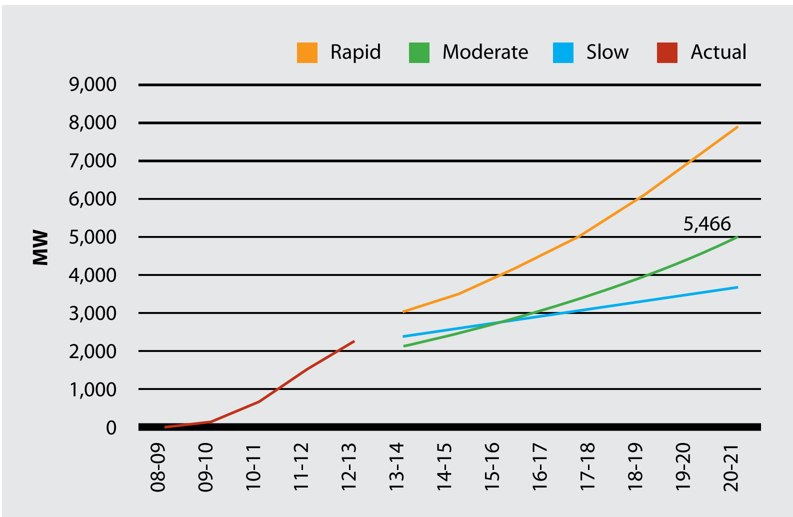
BETTER INFORMATION ON NETWORK CONSTRAINTS

Australian electricity distribution networks publish consistent information about the opportunities for non-network solutions such as embedded generation. Each business publishes a ***Distribution Annual Planning Report*** which includes information on system limitations, overloaded feeders, outcomes of regulatory investment tests, future timing of regulatory investment tests assessing non-network solutions and information on the network's demand management activities. Additionally, as distribution networks assess each project over $5 million in value, they are required to undertake a transparent Regulatory Investment Test, and to publish the results.

DOES EMBEDDED GENERATION NEED GOVERNMENT SUBSIDIES?

Some forms of embedded generation have received significant subsidies by taxpayers and other electricity customers. While it has delivered installed capacity of 3,200 MW in Solar PV, the SRES Scheme has been a high cost form of abating carbon emissions, estimated at between $150 - $500 per tonne of CO2-equivalent abated.[5] Even with changes in feed-in tariffs, it is now forecast to reach its targeted output from Solar PV in 2015, five years earlier than expected. The average size of PV units being installed has increased over time. It is hard to argue Solar PV technology continues to require further subsidies at the expense of other electricity consumers when it is both competitive and mature.

FIGURE 5 ROOFTOP PV - INSTALLED CAPACITY - NEM



Source: AEMO (2013) *National Electricity Forecasting Report*

3 AEMC (2012) *Power of Choice Report*, page 8
4 quoted in *ENA Submission to AEMC Distribution Pricing Principles Rule Change*, December 2013
5 For instance, see AEMC (2011) "Interim Report: *Impact of the enhanced Renewable Energy Target on energy markets*", p.58

THE VALUE OF THE GRID

Falling embedded generation costs and the potential for economic battery storage have led to questions about whether small consumers may choose to disconnect from the grid entirely and rely on onsite supply. This may be a real choice in the near future and it will be important for consumers to make informed decisions which recognise some of the hidden value of the Grid which can be overlooked.

The costs for an average consumer to provide balanced, reliable supply of electricity to their homes after disconnection would be considerable. The costs of technical services include:

- The need to balance supply and demand in sub-second intervals to maintain a stable frequency (i.e., regulation service);
- provide the energy needed to serve the customer's total load during times when on-site generation is inoperable due to equipment maintenance, unexpected physical failure, or prolonged overcast conditions (i.e., backup service);
- provide voltage and frequency control services and maintain high AC waveform quality.

In the USA, the Electric Power Research Institute (EPRI) has estimated the value of the grid to consumers. It estimates that the average US electricity user receives these grid services for approximately US$51 per month – but it would cost them US$275 -US$430 per month to try to replicate that service for themselves onsite, with battery storage, Solar PV and a backup generator. Even with falling technology costs assumed to occur by 2024, the cost of self-supply would remain US$165-US$262 per month.[6]

Of course, perhaps most importantly, a disconnected customer with embedded generation loses one of the great benefits of grid connectivity - the ability to sell energy during hours of excess generation.

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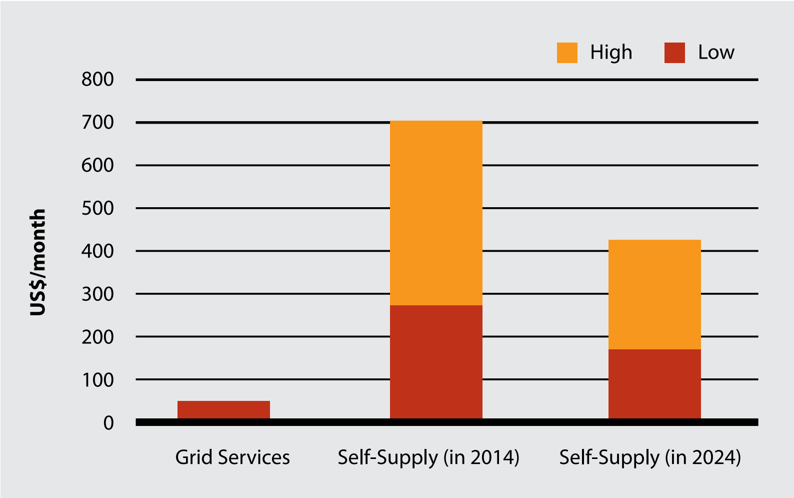
FIGURE 6 **COST OF GRID VS SELF-SUPPLY**



Source: EPRI (2014) *"The Integrated Grid", page 22-23.*

6 EPRI (2014) *"The Integrated Grid", page 22-23.*