ESSENTIAL SERVICES COMMISSION

THE NETWORK VALUE OF DISTRIBUTED GENERATION

Distributed Generation Inquiry Stage 2 Final Report

February 2017

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CHAIRPERSON'S INTRODUCTION

In our draft report, released in November, we presented our study of the network benefits of Victoria's fleet of distributed generation. That analysis drew on data published by network businesses that, until relatively recently, was not in the public domain. It showed that solar PV – the predominant form of distributed generation in Victoria – is creating network benefits, although those benefits are relatively modest at present.

More interestingly, our study also revealed important characteristics of that value: how it is highly variable across time and space, and how harnessing storage and energy management devices can significantly boost the potential value on offer. In short, it showed that there is no single 'network value of distributed generation'. Across Victoria, areas where distributed generation has high network value can be found next door to areas in which distributed generation has little or no network value. And the value of any given system depends on how it is configured and controlled.

Given this pattern of variability, a broad-based feed-in tariff would be an unsuitable tool for remunerating network value. This caused us to consider what arrangements would be necessary to ensure small scale distributed generators received payments for the network benefits they provide.

Drawing upon our analysis of the issues, and having studied the reforms being contemplated in leading international jurisdictions, we concluded that an efficient market for grid services – were one to exist – could be used to deliver payments to small scale distributed generators that reflect the true network value produced by their investment. Our draft report invited stakeholders to help us elaborate on this vision, and contribute their thinking into how it might be brought about.

Following release of the draft report, we held five public forums across Victoria. We also held a number of focused workshops with industry stakeholders. Along with the 18 written submissions we received, these events helped us hone our thinking about the potential shape and implications of a market for grid service in Victoria.

In this final report, we outline the findings of our exploratory work on this subject. We identify some of the potential structures a market for grid services might take, as well as the attributes it would need to ensure small scale providers could participate. We also identify the key issues that need to be resolved for such a market to become fully effective from a small scale provider's perspective.

This includes matters such as ensuring the right information is available, ensuring small providers have sufficient access to the market, having credible and efficient pricing mechanisms, and that a host of technical issues are resolved. We are also mindful that small scale suppliers of grid services will often also be energy customers, and that their protections as customers should be preserved despite the dual role they might play in the market (that is, as suppliers of grid services and consumers of energy).

Although many of the future details are uncertain, one thing is clear: the emergence of the market for grid services is a long term project. It is a large step within the even larger transformations that are sweeping the industry. Our report sets out the main features of the work program that we believe would be necessary to bring it about.

Throughout this inquiry, we have benefited from significant and sustained engagement from many stakeholders. I would like to take this opportunity to thank all those who took the time to make formal submissions or attend the many forums and workshops that we have run.

Dr Ron Ben-David
Chairperson

GLOSSARY

Ancillary services	Services and resources that are required to operate the network on an on-going basis, such as services to control voltage and frequency or to restart the network after an incident.
Behind-the-meter	The realm of energy consumption, generation and services occurring on the ‘customer side’ of the meter (for instance, at a customer’s residential premises). This can be contrasted with activities on the ‘network side’ of a customer’s meter.
Capacitor bank	A grouping of connected capacitors that store electrical energy.
Co-generation	A type of distributed generation system designed to generate electricity and useful heat jointly.
Current	An electric current is the flow of an electric charge at a defined rate.
Demand response	Measures to reduce or ‘reshape’ electricity demand with the intent of reducing the cost of operating the electricity system (either in terms of generation, wholesale market or network costs).

Dispatchable generation	Generation whose output can be controlled, and which therefore can be dispatched according to the instructions of an operator. This can be contrasted to passive generation, the output of which cannot be actively controlled by an operator.
Distributed generation	Refer to section 3.2.
Distribution business	A type of network business who engages in the activity of owning, controlling, or operating a distribution system – referred to in the NER as a Distribution Network Service Provider (DNSP).
Expected unserved energy	The forecasted amount of energy that is required by customers but cannot be supplied due to the failure of a critical piece of network equipment.
Firmness	A shorthand means of referring to matters relating to the reliability of generation, which may include intermittency, predictability, dispatchability.
Flicker	Changes to the output of lighting caused by rapid voltage fluctuations. Also describes a pattern of frequent sudden changes in voltage.
Grid services	A broad term encompassing the full suite of services that are required for the safe, reliable and efficient operation of the electricity network. This may include network support services, ancillary services, or other forms of network services.

Gross output	The total electricity generated by a distributed generation system, which is equal to the electricity consumption that supports the local generator ('own-use'), the local customer's load and internal power losses plus the remaining power exported from the generation site.
Harmonics	Currents or voltages in the electricity grid with frequencies different to an ideal electrical waveform, which can be associated with power quality problems.
Intermittent generation	Generation whose output is a function of the supply of primary energy (i.e. fuel), rather than demand for electricity. Common forms of intermittent generation are solar photovoltaic, wind generation and run-of-river hydropower. This can be contrasted to non-intermittent generation sources such as coal-fired power stations and gas turbines.
Inverter	Apparatus that converts the direct current (DC) output of solar photovoltaic panels into alternating current (AC). Inverters used in conjunction with solar panels may also have additional functionality to control active and reactive power output.
Islanding	The capability of distributed generation to maintain power to a location when external grid supply of electricity is cut.
Low voltage	The normal voltage for supply to small customers: 415 volts three phase or 240 volts single phase.

Micro-embedded generator	A generating system connected to an AS4777 compliant three-phase or single-phase inverter that produces no more than 10 kW single-phase and 30 kW three-phase.
Microgrid	Distributed energy resources within a defined boundary that can act as a single controllable entity. A microgrid may be able to connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.
N-1 rating	The capacity of a zone substation (or any network asset) in a scenario where the largest piece of equipment has failed.
Net output	The portion of a distributed generator's output that is surplus to the 'on site' demand at the location of the generator and which is therefore exported into the grid.
Network augmentation	A modification or upgrade to an existing network for the purposes of increasing the capacity to supply load or to increase reliability of supply. Augmentations are distinct from projects intended to replace existing network infrastructure due to infrastructure assets reaching the end of life.
Network business	A transmission or distribution network business.
Network optimised	The attribute, as it applies to a generation resource, of being fully optimised for the purposes of creating network benefits. Encompasses both reliability and timeliness (i.e. coincidence with peak demand).

Network support facilities Facilities offering services to relieve network congestion, typically purchased by network businesses. Such facilities are commonly electricity generators.

Output profile The pattern of electricity produced across time by a generation technology, such as solar PV systems.

Passive generation Generation whose output cannot be actively controlled by an operator. This includes most forms of solar photovoltaic systems (assuming the array does not include control systems or energy storage).

Power Power is the rate, per unit time, at which electrical energy is transferred by an electric circuit. Apparent power is the product of line voltage and current.

Power factor Total power includes real and apparent power. Power factor is the ratio of real power (kilowatts or kW) to apparent power (kilo volt-amps or kVA).

Power quality The quality of electricity supply with respect to voltage and frequency stability and the absence of harmonic voltages and currents which can damage electrical equipment

Reactive power Reactive power is power where the current is completely out of phase with the voltage and which delivers no net energy to the customer. Reactive power has an important influence on voltage.

Small-scale	For the purposes of this inquiry, small-scale refers to distributed generation of below 5 MW capacity
Third party aggregator	An entity that aggregates the supply from a number of distributed generators and transacts on their behalf. The transactions may be for the supply of energy, via the electricity wholesale market, or conceivably may occur with a network business for the provision of grid services.
Tri-generation	A type of distributed generation system designed to generate useful heat, cooling and electricity jointly.
Value of Customer Reliability	The value of expected unserved energy in dollars per megawatt-hour at any given customer connection point in the network, for example supplied from a zone substation. The value is assessed according to class of customer (e.g. residential, commercial, industrial, agricultural).
Voltage	The amount of potential energy per unit of electrical charge between two points on a circuit.

ACRONYMS

AC	Alternating current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AMI	Advanced metering infrastructure
API	Application programming interface
APR	Annual planning report
ARENA	Australian Renewable Energy Agency
AS/NZS	Joint standards from Standards Australia and Standards New Zealand
CAPEX	Capital expenditure
CESS	Capital Expenditure Sharing Scheme
COAG	The Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAPR	Distribution Annual Planning Report
DC	Direct current

DER	Distributed energy resources
DERMS	Distributed energy resources management systems
deX	Decentralised energy exchange
DG	Distributed generation
DMIA	Demand Management Investment Allowance
DMIS	Demand Management Investment Scheme
DNSP	Distribution Network Service Provider
DRM	Demand Response Mode, as defined in AS/NZS 4777.2:2015
DSO	Distribution System Operator
DUOS	Distribution use of system
EBSS	Efficiency Benefit Sharing Scheme
ESC	Essential Services Commission
FCAS	Frequency Control Ancillary Services
FiT	Feed-in Tariff
GWh	gigawatt hour
Hz	hertz
ICT	Information and communications technology
kV	kilovolt
kVA	kilovolt-amp

kW	kilowatt
kWh	kilowatt hour
LGNC	Local Generation Network Credit
LRMC	Long Run Marginal Cost
MVA	Megavolt-amps
MVAr	Megavolt-amps (reactive)
MW	Megawatt - measure of electrical power
MWh	Megawatt hour – measure of electrical energy
NARUC	National Association of Regulatory Utility Commissioners, US
NSCAS	Network Support and Control Ancillary Services
NEM	National Electricity Market
NER	National Electricity Rules
NLAS	Network Loading Ancillary Service
NSCAS	Network Support and Control Ancillary Services
OPEX	Operating Expenditure
PV	Photovoltaic
REPEX	Capital expenditure for the purposes of replacing assets due to end of serviceable life
REV	Reforming the Energy Vision

RIT-D	Regulatory Investment Test – Distribution
RIT-T	Regulatory Investment Test – Transmission
SGAF	Small Generation Aggregation Framework
SRAS	System Restart Ancillary Service
STPIS	Service Target Performance Incentive Scheme
TNSP	Transmission Network Service Provider
TOSAS	Transient and Oscillatory Stability Ancillary Service
TUOS	Transmission use of system (service charges)
TSS	Tariff Structure Statement
USB	Universal Serial Bus
VAR	volt-ampere reactive
VCAS	Voltage Control Ancillary Service
VCEC	Victorian Competition and Efficiency Commission
VCR	Value of Customer Reliability
VPP	Virtual power plant
ZSS	Zone substation

SUMMARY

INTRODUCTION

In September 2015, the Essential Services Commission ('the Commission') received a terms of reference under section 41 of the *Essential Services Act 2001* to carry out an inquiry into the true value of distributed generation.

In December 2015, we released a paper outlining our proposed approach to the inquiry. In that paper, we proposed to the Government that the inquiry be split into two parts, corresponding to the separate challenges of determining the *energy value* and the *network value* of distributed generation.

In August 2016, the Commission submitted to the Government its final report on the energy value of distributed generation. This report showed that the energy produced by distributed generation has a value based on the wholesale value of electricity, and that this value varied across time and by location. Since distributed generators typically displace conventional fossil fuel based generation, they can also reduce emissions of greenhouse gases. The Commission found that operators of small-scale distributed generation systems could be paid a tariff that reflected their location and the time of day at which they supply electricity to the system, as well as a payment for environmental value.

In addition to these benefits associated with energy supply, distributed generation may provide network benefits, particularly if it reduces peak demand in a predictable way. Following the publication of the Commission's discussion paper into the network value of distributed generation in June 2016, and our draft report in October 2016, this final report presents the Commission's findings into the network value of distributed generation.

SCOPE OF INQUIRY

As required by the terms of reference, this stage of the inquiry has:

1. Examined the value of distributed generation for the planning, investment and operation of the electricity network; and any environmental and social values caused by changes in the way the grid is managed because of distributed generation.

2. Assessed the adequacy of the current policy and regulatory frameworks governing the remuneration of distributed generation for the identified network value it provides.

3. Made recommendations for any policy or regulatory reform required to ensure effective compensation of the network value of distributed generation in Victoria.

The terms of reference state that the inquiry will not consider the policy and regulatory frameworks governing the costs of connecting distributed generation to the network. This is taken to mean that the terms of reference exclude consideration of all costs associated with initiating and maintaining the connection between distributed generation and the network (i.e. encompassing maintenance and augmentation costs associated with having distributed generation connected to the network). This means that the inquiry is focused on understanding the potential benefits produced by distributed generation.

The Commission's task is to identify the various direct and indirect benefits that may be attributed to distributed generation and, to the extent possible, place a monetary value on those benefits. Its task is then to provide advice to Government on how those monetary values might be reflected in remuneration to distributed generators.

The terms of reference do not anticipate the Commission assessing policy options for promoting investment in distributed generation. Nor do they anticipate assessing alternative policy options for achieving the indirect effects that were identified as having been derived from investment in distributed generation.

PURPOSE OF THIS REPORT

Through this report, the Commission seeks to respond to the following questions arising from the terms of reference:

- What are the economic, environmental and social benefits that distributed generation can provide to the operation of electricity networks (distribution and transmission)?
- Can a monetary value be attributed to these identified benefits?
- How does the existing state and national regulatory framework reflect the network value of distributed generation?
- What reforms are needed, if any, to ensure the effective calculation and remuneration of the network value of distributed generation?

THE COMMISSION'S APPROACH

The Commission has taken the following approach to this stage of the inquiry:

- define distributed generation for the purposes of the inquiry
- define the circumstances in which distributed generation can provide network benefits
- develop and apply a methodology for quantifying and valuing the network benefits of distributed generation
- analyse how the existing national and state regulations reflect the network value of distributed generation and
- explore potential reform options, if required.

Definition of distributed generation

For the purposes of this inquiry, we define distributed generation as:

- distributed generation below 5 megawatts (MW) in capacity
- distributed generation from any source or fuel type and
- including battery storage, both standalone and integrated with another distributed generation technology.

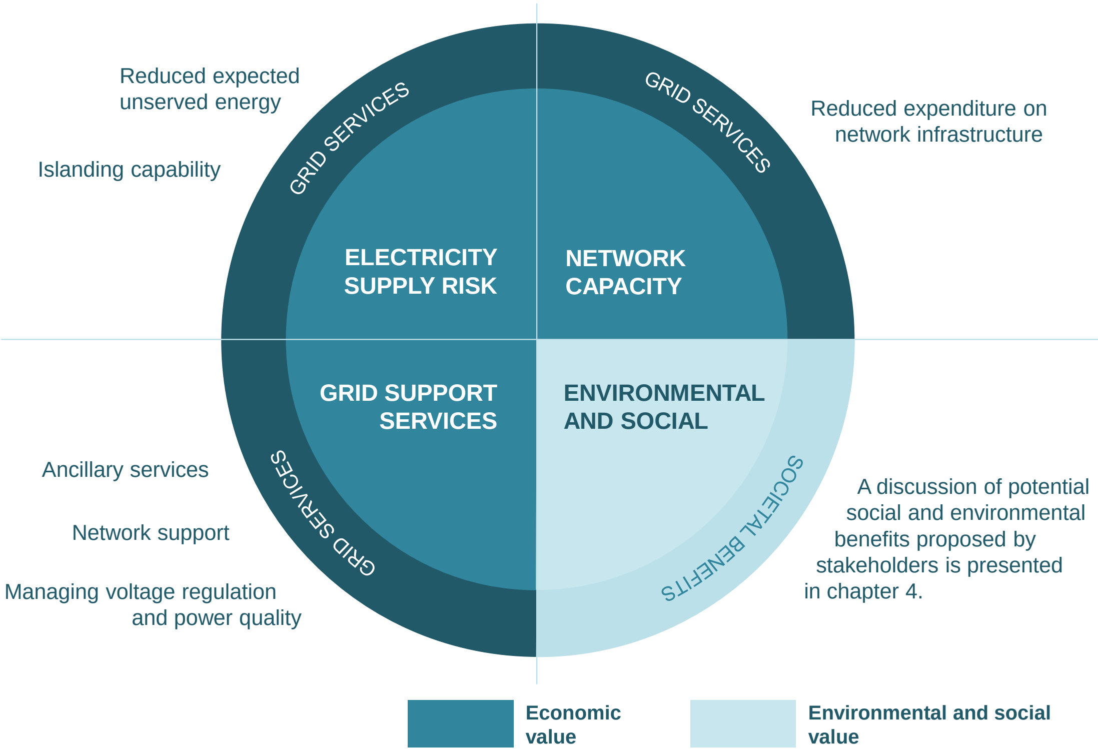
For this stage of the inquiry we distinguish between network-led and proponent-led distributed generation. We have sought to examine how these different categories of distributed generation are accommodated within the regulatory framework. We define the two categories as:

- **network-led** distributed generation, which is procured by a network business and
- **proponent-led** distributed generation refers to systems that are installed by third parties independently of the decision making of the network business.

Circumstances in which distributed generation may provide network benefit

The Commission has identified four categories of network benefit that may arise as a result of investment in distributed generation, along with a range of potential benefits in each of these categories. We conceived the categories relating to economic benefits as 'grid services'. These are outlined in figure S1 below.

FIGURE S1 NETWORK BENEFIT CATEGORIES AND POTENTIAL BENEFITS



Source: ESC

Distributed generation may also impose costs on the network, relating either to initial connection of the system or to maintaining the connection. In some cases, this may include reinforcing the network to handle bi-directional flows, where a sufficient volume of distributed generation has been installed in a given section of the network to make this necessary. However, consideration of costs is outside the scope of the inquiry and so has not been included in the valuation exercise. These costs are already taken into account by distributed businesses when submitting their regulated revenue requirements to the Australian Energy Regulator.

Valuation methodology

Economic value

The Commission’s approach for valuing the network benefits of distributed generation is based on a number of steps. First, we analysed each network benefit category to gauge the materiality of each potential benefit with respect to calculating network value. Where benefits were unlikely to be material, we conducted case studies to test this finding. Where material benefits were likely, we developed calculation methods to quantify and then value that benefit.

We consulted with network businesses and members of the distributed generation industry to ensure the robustness of the methodology. Finally, we applied the calculation methods, largely relying upon publicly available data published by distribution businesses.

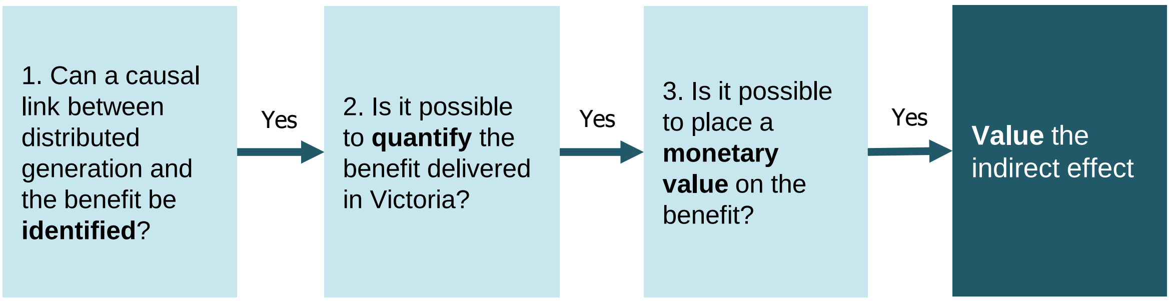
We identified that the key economic benefit provided to electricity networks by distributed generation is through reducing network congestion. We therefore focused on developing a methodology that quantified and valued the benefits caused by reducing network congestion: deferrals of network augmentation projects and reductions in the value of potential unserved energy.

We sought to identify for each zone sub-station in Victoria the value provided by the existing fleet of distributed generation. We also sought to develop a method that would allow us to calculate the value that different forms of new distributed generation may provide if installed in the future.

Environmental and social value

During our work on the energy value of distributed generation, we developed a three-part process for assessing the potential value of environmental and social benefits. We similarly applied this process when examining the network value of distributed generation. The process is outlined in figure S2 below.

FIGURE S2 THREE-PART INDIRECT EFFECT TEST
Method for considering environmental and social value



Source: ESC

THE COMMISSION'S FINDINGS

The economic value of distributed generation to electricity networks

Distributed generation can and does create network value. The main source of that value is the way distributed generation can reduce network congestion, which may defer the need to upgrade the network and thereby save costs. Reducing network congestion can also reduce the amount of expected unserved energy.[1] Distributed generation can also provide other network benefits but these are not currently material with respect to calculating network value for the purposes of this inquiry.

[1] Expected unserved energy is the forecasted amount of energy that is required by customers but which cannot be supplied due to the failure of a critical piece of network equipment.

Distributed generation is one of a number of means through which network value can be delivered. Other demand-side measures, such as demand response[2] and energy efficiency, may also give rise to network value. The potential network benefits provided by all these forms of demand-side measures can be collectively described as 'grid services'. However, because of the focus of this inquiry, we have concentrated on the value of the grid services provided by distributed generation.

The size of the network value of distributed generation is affected by:

- **Location** – the value varies based on the distributed generator's location within the network, specifically in terms of its proximity to areas of the network that are congested, or nearing congestion.
- **Time** – the value varies according to the extent to which the electricity generation coincides with the periods of peak demand within the section of the network to which the generator is connected.
- **Asset life-cycle** – the value varies based on when in the network operator's cycle of upgrade projects the value is being measured. (If the measurement is conducted annually, the value varies year-on-year, subject to the timing of network upgrade projects, as well as the supply and demand for energy in the area of the network to which it is connected).
- **Capacity** – the generation capacity of the distributed generation.
- **Optimisation** – 'optimisation' refers to the extent to which the generation is optimised for delivery of grid services, which is largely a function of being both predictable and responsive to the needs of the network. Commonly used industry terms applied to these qualities are 'firm' and 'dispatchable'. A system that is highly optimised for network benefits is one that reliably produces output at the time it is most needed by the network.

[2] Demand response refers to measures to reduce or 'reshape' electricity demand with the intent of reducing the cost of operating the electricity system (either in terms of generation, wholesale market or network costs). It can include 'shifting' or 'smoothing' demand, for example through adjusting the thermostat on refrigeration units or air conditioners.

The environmental and social value (networks)

Distributed generation may provide a benefit if it provides a lower cost alternative to network projects undertaken for the purposes of bushfire mitigation. This could occur in remote areas, where distributed generation could allow the linking network to be de-energised during high fire risk days, if this was a more efficient alternative to other bushfire mitigation steps, such as undergrounding wires. The Commission did not identify any regulatory impediment to this value being realised. We therefore did not assess the merits of greater investment in distributed generation relative to other forms of bushfire risk mitigation available to network businesses.

The Commission did not identify evidence that the network effects of the distributed generation installed in Victoria is creating additional social or environmental benefits.

Regulatory framework

The primary purchasers of grid services are large, monopoly network businesses, which have access to more information than individual small-scale distributed generation proponents, who may often be residential households. In these circumstances, network businesses are likely to have considerable bargaining power. Conversely, procuring grid services from multiple small-scale providers may be challenging for network businesses, particularly from the perspective of risk allocation and transaction costs.

Some of these factors are acknowledged by the national regulatory framework that applies to monopoly network businesses and which contains:

- incentives for network businesses to appropriately apportion their expenditure between traditional network upgrade projects, such as upgrading the 'poles and wires', and non-network solutions, such as using grid services to defer upgrades of the existing network infrastructure
- requirements that network business provide a level of information about opportunities for the provision of grid services and
- processes network businesses must follow when deciding how to respond to network constraints, including undergoing a tender process for grid services options before undertaking major upgrades of the network.

The framework is not orientated towards ensuring small-scale providers of grid services are able to efficiently participate in the market for grid services. It does not contain any mechanisms designed to ensure network businesses calculate the network value of small-scale distributed generators on an individual basis, nor to ensure they make payments on the basis of that value.

Accessing the value of distributed generation

Distributed generation provides significantly more value when it is 'firm', meaning it can reduce pressure on the network in a controlled and reliable way. The greatest value occurs when the quantity of generation is matched to the needs of the network and local customers. To reduce congestion in a way that produces the greatest value may require larger quantities of generation capacity than small-scale distributed generators can provide individually. However, this value can be unlocked by larger distributed generation systems, or by multiple smaller systems acting in unison.

Technology is available to transform intermittent distributed generation, such as solar PV, into firm generation. Such technologies include energy storage (batteries), 'smart' inverters and energy management systems. This technology is not new, but it is becoming increasingly economic for small-scale distributed generation owners to install. If distributed generation proponents invest in technologies that increase the firmness of their generation, their potential to provide valuable grid services will also increase.

Technology is also emerging that enables coordination of large numbers of small-scale distributed generation installations. These technologies enable multiple distributed generation systems to be coordinated, or 'orchestrated', in order to deliver grid services at the times and in the locations they have the greatest value. The maturity and capability of this technology are currently being illustrated in Victoria through demonstration projects that are proceeding with the assistance of grants and allowances.

Investment in these technologies is likely to be driven, in part, by the decisions of energy customers rather than by traditional energy businesses such as network providers. We therefore consider it appropriate, given these technology changes, to examine whether small-scale distributed generators will have adequate opportunities to monetise the grid services they are capable of providing, now and into the future.

Network value and the feed-in tariff

Because of the characteristics of network value, a broad-based feed-in tariff is unlikely to be an appropriate mechanism to support the participation of small-scale distributed generation in a market for grid services. The value of the grid services that distributed generation can provide is too variable – between locations, across times, and between years – to be well suited for remuneration via a broad-based tariff.

If a broad-based network value feed-in tariff (FiT) was calculated with sufficient granularity to reflect the underlying network value it would be disproportionately complex and costly to implement. If it were made simple enough to implement, it would be inadequately reflective of value and could lead to payments to distributed generators who were not providing benefits, while at the same time, not sufficiently rewarding those who were.

A market for grid services in Victoria

A market for grid services is a 'place' where network businesses transact with providers of grid services. In a market for grid services the primary buyers would be network businesses and any sellers of grid services, including the operators of distributed generation, would be remunerated for the services they provide.

Unlike other jurisdictions in the National Electricity Market (NEM), Victoria has advanced metering infrastructure (AMI), or 'smart meters', which allow grid services to be deployed more easily and at lower cost than is possible under traditional analogue metering. This is because smart metering enables near to real-time remote monitoring of electricity flows to and from customers. Providers in Victoria can therefore provide accurate and timely grid services without the need to install additional metering infrastructure.

For reasons including but not limited to the roll out of advanced metering infrastructure, a market for grid services in Victoria may present opportunities for small-scale providers that are not currently available in other jurisdictions.

Emergence of the grid services market in Victoria

The market for grid services in Victoria is nascent. To the extent any transactions are occurring, they are limited to interactions between networks and very large scale providers and some pilots and trials by network businesses focused on testing the incorporation of small-scale providers.

Importantly, whether it emerges entirely as a result of market forces or with the assistance of regulatory intervention, a market for grid services is likely to evolve in stages rather than emerge abruptly. The main drivers of this evolution are the increasing maturity of technology and commercial models, the increasing demand for grid services as the grid becomes more congested over time, and the gradual modernisation of the national regulatory framework.

The precise shape and structure of the future market is therefore uncertain. However, in order to be a market in which the network value of small-scale distributed generation could be optimised and remunerated, the market would need specific attributes, particularly related to information, access, payment, protections and efficiency. In order for such a market to emerge, a number of issues will need to be addressed, including issues related to information, access (including risk allocation), market design (including pricing and payment mechanisms), technical factors and customer protections.

Practical steps to support the development of a market for grid services

A fully developed market for grid services may be many years in the future. At this stage it may be too early to identify specific regulatory reforms that are necessary to enable its emergence. However, Victoria is well placed to become a leading jurisdiction in this area, largely because one of the key enablers – widespread penetration of advanced metering infrastructure (smart meters) – is already in place. If the right steps are taken, Victorian distributed generators may be amongst the first to access, on an effective and efficient basis, remuneration for the network value of their investment.

The scale of this endeavour should not be underestimated. Developing a fully mature market for grid services involves efficiently integrating thousands of small distributed generators – possibly tens of thousands – into the management of the grid. The technical challenges of this alone are significant, to which myriad commercial and regulatory challenges are added. Our analysis leads us to conclude that the development of a market for grid services warrants careful and sustained analysis, consultation and planning. It is not a minor reform, but rather a material step towards ensuring the ongoing energy industry transformation unfolds in an efficient and equitable manner.

There are various processes occurring at the national level which are investigating reforms that may assist with the emergence of the market for grid services. Some of these processes commenced or were publically announced following the release of our Draft Report in October 2016. Significant among those are the Australian Energy Market Commission's Distribution Market Model project, rule change requests on the contestability of energy services and demand response and network support, and the Network Transformation Roadmap project being delivered by Energy Networks Australia and CSIRO. These processes and developments may address some of the issues we have identified in this report, although their outcomes and their timing are uncertain.

For a market for grid services to emerge that enables participation by small scale operators, a great deal of commercial and technological detail needs to be addressed. This includes how regulated entities would participate in such a market. We are not confident that a market of this nature will emerge without some external assistance, but nor are we certain that this won't be the case. Some elements may need external assistance while others may not. A work program aimed at facilitating the emergence of a market should proceed in carefully sequenced stages so as not to preclude the opportunity for a market to emerge of its own accord. It should also account for developments in the national framework.

Progressing the development of a market for grid services in which small-scale operators can engage will require a work program consisting of the following elements:

- A focus on promoting the availability of appropriate information for all existing and potential market participations – including information about the opportunities to supply grid services – taking into account the need to ensure the relevant information is available in the appropriate form and at an appropriate time. In the context of the information asymmetry that currently exists between network businesses and small-scale distributed generation owners, consideration should be given to balancing the need for clear, simple, location-specific information against costs to network businesses of providing that information.
- A review of the means by which customers can access the market for grid services as suppliers, including the reasonableness and clarity of the technical and

contractual requirements for participation, and the associated allocation of risk between parties. As part of this review, consideration should be given to the question of whether standardised arrangements are warranted.

- An investigation of the design of potential market mechanisms, including auctions, to ensure prices are revealed in a robust and efficient manner and account for the benefits provided by distributed generators, in the context of network tariff arrangements. Such mechanisms could be designed in such a way as not to preclude the participation of all forms of demand side participation, and could be designed to be scalable and thus inform the development of similar mechanisms at a national level. Consideration should be given to ensuring such mechanisms do not preclude efficient 'stacking' of revenue streams from distributed generation, including the revenue derived from sales of energy, and the risks of inadequate competition.
- A focus on promoting the establishment of technical standards to support the interoperability of relevant technologies, such as solar photovoltaic (PV) systems, energy storage devices (batteries), energy management systems, inverters, appliances, and platforms. Such standards may be supported via a formal Australian Standards process or may be supported to emerge via the coordination of private actors within the market.
- A review of existing customer protections to ensure customers are empowered to provide grid services while maintaining their ability to participate in the retail market in an effective and efficient way. Privacy and cyber security risks associated with a data-driven market should also be considered.
- Facilitation of grid services market trials and pilots in Victoria in order to progress the practical deployment of grid services market elements and mechanisms. Pilots could be focused on advancing understanding – for commercial operators, policymakers and regulators – of key elements of the market, such as platform development and interoperability issues, product specification (including ancillary services based products, such as coordinated voltage control), pricing mechanisms, customer interactions, and associated risks.

FINDINGS

Finding 1: Network value of distributed generation

Distributed generation can and does provide network value. The value is primarily derived from reductions in network congestion, which can lead to the deferral of network augmentation expenditure and reduce the quantity of expected unserved energy. Distributed generation can also provide other network benefits but these are not currently material with respect to calculating network value for the purposes of this inquiry.

Finding 2: Network value is highly variable

The size of the network value of distributed generation is affected by:

- **Location** – the value varies based on the distributed generator's location within the network, specifically in terms of its proximity to areas of the network that are congested, or nearing congestion.
- **Time** – the value varies according to the extent to which the electricity generation coincides with the periods of peak demand within the section of the network to which the generator is connected.
- **Asset life-cycle** – the value varies based on when in the network operator's cycle of upgrade projects the value is being measured. If the measurement is conducted annually, this means the value varies year-on-year, subject to the timing of network upgrade projects, as well as the supply and demand for energy in the area of the network to which it is connected.
- **Capacity** – the generation capacity of the distributed generation.
- **Optimisation** – 'optimisation' refers to the extent to which the generation is optimised for delivery of grid services, which is largely a function of being both predictable and responsive to the needs of the network. A system that is highly optimised for network benefits is one that reliably produces output at the time it is most needed by the network.

Finding 3: 'Firm' distributed generation has significantly more network value than 'intermittent' generation

Distributed generation can provide significantly more network value when it is 'firm'. The greatest value is created when distributed generation can provide firm output in capacity increments that match the extent of the network congestion.

Finding 4: Technology can transform intermittent generation into firm generation

When intermittent distributed generation systems are supplemented with additional technologies – such as energy storage (batteries) and energy management technologies – they may be capable of operating as firm generators, which would increase their potential value. Technology also exists to coordinate, or 'orchestrate', multiple small-scale distributed generators in order to produce larger increments of firm generation and thereby maximise their network value.

Finding 5: Social and environmental benefits of network effects

Distributed generation may provide a benefit if it provides a lower cost alternative to network projects undertaken for the purposes of bushfire mitigation. This could occur in circumstances where deploying distributed generation in a remote area, and thereby enabling the linking network to be de-energised during high fire risk days, was a more efficient alternative to other bushfire mitigation steps, such as undergrounding wires. The Commission did not identify any regulatory impediment to this value being realised.

Finding 6: Sources of grid services

Reducing network congestion is a form of 'grid service'. Network congestion can be reduced by a number of means, of which distributed generation is only one. Measures implemented for the purposes of remunerating distributed generation for the provision of grid services could be designed in a way that does not preclude the remuneration of other means of delivering grid services, such as demand response.

Finding 7: A market for grid services

Distributed generation in Victoria could be remunerated for its network value through a market for grid services, assuming it provides adequate opportunities for the participation of small-scale grid service providers, including distributed generation.

Finding 8: A broad-based feed-in tariff is unlikely to be an appropriate mechanism to remunerate network value

A broad-based feed-in tariff is unlikely to be an appropriate mechanism to support the participation of small-scale distributed generation in a market for grid services. If a network value FiT was calculated with sufficient granularity to reflect the underlying network value it would be disproportionately complex and costly to implement. If it were made simple enough to implement, it would be inadequately reflective of value and could lead to payments to distributed generators who were not providing benefits while, at the same time, not sufficiently rewarding those who were.

Finding 9: Opportunities for the grid services market in Victoria

For reasons including but not limited to the roll out of advanced metering infrastructure, there may be opportunities in Victoria for the earlier development of an established market for grid services that are not currently available in other jurisdictions. Such a market could provide adequate opportunities for small-scale grid service providers, including distributed generators, to be remunerated for the grid services they are capable of providing.

Finding 10: Proposed way forward

Progressing the development of a market for grid services in which small-scale operators can engage will require a work program consisting of the following elements.

- A focus on promoting the availability of appropriate information for all existing and potential market participations – including information about the opportunities to supply grid services – taking into account the need to ensure the relevant information is available in the appropriate form and at an appropriate time.

- A review of the means by which customers can access the market for grid services as suppliers, including the reasonableness and clarity of the technical and contractual requirements for participation, and the associated allocation of risk between parties.
- An investigation of the design of potential market mechanisms, including auctions, to ensure prices are revealed in a robust and efficient manner and account for the benefits provided by distributed generators, in the context of network tariff arrangements.
- A focus on promoting the establishment of technical standards to support the interoperability of relevant technologies, such as solar photovoltaic (PV) systems, energy storage devices (batteries), energy management systems, inverters, appliances, and platforms.
- A review of existing customer protections to ensure customers are empowered to provide grid services while maintaining their ability to participate in the retail market in an effective and efficient way.
- Facilitation of grid services market trials and pilots in Victoria in order to progress the practical deployment of grid services market elements and mechanisms.

CONTENTS

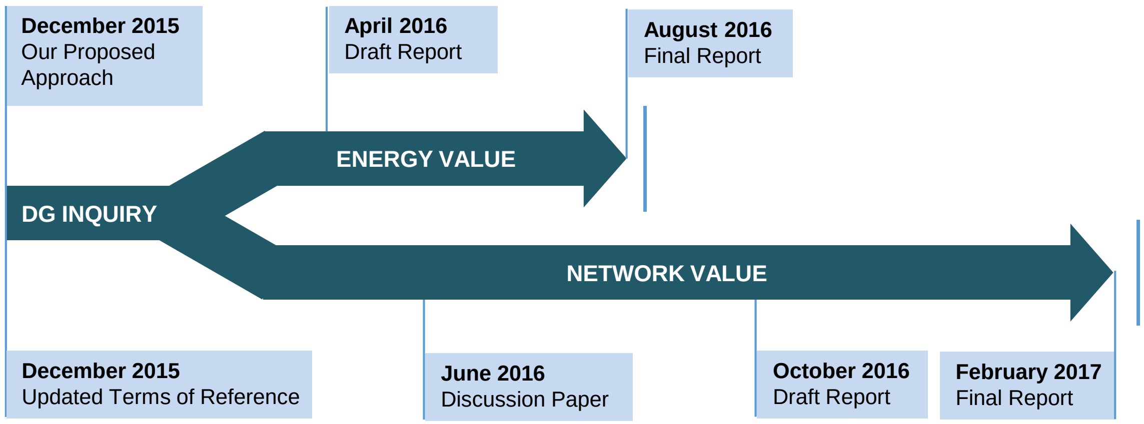
1 INTRODUCTION

1.1 BACKGROUND

In September 2015, we received terms of reference under section 41 of the Essential Services Commission Act 2001, to carry out an inquiry into the true value of distributed generation (the inquiry).

In December 2015 we published a paper outlining our proposed approach to the inquiry. In that paper, we proposed to the Government that the inquiry be split into two parts, corresponding to the separate challenges of determining the true *energy value* and the true *network value* of distributed generation. We also proposed extending the timelines of the inquiry. The Government accepted the proposed changes and issued revised terms of reference in December 2015. The inquiry structure is outlined in figure 1.1. The full (revised) terms of reference can be found in appendix B.

FIGURE 1.1 INQUIRY STRUCTURE



Source: ESC

In August 2016, the Commission submitted to the Government its final report on the energy value of distributed generation.[3] This report showed that the energy produced by distributed generation has a value based on the wholesale value of electricity, and that this value varies across time and by location. Since distributed generators typically displace conventional fossil fuel based generation, they can also reduce emissions of greenhouse gases. In its energy value report, the Commission found that operators of small-scale distributed generation systems could be paid a tariff that reflected their location and the time of day at which they supply electricity to the system, as well as a payment for environmental value.

In addition to these benefits associated with energy supply, distributed generation may provide network benefits, particularly if it reduces peak demand in a predictable way. In June 2016 we published a discussion paper on the network value of distributed generation. In response, we received 14 submissions. In October 2016, we published our draft report on the network value of distributed generation, with 18 submissions in response.

1.2 PURPOSE

This final report sets out the Commission's findings with regard to the *network value* of distributed generation, as well as a discussion of reform options focused on facilitating remuneration of owners of distributed generation for the value of the network benefits they provide.

1.3 STRUCTURE OF THIS REPORT

This final report is divided into the following chapters:

[3] The Victorian Government responded to the final report on the energy value of distributed generation, accepting most of the Commission's findings. Department of Environment, Land, Water and Planning 2016, *Victorian Government Response to the Essential Services Commission's Energy Value of Distributed Generation Final Report*, October.

- chapter 1 contains the introduction
- chapter 2 sets out the context and scope of the inquiry
- chapter 3 outlines the framework the Commission has developed to identify and analyse the network benefits of distributed generation
- chapter 4 presents the results of the analysis to identify and quantify the network value of distributed generation
- chapter 5 outlines how the current regulatory framework relates to the network value of distributed generation
- chapter 6 outlines a proposed reform direction to enable the participation of small-scale distributed generation in a market for grid services
- chapter 7 presents an analysis of distributed generation within a market for grid services and the key issues relating to the emergence of such a market, and
- chapter 8 sets out the Commission's views with regards to practical measures to support the emergence of a market for grid services in Victoria.

2 CONTEXT AND SCOPE

2.1 CONTEXT OF THE INQUIRY

Distributed generation is a growing segment of the market for the supply of electricity. Current small-scale distributed generation capacity in Victoria is estimated to be approximately 930 megawatts (MW).[4] By way of comparison, total electricity generation capacity in Victoria is estimated at 13,200 MW.[5]

Most distributed generation that is currently installed in Victoria is small-scale solar photovoltaic (PV) generation, but distributed generation can come in a range of sizes and be powered by a variety of sources, including wind, biomass and natural gas.

Distributed generation typically supplies some, or in some cases all, of the electricity demand at the place it is installed, with excess electricity exported to the grid. In 2015, electricity generation in Victoria from small-scale solar PV was estimated to be 1,043,000 megawatt hours (MWh),[6] with a further 188 MWh[7] from small-scale wind power.

[4] Small scale distributed generation refers to systems with a capacity of less than 100 kilowatts (kW). The data are Commission estimates based on Victorian data for eligible small-scale solar PV, wind and hydro under the Small-scale Renewable Energy Scheme from the Clean Energy Regulator 2016, *Postcode data for small-scale installations*, March, and additional data provided by Victorian distribution network service providers (DNSPs) for the purposes of this inquiry.

[5] The Commission's estimate based on existing in service scheduled, semi-scheduled and non-scheduled generation nameplate capacity in Victoria from Australian Energy Market Operator (AEMO) data, and data from the Clean Energy Regulator 2016 and Victorian DNSPs for small-scale systems.

[6] Based on data from Clean Energy Regulator 2016, *Postcode data for small-scale installations,* March; and estimated by the Commission using yearly Victorian solar PV electricity production provided by ACIL Allen for the inquiry.

[7] Based on data from Clean Energy Regulator 2016, *Postcode data for small-scale installations,* March; and estimated by the Commission using yearly Victorian wind power electricity production provided by ACIL Allen for the inquiry.

2.2 SCOPE OF THE INQUIRY

The terms of reference state that the inquiry will:

1. Examine the value of distributed generation including: the value of distributed generation for the wholesale electricity market; the value of distributed generation for the planning, investment and operation of the electricity network; and the environmental and social value of distributed generation.
2. Assess the adequacy of the current policy and regulatory frameworks governing the remuneration of distributed generation for the identified value it provides.
3. Make recommendations for any policy or regulatory reform required to ensure effective compensation of the value of distributed generation in Victoria. These recommendations should have regard to the most appropriate policy and regulatory mechanisms for compensating the different benefits of distributed generation, including their practicality and costs.

The terms of reference state that the inquiry will not consider the policy and regulatory frameworks governing the costs of connecting distributed generation to the network. This is taken to mean that the terms of reference exclude consideration of all costs associated with initiating and maintaining the connection between distributed generation and the network (i.e. encompassing maintenance and augmentation costs associated with having distributed generation connected to the network). This means that the inquiry is focused on understanding the potential benefits produced by distributed generation.

Although the terms of reference exclude consideration of the elements of the regulatory framework governing costs of connection, for the purposes of the inquiry it is important that the Commission understands how the costs of connecting distributed generation to networks are accounted for. We understand that these costs comprise two elements:

- **Individual connection costs** – the costs of connecting a specific distributed generator to the network. This process, including the contribution that individual distributed generators should make to the cost of connecting, is underpinned by elements of the National Electricity Rules (NER) and Victorian specific guidelines.[8]

- **Aggregate connection costs –** the costs associated with modifying the infrastructure and operation of the network to accommodate distributed generation.

Network businesses forecast the level of aggregate connection costs during the process of developing their five-yearly regulatory determination proposals. These forecasts are based on their assessment of the amount of distributed generation that will be connected to their networks during the regulatory period. These costs, once approved by the Australian Energy Regulator (AER), are recovered from all electricity consumers.

Based on this understanding of how the costs of connecting distributed generation are dealt with, the Commission will assume, for the purposes of this inquiry, that the costs to distribution businesses of connecting distributed generation and using the network are already accounted for.

The Commission's task in this inquiry is to identify the various direct and indirect benefits that may be attributed to distributed generation and, to the extent possible, place a monetary value on those benefits. Its task is then to provide advice to the Government on how those monetary values might be reflected in remuneration to distributed generators.

The calculation of monetary value in this inquiry is limited to the potential direct and indirect benefits of investment in distributed generation. The inquiry does not examine:

- an expansion of the feed-in tariff (FiT) to cover other actions customers may take to reduce their energy consumption
- other strategies that may be implemented to reduce the emissions intensity of energy supply, and
- other steps that may be taken to reduce demands on the network.

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[8] See chapter 5 for a discussion of these mechanisms.

The terms of reference do not anticipate the Commission assessing alternative policy options for promoting investment in distributed generation or assessing alternative policy options for achieving the indirect effects that were identified as having been derived from investment in distributed generation.

2.2.2 GUIDING PRINCIPLES OF THE INQUIRY

We have adopted three broad principles to guide our work in identifying value through this inquiry. These principles are:

- **Simplicity.** The benefits must be readily convertible into a mechanism that is simple to understand (and administer) by all relevant market participants.
- **Behavioural response.** Any mechanism for rewarding distributed generation for any network benefit it provides, must align signals for investment in, and use of, distributed generation with the benefits (direct and indirect) identified in this inquiry.
- **Materiality.** The benefits being investigated must be large enough to have a material impact on payments made to the distributed generator.

In conducting the inquiry, the Commission also has regard to its objectives under the *Essential Services Commission Act 2001*, which are to promote the long term interests of Victorian consumers with regard to the price, quality and reliability of essential services.[9]

2.3 STAKEHOLDER FEEDBACK ON THE SCOPE OF THE INQUIRY

This is the third report focussing on the network value of distributed generation. We received 14 submissions to our discussion paper in June 2016, with the majority (13) from organisations across the energy sector (retailers, network owners and operators, energy industry groups). Our draft report in October 2016 received 18 submissions.

With regard to the scope of the inquiry, the main issues raised in the submissions were:

[9] *Essential Services Commission Act 2001* (Vic)

- ‘behind-the-meter’ demand reduction from distributed generation has the same benefit as demand reduction from other technologies/activities and
- the need to consider the costs imposed by distributed generation on the network.

DISTRIBUTED GENERATION AND DEMAND REDUCTION

A number of submissions pointed out that distributed generation is not the only technology or activity that can provide the benefit of peak demand reduction. They suggested that making payments to distributed generation on the basis of network benefits while not making payments to other forms of demand reduction technologies and activities would favour distributed generation above other demand reduction measures. Stakeholders argued that if distributed generation is more expensive than other forms of demand response, then any payment mechanism that favours distributed generation over other technologies could increase overall costs.

The fundamental source of network benefit provided by distributed generation is its capability to reduce network congestion by reducing network peak demand. The value of reduced peak demand is not tied to any particular technology – any technology, tool or approach that reduces network congestion may produce network value in a similar fashion to distributed generation. A reduction in network congestion has value however it is achieved. The terms of reference make clear that this inquiry is focused exclusively on identifying the network benefit (and value) of distributed generation. However, in developing our findings we have been mindful that distributed generation is only one form of demand response. The way forward that we have proposed – a market for grid services – is one that can accommodate all forms of demand side participation.

THE COSTS OF DISTRIBUTED GENERATION

Submissions from network businesses suggested that the Commission should identify and calculate the costs that distributed generation can impose on the network. They questioned the appropriateness of paying a distributed generator for network benefit, while it does not also face the full costs of being connected to the network.

As the Commission has indicated, the terms of reference exclude consideration of the costs that distributed generation may impose on network operators. We nonetheless acknowledge that the addition of distributed generation to the network can result in costs to network businesses, both to establish the initial connection and to ensure the network can adequately maintain that connection. In some cases, this may include reinforcing the network to handle two-way flows, where a sufficient volume of distributed generation has been installed in a given section of the network to make this necessary.[10]

However, given that these costs are outside the scope of the inquiry, they have not been included in the valuation exercise. Hence, the results of the valuation exercise do not necessarily indicate the appropriate payments that might be made to distributed generators based on network value. Were a mechanism developed to facilitate payments for network value – on the basis of a 'price for grid services', for instance – a separate exercise would be required to identify an appropriate basis and size for such payments, having regard to the structure of prevailing network tariffs for imports and exports (if any) at the customer site.

[10] For instance, Powercor has proposed to install around 90 bi-directional regulators on its rural feeder network where feeders have high levels of forecast distributed generation. These installations are scheduled to occur between 2016-2020, CitiPower and Powercor 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation - Proposed Approach Paper,* February, p. 5.

3 OUR APPROACH

3.1 INTRODUCTION

This chapter provides our definition of distributed generation and explains our approach to measuring its network value. It sets out how we identified potential network benefits provided by distributed generation, and the methods we used to assess their scale and monetary value.

It outlines the two broad contexts in which this measurement applies:

- the effect of distributed generation on the planning and management of Victoria's electricity network and
- the environmental and social effects that might flow on from any changes to the network caused by distributed generation.

3.2 DEFINITION OF DISTRIBUTED GENERATION

'Distributed generation' can refer to any electricity generation that is connected to the electricity distribution system. This can be contrasted to 'central generation', which refers to generation systems connected to the transmission network and which are typically large scale.[11] Distributed generation can come in varying sizes and be powered by a variety of fuel sources.

[11] Examples of central generation include the coal fired power stations located in the Latrobe Valley and wind farms in Western Victoria which are connected to the transmission system.

In this inquiry, we define distributed generation as:[12]

- **Distributed generation below 5 megawatt (MW) capacity**. Distributed generators of this size are typically not stand-alone generators; they are normally installed in or on a host's property and supply electricity to the host's site.
- **Distributed electricity generation from any source or fuel type**. Electricity from distributed generation can be generated from a range of sources including wind, solar, biomass, hydro, diesel and natural gas. In Victoria, solar is most common.
- **Battery storage**. In our report on energy value we concluded that batteries provide a 'private value' insofar as they enable the distributed generator to avoid retail tariffs by storing any excess energy for later use. When assessing network value, batteries become more significant. We revisit the role, and value, of battery storage in this stage of the inquiry.

For this stage of the inquiry we also distinguish between network-led and proponent-led distributed generation. We have sought to examine how these different categories of distributed generation are accommodated within the regulatory framework. We define the two categories as:

- **network-led** distributed generation is that which is procured by a network business and
- **proponent-led** distributed generation refers to systems that are installed by third parties independently of the decision making of the network business.

3.3 CONCEPT OF VALUE

In our Stage 1 draft report we set out the concept of value that we are using in this inquiry.[13] This section describes this concept in the context of network value.

[12] For further discussion of the definition of distributed generation, please refer to our earlier report: Essential Services Commission 2016, *The Energy Value of Distributed Generation - Distributed Generation Inquiry Stage 1 Final Report*, August, p. 26.

[13] Essential Services Commission 2016, *The Energy Value of Distributed Generation - Distributed Generation Inquiry Stage 1 Draft Report*, April, p. 27.

FOCUS ON 'EXTERNAL' EFFECTS

The first distinction we make is between the 'internal' and 'external' effects of distributed generation. 'Internal effects' refers to anything that only affects the investor in distributed generation, without any intervention from government. This could include the benefit that the distributed generation owner gets from reduced power bills, or the enhanced wellbeing they experience as a result of having taken steps to help the environment. Because the benefits of internal effects accrue directly to the investor, they are excluded from our analysis in this inquiry.

'External effects' of distributed generation are those that are experienced by parties other than the investor in distributed generation. These other parties could include other people, communities, organisations or the physical environment in which the distributed generation unit operates.

DIRECT AND INDIRECT EXTERNAL EFFECTS

There are two types of external effects. The first are 'direct external effects'. Direct external effects are those that manifest in the electricity network when, for example, a distributed generator produces electricity or when they export their surplus electricity into the grid.[14]

The second type is 'indirect external effects'. Indirect effects are those that flow on from the direct effects. If those effects enhance the wellbeing of someone or something, then those effects can be said to generate benefits.

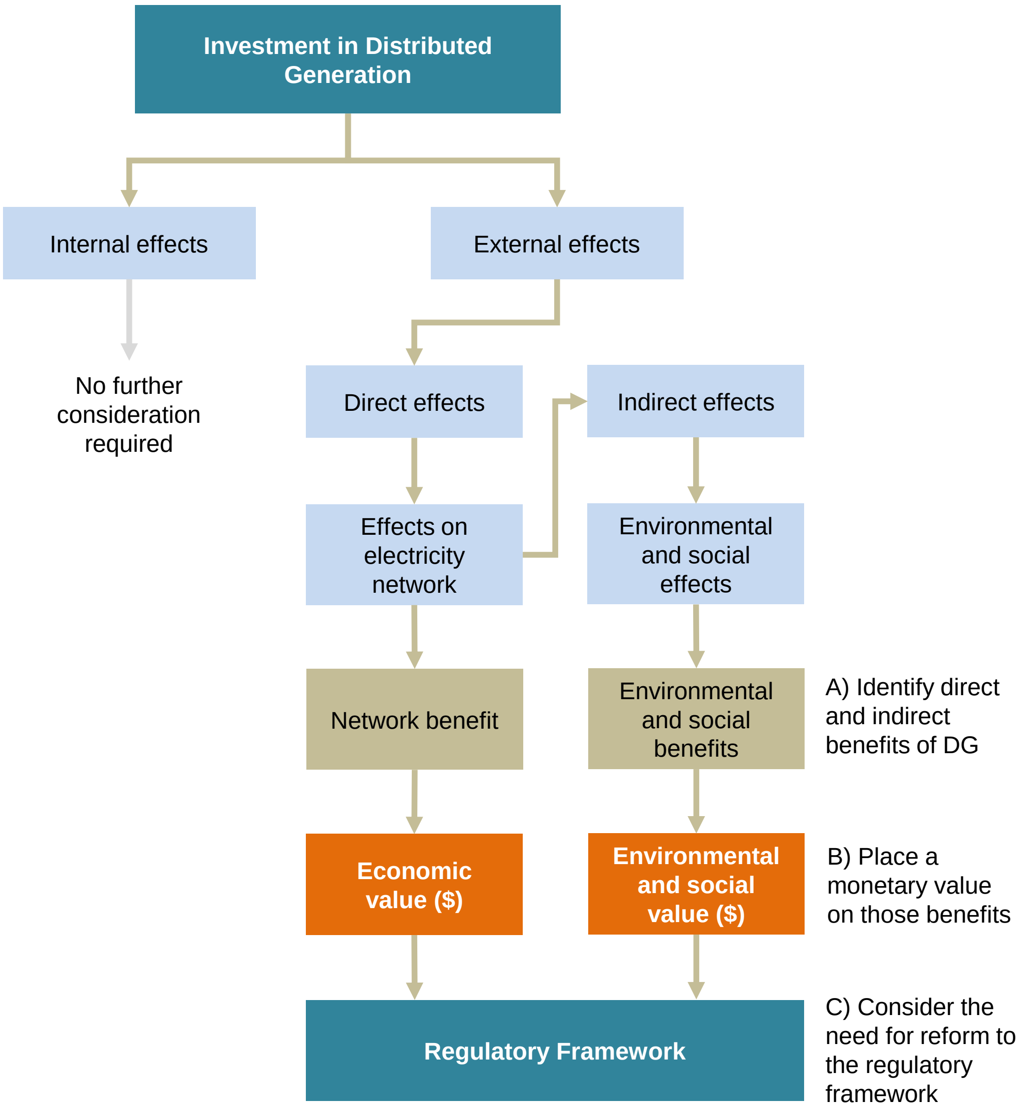
By definition, benefits have a positive value. For example, if distributed generation leads to a reduction in expenditure on network infrastructure, then this could produce a benefit to network businesses. To the extent the reduction in costs is reflected in lower network tariffs, this would produce a benefit to electricity consumers.

[14] A separate series of Commission reports examines the value of distributed generation electricity: Essential Services Commission 2015, *The Energy Value of Distributed Generation – Distributed Generation Inquiry – Our Proposed Approach*, December; Essential Services Commission 2016, *The Energy Value of Distributed Generation – Distributed Generation Inquiry Stage 1 Draft Report*, April; Essential Services Commission 2016, *The Energy Value of Distributed Generation – Distributed Generation Inquiry Stage 1 Final Report*, August.

Measuring that value is not straightforward. However, because this review focusses on identifying how value (or 'true value') might be reflected in remuneration to distributed generators, we confine our approach to defining value in monetary terms only.

We set out this typology of effects as it applies in the network stage of the inquiry in figure 3.1.

FIGURE 3.1 TREATMENT OF NETWORK VALUE IN THIS INQUIRY



Source: ESC

Typically, an investor in distributed generation cannot, all things being equal, gain a return on the benefits enjoyed by other parties via the indirect effects of that investment. (Economists usually refer to situations such as these as externalities or spill-overs). One purpose of this review is to identify and quantify the value of the indirect benefits of investment in distributed generation. Specifically, the terms of reference for this inquiry request that we identify and evaluate the environmental and social value derived from distributed generation.

Identifying the environmental benefits of distributed generation is conceptually more straightforward. Following further discussions with the department,[15] we have defined the term 'social' to cover benefits that manifest themselves in domains such as: health, justice, safety and amenity. These all pertain to the well-being of individuals and communities (and potentially their productivity).

In our role in assessing the 'true value' of distributed generation we do not examine matters such as: the optimal profile for future investment in distributed generation; how the benefits of that investment might be maximised; whether the benefits could be delivered by alternative means; or the cost of delivering them.

3.4 IDENTIFYING POTENTIAL NETWORK BENEFITS

Distributed generation can provide benefits to electricity networks in a number of ways. In terms of economic network benefits, distributed generation may alter the way network businesses build and maintain their electricity networks. Consequently, cost savings may be partially or fully passed on to customers, who may also benefit if distributed generation reduces the 'expected unserved energy' in an area of the network.[16]

The first step in the analysis involved identifying the range of potential benefits that distributed generation may provide to networks. Drawing upon stakeholder

[15] Department of Economic Development, Jobs Transport and Resources, Victorian Government.

[16] Expected unserved energy is the forecasted amount of energy that is required by customers but which cannot be supplied due to the failure of a critical piece of network equipment.

submissions and a review of Australian and international literature,[17] the Commission identified four broad benefit categories that may either result in economic, environmental or social value (see figure 3.2). These categories are:

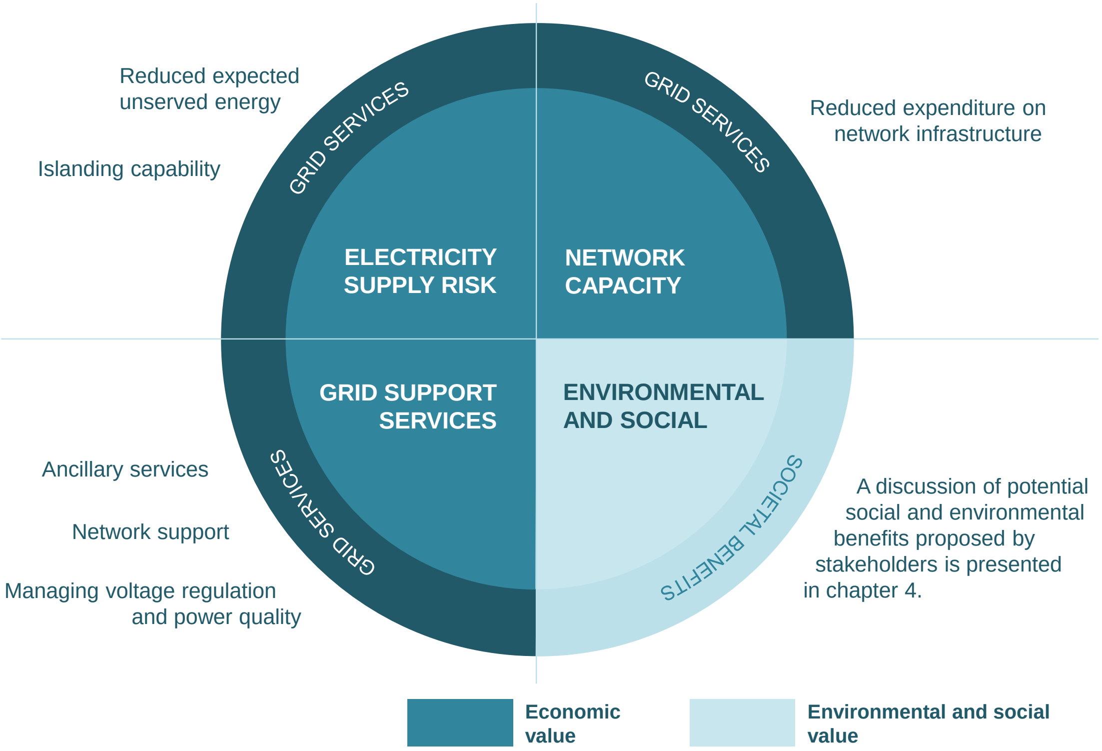
- **Network Capacity** – the effect of distributed generation on improving the capacity of the network, which may defer the need to build or replace network infrastructure or improve the current capacity of the network and thereby relieve network congestion.
- **Electricity Supply Risk** – the effect of distributed generation in improving the continuous supply of electricity and resilience of the grid.
- **Grid Support Services** – the effect of distributed generation on services required to enable the reliable operation of the grid, such as voltage regulation.
- **Environmental and Social** – where distributed generation leads to changes in the way the network is managed, this may also cause flow-on, or indirect, social and environmental benefits.

Within each of these broad categories are a number of more specific potential benefits, listed in table 3.1.

[17] Papers reviewed by the Commission include: Ernst & Young 2015, *Evaluation Methodology of the Value of Small Scale Embedded Generation and Storage to Networks*, Clean Energy Council, July; Frontier 2015, *Valuing the impact of local generation on electricity networks*, February; Rocky Mountain Institute eLab 2013, *A Review of Solar PV Benefit & Cost* Studies, September.

FIGURE 3.2 NETWORK BENEFIT CATEGORIES

Potential network benefits by category



Source: ESC

TABLE 3.1 DESCRIPTION OF POTENTIAL NETWORK BENEFITS

Benefit category	Potential network benefit	Description of potential benefit
Network Capacity	Reduced expenditure on network infrastructure	Network congestion arises when part of a network approaches the limits of its capacity to supply sufficient electricity during periods of peak demand. Network businesses generally build or replace network infrastructure to improve the capacity of the network and relieve network congestion. Congestion can occur, and be relieved, within both the distribution and transmission networks.[18] Distributed generation can relieve network congestion by reducing peak demand or increasing the supply capacity at specific points throughout the network. This could defer the need for network businesses to invest in upgrading network infrastructure.

[18] Our discussion of the benefit of reduced network congestion encompasses the way this benefit manifests at the transmission level, thereby incorporating the benefit that some studies seek to approximate through calculating avoided Transmission Use of Service (TUOS) charges.

Benefit category	Potential network benefit	Description of potential benefit
Electricity Supply Risk	Reduced expected unserved energy	To meet service standards, the network must be able to deliver electricity under certain standards, including under adverse conditions or where there is network congestion. The 'expected unserved energy' is the forecasted amount of energy that is required by customers but cannot be supplied due to the failure of a critical piece of network equipment. Distributed generation can generate electricity at a time of peak demand to reduce the amount of expected unserved energy faced by network customers in an area.
	Islanding capability	Distributed generation can provide islanding capability for consumers (or a group of consumers). This may lead to private benefits to consumers, and potentially further reliability for the network.
Grid Support Services	Ancillary services	Services and resources are required to operate the network on an on-going basis. Some of these services relate to controlling frequency or restarting the network after an incident. AEMO procures such services to support the operation of the grid through a variety of markets, specifically being Frequency Control Ancillary Services (FCAS), Network Support Control Ancillary Services (NSCAS), and System Restart Ancillary Services (SRAS) markets. Dispatchable distributed generation can be contracted by a network business to provide ancillary services.
	Network support	During network peak periods, DNSPs sometimes purchase generation from network support facilities such as backup diesel engines. Distributed generation could potentially avoid or reduce the costs of such network support.
	Managing voltage regulation and power quality	Network businesses operate equipment and conduct maintenance to regulate voltage levels through the network (by adjusting taps on transformers or upgrading them entirely). The operation of the network is also impacted by power quality, which can be impacted by fluctuations in voltage and harmonics faced by a distribution system. Distributed generation may assist in the management of voltage regulation, either through exported energy into the grid or via control of its network interfacing equipment (i.e. inverter). Certain technologies of distributed generation could also provide benefit by working with the network to manage issues such as those related to power quality.
Environmental and Social	Bushfire risk mitigation	Stakeholders suggested that distributed generation may reduce bushfire risk, by limiting or avoiding the use of above-ground electricity assets (such as poles and wires) on high fire risk days in high risk areas.
	Amenity and aesthetic benefit	Stakeholders suggested that distributed generation could reduce the need to build poles and wires, which may increase amenity and aesthetic in the surrounding area.
	Customer empowerment	Stakeholders suggested that distributed generation that allows for the ability to consume electricity without the need for the grid (to go 'off-grid') can provide that customer with a sense of empowerment.

Source: ESC, Jacobs

In response to our draft report, some stakeholders suggested there were other benefits not considered in our analysis. The Institute for Sustainable Futures suggested that the inquiry consider the benefit of maintaining network utilisation or avoiding grid defection:

> *The importance of maintaining utilisation is as follows. If consumers stop paying charges for the proportion of their load which is removed – and it would be difficult to envisage a system where they continue to pay the same share regardless – and network costs remain the same, the consumers who do not reduce their load pay proportionately more.*[19]

The Commission acknowledges that, in general the cost per unit of electricity delivered in using the grid reduces the more consumers use it. However, it is not clear how this general benefit could be calculated and monetised for individual distributed generators, and therefore we have not sought to include it in this valuation exercise.

This methodological exclusion notwithstanding, effectively remunerating distributed generation for their grid services can be expected to encourage consumers to remain connected to the grid. Developing the kind of market for grid services outlined in this report may therefore contribute to ongoing grid utilisation by consumers with distributed generators.

3.5 ASSESSING ECONOMIC BENEFITS FOR VALUATION

Having identified the potential economic benefits of distributed generation, we proceeded to identify which benefits were sufficiently extant and material with respect to calculating network value for the purposes of this inquiry to warrant further examination. We used a three-part test similar to the approach we use to examine potential social and environmental benefits of distributed generation.[20] The three-part test operates as follows:

a. **Identification –** Is it possible to establish a causal link between a potential network benefit and distributed generation?

[19] Institute for Sustainable Futures 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December, p. 3.

[20] See approach developed through our final report on Energy Value, Essential Services Commission 2016, *The Energy Value of Distributed Generation - Distributed Generation Inquiry Stage 1 Final Report*, August.

b. **Quantification –** If a benefit can be attributed to distributed generation, what is the scale of that benefit and is it material with respect to calculating network value for the purposes of this inquiry?
c. **Valuation** – For material benefits, is it possible to place a monetary value on the benefit?

By applying this test we sorted the potential benefits into three categories. The first category applies to those potential benefits that we found – on the basis of currently available data, regulatory settings and/or maturity of existing technologies – we could not attribute to distributed generation. We did not proceed to calculate the value of these benefits and excluded them from further analysis. The rationale for this conclusion as it applies to each case is contained in chapter 4.

The second category contains benefits that may be attributable to distributed generation, but which, on the basis of our initial analysis, were not expected to lead to material value in the context of calculating value within this inquiry. For these benefits, we developed case studies or sample calculations to test whether our assessment of low-materiality was correct. The outcomes of these studies and calculations are contained in chapter 4.

The final category are those benefits that we found can be attributed to distributed generation, and which our initial analysis indicated may lead to material value across the Victorian electricity network. For these benefits, we proceeded to develop methods designed to calculate the value that distributed generation provides. An explanation of these methods is provided in the following section and the results are presented in chapter 4. A summary of the results of our assessment of network benefits is presented in table 3.2.

TABLE 3.2 SUMMARY OF POTENTIAL NETWORK BENEFITS

Category	Network benefit		Treatment
Network Capacity	Reduced expenditure on network infrastructure	✓	Quantifiable network value
Electricity Supply Risk	Reduced expected unserved energy	✓	Quantifiable network value
	Islanding capability	✗	Excluded (a private benefit)
Grid Support Services	Ancillary services	✗	Excluded (not reliably attributable at present)
	Network support	-	Non-material benefit with respect to calculating network value for the purposes of this inquiry
	Managing voltage regulation and power quality	-	Non-material benefit with respect to calculating network value for the purposes of this inquiry
Environmental and Social Benefit	Bushfire risk mitigation and reduction	✗	Excluded (not attributable to existing systems)
		-	Future systems could provide benefit (if lower cost alternative to alternative mitigation measures)
	Various other potential benefits	✗	Excluded (not reliably attributable, or are private benefits)

Source: ESC, Jacobs

3.6 METHOD FOR VALUING ECONOMIC BENEFITS

Having performed an assessment of the various potential network benefits of distributed generation, we focus our attention on establishing the monetary value of two key types of benefits:

1. reduced expenditure on network infrastructure[21]
2. reduced expected unserved energy.

Together, these two benefits flow from the wider benefit of reducing network congestion. The first benefit reflects the fact that reduced congestion may allow network businesses to defer or reduce their expenditure on the network. The second benefit is related to reducing the amount of expected unserved energy from a network, which decreases the likelihood of a power outage. The reduction in expected unserved

[21] This includes reduced congestion in the transmission network, thereby incorporating the benefit that some studies seek to approximate through calculating avoided TUOS charges.

energy has a monetary value based on a metric set by the Australian Energy Market Operator (AEMO). Working with Jacobs Consultancy, we co-developed a single method to calculate the value of both benefits (section 3.6.1).

In response to our approach outlined in our draft report, some stakeholders suggested we undertake the valuation using a 'long-run' assessment of network costs, noting that cost reflective network tariffs are now calculated on the basis of the long run costs of delivering the required network services to consumers.[22]

The valuation exercise in this inquiry sought to identify the value of the network benefits provided by distributed generation in a given year (2017). This method was applied for the purposes of understanding the nature and scale of the network benefits provided by distributed generation in Victoria. Accordingly, it was based on a calculation of short run value.

The method was not intended to calculate the value that should be paid to distributed generators via some future remuneration arrangement. How that value might be calculated is appropriately considered in the context of subsequent analysis around the development of potential payment mechanisms within a market for grid services. The approach we have taken for this report does not preclude using a long run valuation method in context of any pricing mechanism that emerges, whether as a result of market forces or through conscious design.

We commissioned Jacobs to quantitatively and qualitatively confirm that the other identified benefits (additional to the benefits of reduced network congestion) should be classified as non-material for the purposes of this inquiry. Table 3.3 summarises the calculation approaches used to assess potential network benefits.

[22] Institute for Sustainable Futures 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December.

TABLE 3.3 SUMMARY OF CALCULATION APPROACHES

A description of the calculation approach applied to determine the extent (or realisation) of an identified network benefit

Benefit	Calculation approach	Calculation description
Network Capacity		
Reduced expenditure on network infrastructure	'Probabilistic planning approach'	A specific valuation methodology applied to account for the amount of avoided network deferral in capital expenditure (CAPEX) and operating expenditure (OPEX). This is incorporated as part of the benefit of reducing network congestion, as per section 4.2. Avoided OPEX was estimated as a proportion of deferred CAPEX value. Avoided line losses were also estimated at the customer connection point. In these cases, adjustment factors have been incorporated and applied in the valuation method.
Electricity Supply Risk		
Reduced expected unserved energy	'Probabilistic planning approach'	Expected unserved energy is currently valued by AEMO using the Value of Customer Reliability (VCR). VCR is incorporated into the calculation applied to account for reduced expenditure on network infrastructure, and incorporated as part of the benefit of reducing network congestion. See discussion in section 4.2.
Islanding capability	No calculation (excluded)	No calculation required, as these potential benefits are excluded due to it being a private benefit to the DG investor. See discussion in section 4.3.4.
Grid Support Services		
Network support	Case-study	A test calculation to consider the extent of avoided costs of network support facilities (backup generation). See discussion in section 4.3.1.
Managing voltage regulation and power quality	Case-study	A test calculation performed to understand the extent that DG can manage voltage regulation for networks. See discussion in section 4.3.2.
Ancillary services	No calculation (excluded)	No calculation required, as these potential benefits are not reliably attributable to current DG. See discussion in section 4.3.3.
Environmental and Social		
Bushfire risk mitigation, amenity and aesthetic benefit, customer empowerment	Indirect benefits test	An indirect benefits test has been applied against each potential benefit. The test considers whether the benefit is attributable to DG, and whether it can be quantified and monetised. See discussion in section 4.4.

Source: ESC, Jacobs

3.6.1 REDUCING NETWORK CONGESTION – CAPACITY AND UNSERVED ENERGY

To assess the value of the benefits of reduced network congestion, we developed a method that mirrors the probabilistic planning method used by network businesses in Victoria to plan their network expenditure.[23] This section sets out the basis and scope of this method, and describes how it is applied.

PROBABILISTIC NETWORK PLANNING

To explain the valuation method applied in this inquiry, it is necessary to first explain the probabilistic planning approach used by network businesses in Victoria.

Under the national framework overseen by the Australian Energy Regulator (AER), the electricity network must be designed to minimise the total cost of the distribution network, the transmission network and the disruption to customers of any unserved electricity. A key element of the network's ability to meet this standard is whether it has the capacity to cope with increases in demand for energy into the future. Network businesses regularly assess whether their network is capable of meeting this demand, or whether it is reaching its supply capacity and therefore requires upgrading. Upgrades designed to expand the capacity of the existing network are typically referred to as 'network augmentations'. When network businesses augment their network, the cost is recovered from customers through the electricity distribution charges that form a portion of all customers' bills.

Network businesses, as monopoly businesses, must justify their expenditure to the AER. The approach used to justify the expenditure on network upgrades in Victoria, and to identify the time they should occur, is referred to as a 'probabilistic planning approach'.

[23] There are various methods to calculate the value of network benefits, particularly regarding deferral of network upgrade projects, and these methods differ by the objective they seek to answer. The Commission reviewed a number of reports and studies that present and discuss various valuation methods, such as: National Association of Regulatory Utility Commissioners 2016, *NARUC Manual on Distributed Energy Resources Compensation Draft*, July; Ernst & Young 2015, *Evaluation Methodology of the Value of Small Scale Embedded Generation and Storage to Networks*, Clean Energy Council, July; Frontier 2015, *Valuing the impact of local generation on electricity networks*, Energy Networks Australia, February; Energeia 2016, *LRMC Methodology Paper,* Institute for Sustainable Futures, March.

This approach essentially has two objectives. First, it seeks to identify whether the network is becoming congested, which it does by requiring network businesses to conduct and publish annual forecasts of the power flows throughout their networks. Second, it seeks to identify whether the benefits of expanding the network's capacity are worth the expense of doing so. This decision is based on comparing the cost of the network upgrade with the value that customers place on the decreased likelihood of 'unserved energy' as a result of the upgrade. This approach recognises that in some instances, customers would prefer to risk experiencing an occasional blackout rather than have an increase in their bills.

WHEN IS UPGRADING THE NETWORK WORTH THE EXPENSE?

The demand for electricity may approach the supply capacity of the network for a few hours during a year. If a critical piece of network equipment (such as a transformer) fails during this period, the network will experience an outage.[24] When network planners plan their network, they must actively consider this scenario. In other words, the key factor that relates to network planning is not the capacity of each network asset – such as a zone substation – while all equipment is operating as expected. Rather, the key factor is the capacity of that asset if one critical piece of equipment fails.

Each network asset in Victoria has a capacity rating based on this scenario – that is, a rated 'maximum capacity' in the event that a critical piece of equipment fails. This rating is referred to as the asset's 'N -1' rating (that is, its capacity 'minus the most critical piece of equipment'). For some network assets, the annual forecast of demand for energy at that location will indicate that, from time to time, demand is forecast to exceed the N -1 rating for the asset.[25]

The number of hours that the N -1 rating is exceeded, and the extent to which it is exceeded in each of those hours, determines the amount of energy that is 'at risk' if a piece of equipment fails. This quantum of energy is referred to as the 'energy at risk'. Under the framework for regulating electricity networks, the expected unserved energy

[24] In practice, the power supply to some customers may need to be curtailed to prevent overload of the remaining equipment.

[25] This may be acceptable because the plant is so reliable and the duration of peak demand is so short and infrequent that the exposure to load shedding is very small and the cost much less than what would have to be spent to avoid that risk.

at any location is calculated by multiplying the amount of energy at risk at any given point in the network by the probability of outage.

To construct a network in which there was no ‘energy at risk’ – that is, a network that would have absolutely no expected unserved energy – would be prohibitively expensive, and this expense would be met by all customers through their electricity bills. So that the network is constructed based on balancing the needs of customers and network costs, the probabilistic planning approach is intended to ensure that network upgrades only occur when the benefits of reduced expected unserved energy are greater than the costs of the upgrade.

To identify the value of this reduced expected unserved energy, the Australian Energy Market Operator (AEMO) has undertaken studies of the willingness of customers to pay for the supply of energy in the event of an outage.[26] This measure is known as the value of customer reliability (VCR). [27] The VCR varies by type of customer (residential, commercial, industrial, and agricultural) and the value at a location or region is based upon the customer mix in that location.

The value of ‘expected unserved energy’ at any given point within the network – such as at a zone substation – can be calculated by multiplying the total volume of ‘expected unserved energy’ at that zone substation by the VCR published by AEMO.

An upgrade is worth the expense when the cost of the upgrade is less than the value of the expected unserved energy at that zone substation. In other words, the trigger point for an upgrade is when society values the increased risk of a blackout, under an N -1 scenario, as more costly than actually undertaking the upgrade.

SCOPE AND FOCUS OF OUR VALUATION METHOD

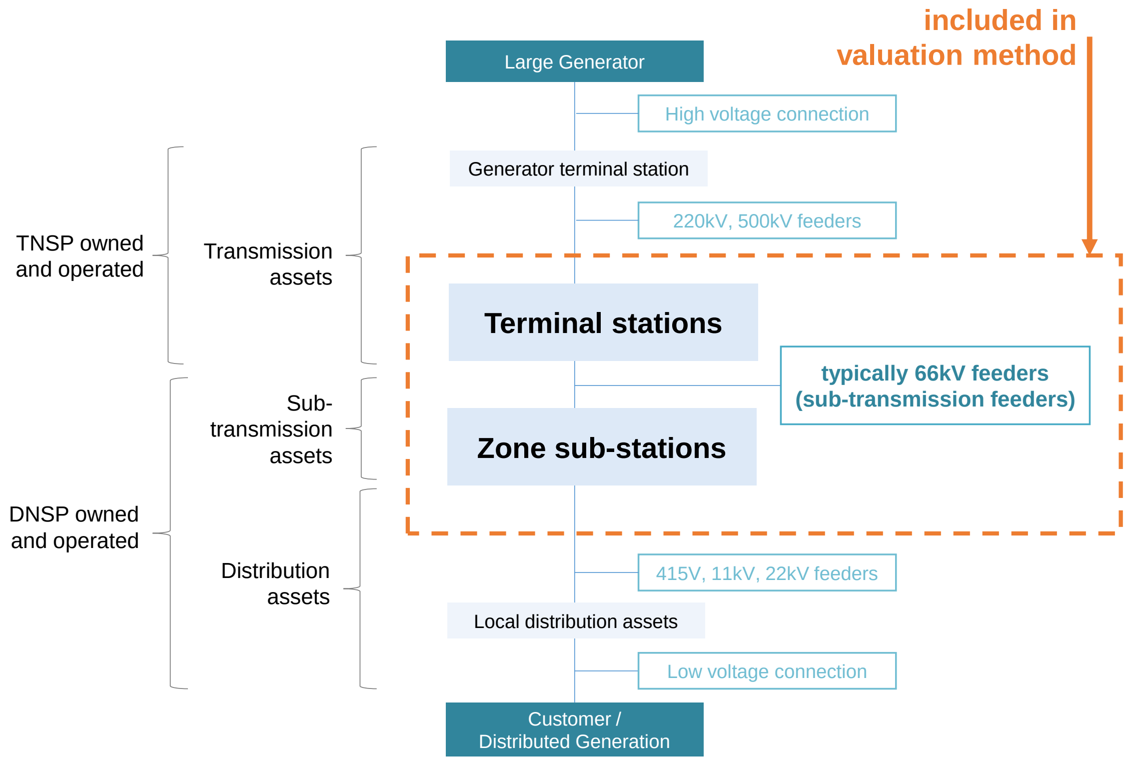
Our study examines the value of the network benefits produced by distributed generation. Distributed generation can influence the capital expenditure of network business at each level of the network.

[26] AEMO tested with stakeholders a range of modelling approaches, settling on a combination of a choice modelling and contingent valuation techniques.

[27] Australian Energy Market Operator 2014, *Value of Customer Reliability final report,* November.

However, the extent of our valuation exercise is limited by the public availability of data and therefore has been focused on zone sub-stations, terminal stations and sub-transmission feeders (figure 3.3).

FIGURE 3.3 SCOPE OF VALUATION METHOD, BY NETWORK ASSETS



Source: ESC, Jacobs

The valuation figures presented in this report therefore do not encompass all levels of the network. For instance, we did not apply the valuation method to low voltage distribution assets because there is insufficient data that is publicly available or robust enough to determine the value from these assets. Backroad Connections, on behalf of Solar Citizens, the Tasmanian Renewable Energy Alliance, the Total Environment Centre and the Alternative Technology Association, suggested that the valuation method account fully for the fact that distributed generation makes no use of the transmission network. They stated:

> *…energy that is generated and consumed locally makes no use of the transmission network and makes less use of the distribution network.*[28]

As shown in figure 3.3, the valuation method applied in this inquiry accounts for potential augmentations at transmission assets between 66kV sub-transmission feeders and including terminal stations. We recognise there are proposed network projects above these assets, but only a small subset of these projects would be impacted by distributed generation (such as transmission line projects borne out of a need to supply growing local demand). Most of these projects were instead associated with allowing connection of increased generation assets, such as large-scale wind and solar farms.[29] The probabilistic planning method applied has captured savings in transmission system investment that result from distributed generation.

Some stakeholders also suggested that the valuation should consider avoided transmission use of system (TUOS) charges as a method for conducting the valuation. The Alternative Technology Association stated that:

> *We also note that the avoided transmission use-of-system costs of distributed generation are significant, but not realised with respect to generators of less than 5 MW…TUOS costs should not be charged to customers consuming electricity fed into the distribution network irrespective of the size of the generator.*[30]

The rationale for including the avoided TUOS costs within a valuation method is to adequately capture the benefit that distributed generation provides at the transmission network level. Our method does in fact encompass this benefit, and does so by examining the impact of distributed generation on key elements of the transmission networks at a more fundamental level. That is, it identifies the way distributed generation is affecting the capital expenditure within the transmission network (which are the costs, among others, that TUOS charges are intended to recover). In other words, our method already takes into account transmission level benefits and to incorporate avoided TUOS charges would count them twice.

[28] Backroads Connections 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December, p. 4.

[29] AEMO 2016, *Victorian Annual Planning Report,* June.

[30] Alternative Technology Association 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December, pp. 4-5.

Similarly, some stakeholders question whether avoided TUOS charges represent an efficient way to calculate the benefit that distributed generators provide to distribution businesses in the context of a future payment arrangement. Stakeholders raised this idea with particular reference to the possibility that such benefits may be less locationally granular, and therefore more amendable to being remunerated via a broad based tariff.

While transmission level benefits are spread over larger geographic areas than distribution level benefits, the relevant portions of TUOS payments remain locational (there are approximately 20 difference transmission zones in Victoria). This means that any method that sought to calculate value in this way would still be difficult to reconcile with a broad based energy tariff structure.

We investigated this methodology and compared it to the valuation method we applied. Beyond the locational issues discussed above, we did not find the method of calculating avoided TUOS charges an appropriate alternative valuation method. The avoided TUOS methodology is based on historical terminal station costs and reflects customer charges for transmission assets, which is not an accurate reflection of the value provided by distributed generation to such assets.

The process for developing any future pricing mechanism within a market for grid services will need to give consideration to the manner in which transmission level benefits are incorporated into payments to distributed generation systems to ensure they are appropriately captured.

Although our method encompassed the effects of distributed generation at several levels of network asset, we represent the results in terms of the value provided at each zone substation. This equates to identifying the zone substation as the 'unit of analysis'. In practice, the value ascribed to each zone substation in our final results is the cumulative total of the value of reduced expected unserved energy and augmentation deferrals at that zone substation, plus an apportioning of the value produced at the sub-transmission feeders and transmission assets to which that zone substation is connected.

OUR VALUATION METHOD

The objective of our valuation method is to identify the value of the benefits produced by distributed generation in Victoria in a given year.[31] We examined a range of potential methods for undertaking this analysis, and ultimately used a form of counterfactual method that was best suited to the purpose. Following release of this report, a staff paper will be issued that outlines the various methods considered and the implications of applying them in different contexts.

For the purposes of our analysis, we have applied the method to 2017.[32] Our analysis is based on identifying the value of the benefits of distributed generation that is connected to the network at the start of 2017, plus any additional generation that the network businesses have forecasted will be added over the course of that year.

The method applies to all forms of distributed generation. In practice, the current fleet of distributed generation in Victoria can be divided into two categories based on the profile of its electrical output. The first category is solar photovoltaic (PV), which accounts for the majority of systems currently deployed in Victoria. In the second category, we grouped all other forms of distributed generation, which share the attribute of being controllable – or in other words, 'dispatchable'. We did not create a separate category for distributed wind generation because of the limited number of small-scale wind systems in Victoria.

The valuation method is based on performing an analysis of the network, on an asset-by-asset basis at the zone substation level, through which a counterfactual scenario is established in which all distributed generation connected to that zone substation is removed from the network. Drawing upon the information published by network

[31] This can be contrasted to a method such as the Turvey Incremental, a form of which was employed by consultancy ENEA in a recent study for Powercor. The objective of ENEA's study was to determine whether and where additional distributed generation may provide benefits for the management of the network in Powercor's distribution area. Unlike our approach, ENEA's method is geared towards identifying the value of a tranche of additional distributed generation that is capable of deferring a network augmentation project by one year. As such, it should not be expected to produce similar results to our analysis. CitiPower and Powercor 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, pp. 2-3.

[32] Because the source data, which comes from the distribution businesses annual planning reports, is provided in 5 year tranches, we have also conducted the analysis out to 2020, primarily for the purposes of evaluating the extent to which the value shifts from year to year.

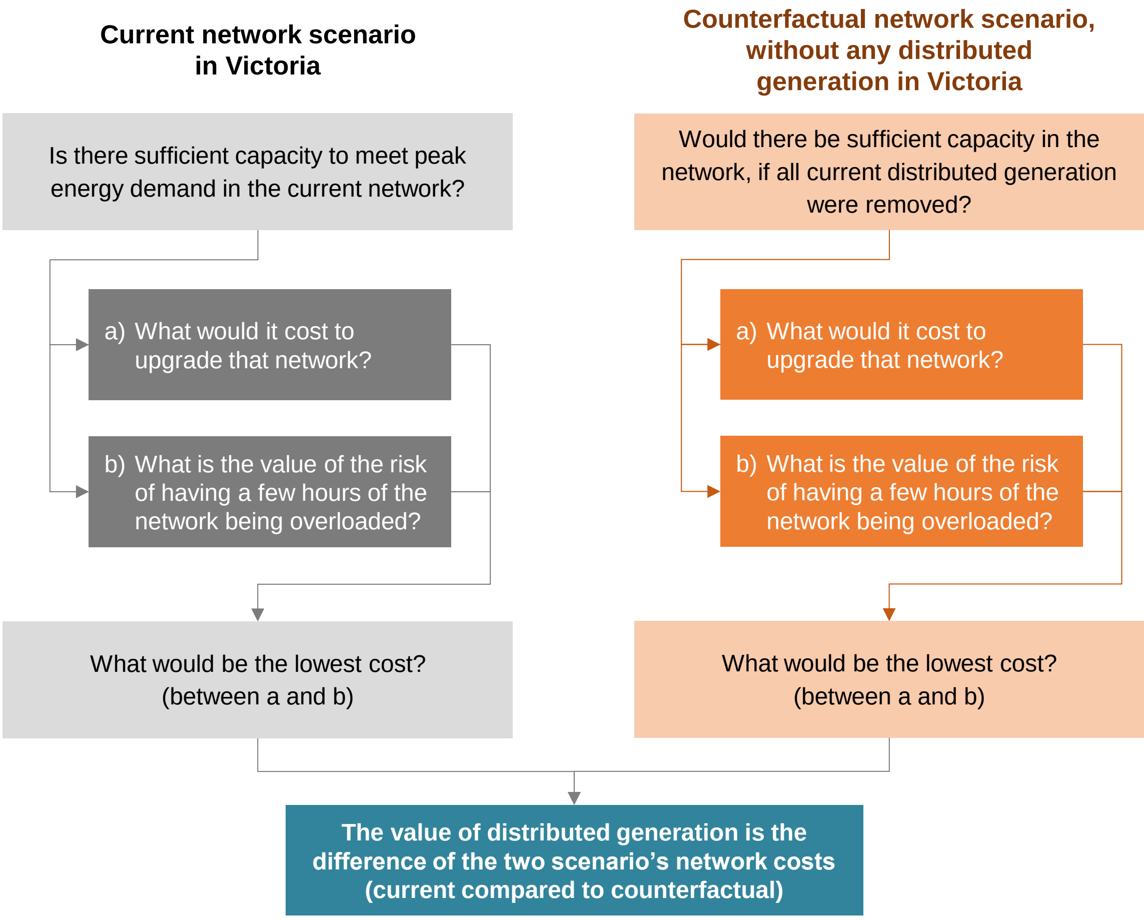
businesses in their annual planning statements, the method applies a version of the probabilistic planning method outlined above to identify two results:

- The monetary value of the additional expenditure network businesses would need to maintain their network in the absence of the distributed generation[33] and
- The expected unserved energy in the absence of the distributed generation, as measured by the value of the 'energy at risk' and probability of failure at each network asset in the absence of the distributed generation.

The value, under the counterfactual scenario, in each of these benefit categories is then compared to values under the existing real-world scenario, and combined to produce a total value of reduced congestion. The value of reduced network expenditure is presented as an annualised value of the changed level of capital and operational expenditure, while the value of reduced expected unserved energy is presented as an annual value for that year. The valuation method is summarised in figure 3.4.

[33] It should be noted that there is no explicit standard for reliability and capacity at the distribution and transmission level network in Victoria. Network capacity and supply reliability are a result of the cost minimisation analysis and planning and the completion of network augmentation projects, on the basis of the 'probabilistic planning approach'. AER 2015, *Issues Paper, Victorian electricity distribution pricing review, 2016 to 2020*, June, p. 14.

FIGURE 3.4 VALUATION METHOD BASED ON THE 'PROBABLISTIC PLANNING APPROACH'



Source: ESC, Jacobs

This method assumes that the network business has identified the least cost option to respond to the network constraint, and incorporated that into its annual planning report.[34] Where the cost of a planned augmentation exceeds $5 million, the national framework requires network businesses to conduct a tender process that is open to non-network solution providers.[35] It is conceivable that in some of these instances, the

[34] Distributed Annual Planning Report (DAPR)

[35] Regulatory Investment Test – Distribution (RIT-D)

network business may identify a lower cost non-network alternative to the network augmentation they identified in their planning report.

To the extent this occurs within a measurement period, the forecasted value identified using our valuation method will exceed the actual value that is ultimately created by the distributed generation in that section of the network in that period.

3.7 ENVIRONMENTAL AND SOCIAL BENEFITS

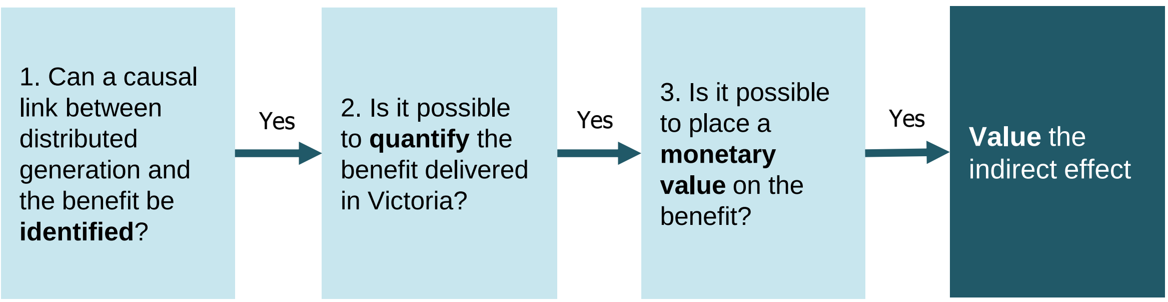
When examining the energy value of distributed generation in stage one of this inquiry, we developed a three-part indirect effects test as a method for considering environmental and social value.

The three-part process applied was:

a. **Identification –** We considered the potential benefits of distributed generation and whether it is possible to establish a causal link between that benefit and its association with the electricity network.
b. **Quantification –** We considered whether it is possible to measure the quantum of benefit delivered in Victoria by a unit of distributed generation.
c. **Valuation –** We considered whether it is possible to place a monetary value on the benefit.

Only where all three parts of the test can be completed, can a monetary value on that environmental and social benefit be determined.

FIGURE 3.5 INDIRECT BENEFITS TEST



Source: ESC

4 THE NETWORK VALUE OF DISTRIBUTED GENERATION

4.1 INTRODUCTION

This chapter sets out the results of our empirical study into to the network value of distributed generation across the Victorian electricity network.

It also presents our findings on the social and environmental value that may arise as an indirect result of distributed generation effects on the operation of the network.

OVERVIEW

Distributed generation can and does provide network value. Distributed generation causes this value when it reduces peak electricity demand within the network in a predictable way. Reductions in peak network demand can allow network businesses to defer network augmentation projects, thereby saving costs. These cost savings are ultimately passed on to end use customers. Distributed generation can also provide value by reducing expected unserved energy. This benefit is experienced by customers generally as a lower incidence of electricity supply disruption when network equipment fails at times of extremely hot or cold weather. Distributed generation can also provide a number of other network benefits but these are not currently material with respect to calculating network value for the purposes of this inquiry. Together, these benefits provided by distributed generation can be described as grid services.

The network value of distributed generation arises as a result of its effect on the entire network, from transmission level assets through to the low-voltage sections of the distribution network. We calculated the value of the benefits that distributed generation provides at the transmission, sub transmission and zone substation levels of the network. That is, our method explored the value of distributed generation at three out of the four levels of Victoria's electricity network. Limitations on the availability of public data meant that it was not possible for us to calculate, on a locational basis, the network value of distributed generation in the fourth level: the low and medium voltage portions of the distribution network.

Distributed generation creates network value in Victoria through reducing and deferring network expenditure and by reducing expected unserved energy. Combining these two sources of value, we estimate that in 2017 the network benefits of solar photovoltaic (PV) systems provide a total of approximately $3 million of network value in Victoria.

This value reflects the specific attributes of Victoria's current fleet of solar PV, not distributed generation more broadly. Forms of distributed generation that are specifically optimised for network value can produce considerably more value than is expressed in our study of solar PV.

The size of network value is affected by:

- **Location** – the value varies based on the distributed generator's location within the network, specifically in terms of its proximity to areas of the network that are congested, or nearing congestion.
- **Time** – the value also varies according to the extent to which the electricity generation coincides with the periods of peak demand within the section of the network to which the generator is connected.
- **Asset life-cycle** – the value varies based on when in the network operator's cycle of upgrade projects the value is being measured.
- **Capacity** – the generation capacity of the distributed generation.
- **Optimisation** – 'optimisation' refers to the extent to which the generation is optimised for delivery of grid services. A system that is highly optimised for network benefits is one that reliably produces output at the time it is most needed by the network.

Distributed generation may provide a benefit if it provides a lower cost alternative to network projects undertaken for the purposes of bushfire mitigation. This could occur in circumstances where deploying distributed generation in a remote area, and thereby enabling the linking network to be de-energised during high fire risk days, was a more efficient alternative to other bushfire mitigation steps, such as undergrounding wires. The Commission did not identify any regulatory impediment to this value being realised. We therefore did not assess the merits of greater investment in distributed generation relative to other forms of bushfire mitigation available to network businesses.

4.1.1 STRUCTURE OF THIS CHAPTER

This chapter is divided into five sections:

4.1 Introduction

4.2 Economic value of reduced network congestion

4.3 Economic value of other network benefits

- network support
- managing voltage regulation and power quality
- ancillary services and
- islanding capability.

4.4 Social and environmental benefits

- bushfire risk mitigation and reduction
- amenity and aesthetic benefit and
- customer empowerment.

4.5 Conclusion

4.2 ECONOMIC VALUE – REDUCED NETWORK CONGESTION

In chapter 3, we set out our approach to assessing whether distributed generation may lead to economic network benefits, and our approach to calculating that value in Victoria.

As shown in figure 4.1, we found that two network benefits are material in the context of the examination of network value within this inquiry, and provide value in Victoria: reduced expenditure on network infrastructure and reducing expected unserved energy. Because they both relate to reduced power flows through the network, these two benefits can be described together as ‘reduced network congestion’.

In response to our draft report, some stakeholders suggested there are inconsistencies between the valuation method conducted in this inquiry and the way that network companies set tariffs (prices) for the use of their network, particularly at peak times.

Bruce Mountain highlighted that the time-of-use network tariffs currently offered by the five distributors in Victoria have significant peak/off-peak differentials. He contrasted this to the conclusion of our draft report that given the current capacity surplus across the network distributed generation provides little value in terms of reduced network demand, suggesting:

> *The prices in the distributors’ time of use tariffs – which they have long promoted – tell consumers (via their retailers) that those distributors would be willing to provide their services at night for a quarter of the price they charge during the day. Is this not sufficiently compelling to suggest that distributed generation, by injecting power back into the grid at the point of use and thereby reducing demands on the grid during the day, has value that distributors could be expected to compensate?* [36]

We consider that the network value of distributed generation is distinct from the price paid by consumers for using the grid and from any price paid to distributed generators for providing network benefits. The time-of-use consumption tariffs (prices) offered by the Victorian distributors reflects the cost of using the grid at certain times of the day (peak and off-peak periods) but also includes a range of other costs related to the

[36] B Mountain 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December, p. 2.

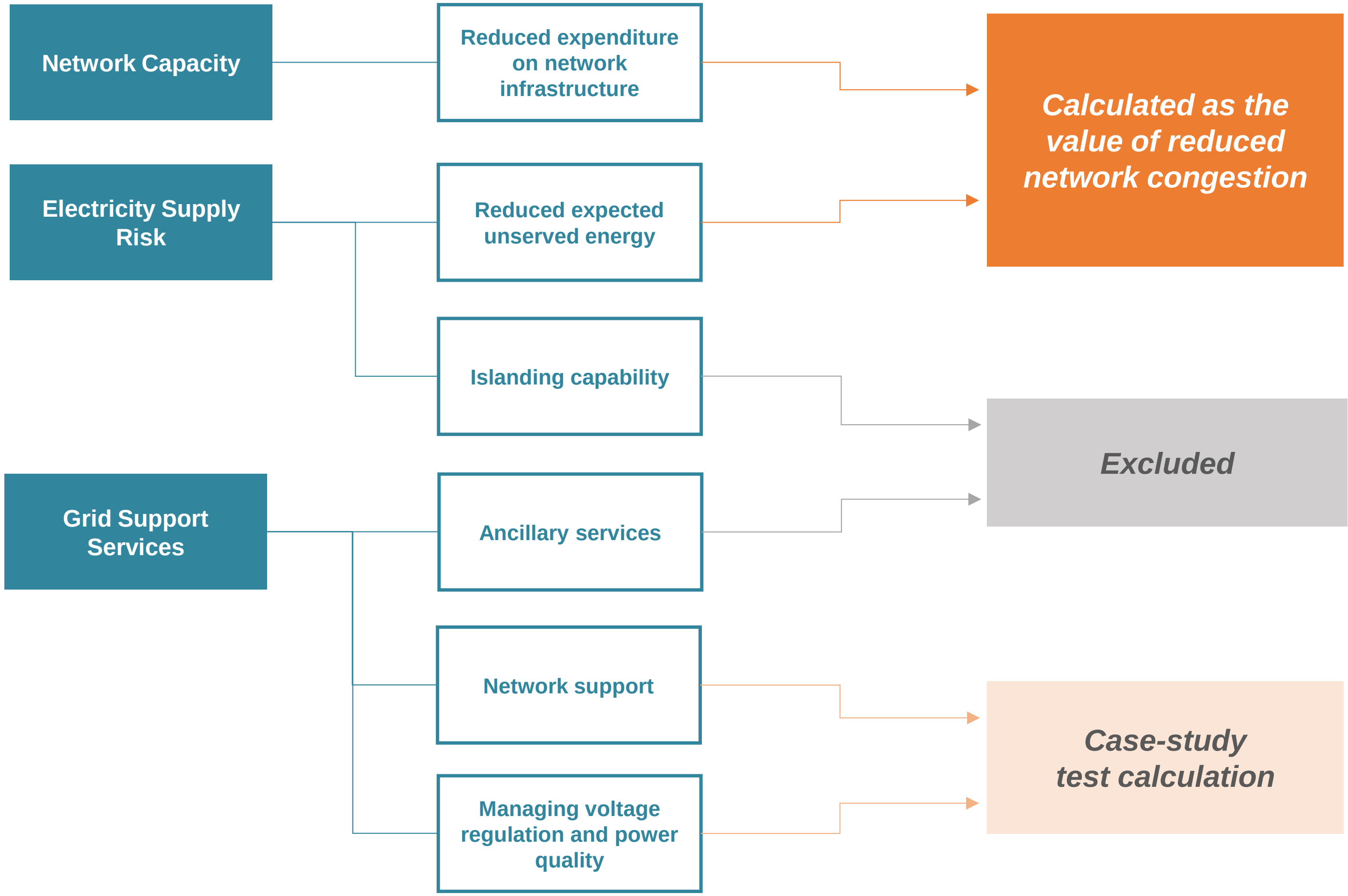
operation of the network businesses. This means that there is not a direct correlation between the price paid for using the network at certain times and the value of any electricity provided to the network by distributed generation.

Network prices are also averaged across locations and voltage levels in a distribution area. By contrast, our valuation exercise examined the value of distributed generation in specific locations in Victoria (discussed in section 4.2.1). The fact that network businesses prefer to sell network services, across their distribution area, at higher prices in peak periods does not necessarily reflect the economic value associated with electricity sourced from distributed generation located in a specific location within the network.

Additionally, in section 3.4 we identified several potential benefits that we assessed as currently being not material in Victoria for valuation. A price paid to distributed generation systems could account for such potential benefits in the future, but may also account for related costs of deploying such systems. We discuss issues related to pricing the services offered by distributed generation in more detail in section 7.4.3.

In this section, we provide the results of our assessment of reducing network congestion (reduced expenditure on network infrastructure and reduced expected unserved energy).

FIGURE 4.1 SUMMARY OF NETWORK ECONOMIC VALUE ASSESSMENT



We calculated the value of reduced network congestion, which incorporates both the benefits of reduced expenditure on network infrastructure and reduced expected unserved energy. We discuss this assessment further in section 4.2.1.

We excluded these specific potential benefits as we consider they cannot be reliably attributed to distributed generation, or found to be a private benefit. We discuss this further in sections 4.3.3 and 4.3.4.

We used case-study test calculations to confirm that these specific potential benefits are currently not material in Victoria. We discuss this further in sections 4.3.1 and 4.3.2.

Source: ESC

4.2.1 REDUCING NETWORK CONGESTION

The primary means by which distributed generation provides network value is through reducing network congestion. 'Network congestion' refers to circumstances in which a part of the network is operating close to the limits of its designed capacity. This typically occurs during periods of network peak demand. To the extent that distributed generation can reliably reduce demands on the network during peak periods, it can reduce network congestion.[37]

Reducing network congestion can lead to two specific network benefits. The first is to defer or reduce expenditure on network infrastructure upgrades (augmentations). As noted by the Energy Networks Australia:

> *…private investment in distributed generation can defer augmentation of Victoria's electricity network, under certain circumstances. This will be the case if it reduces the use of distribution network at peak times when the network is constrained.*[38]

The second benefit, as noted by AusNet Services, is by reducing the quantum of 'energy at risk', which can cause a reduction in expected unserved energy. That is, through a reduction in the likelihood of customers' energy not being supplied due to an outage.

> *Whilst in many cases on AusNet Services' distribution network solar contributes minimal reduction in the network peak demand, a more material contribution may be expected over the broader set of hours for which there may be energy at risk.*[39]

In chapter 3, we set out a method for calculating the value of reducing network congestion based on the probabilistic planning approach used by Victorian network businesses. This chapter sets out the results of applying this method to the network in 2017.

[37] In the section on the time varying nature of network value below, we discuss network congestion in terms of periods in which demand for electricity exceeds the N-1 rating of a network asset.

[38] Energy Networks Australia 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 1.

[39] AusNet Services 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 8.

DISTRIBUTED GENERATION PROVIDES NETWORK VALUE IN VICTORIA

Distributed generation creates network value in Victoria through reducing and deferring network expenditure and by reducing expected unserved energy. Combining these two sources of value, we estimate that in 2017 the network benefits of solar PV systems will provide a total of approximately $3 million of network value in Victoria.[40]

This value reflects the specific attributes of Victoria's current fleet of solar PV, not distributed generation more broadly. As subsequent sections illustrate, forms of distributed generation that are specifically optimised for network value can produce considerably more value per unit of installed capacity than is expressed in our study of solar PV.

Operator controlled, or dispatchable distributed generation such as gas turbines, co-generation, tri-generation or diesel generators, may produce additional value in 2017. However, it is not possible to estimate this value without knowing how these systems will be operated. As a result, our findings are expressed largely in terms of solar PV systems, which are the most common form of distributed generation in Victoria.[41]

In 2017, the majority of the value (89 per cent) is projected to arise through reducing congestion at zone substation (ZSS) and terminal station assets (figure 4.2). Around 11 per cent of value was caused through reduction of congestion at the sub transmission level. However, our study indicated that the proportion of total value attributed to each level of the network varies between years. The split of value between different levels of network asset in 2017 should therefore not be treated as indicative of a trend. In other years, reduced congestion in the sub-transmission network may be responsible for a far smaller proportion of the total value.

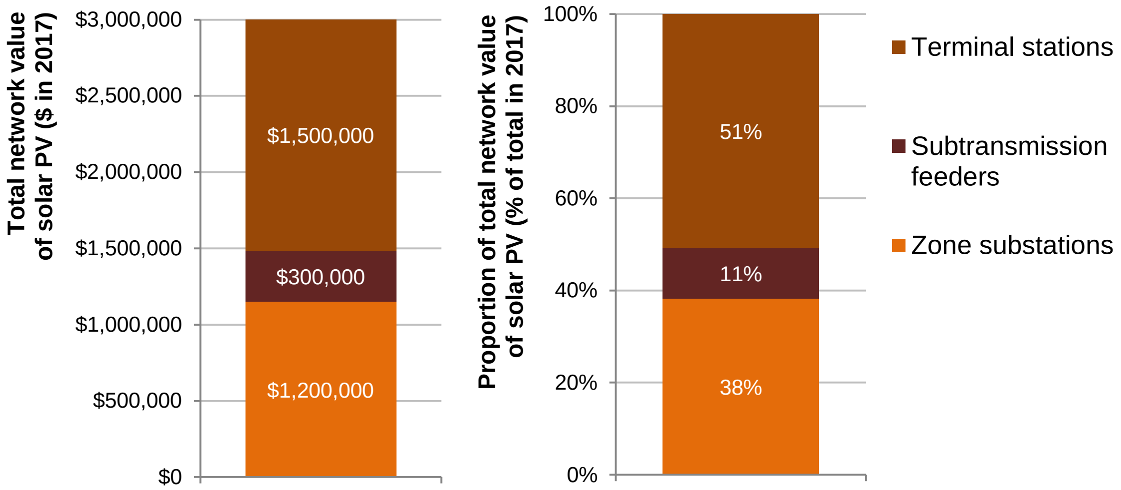
As explained in chapter 3, we did not examine the value of the benefits provided by distributed generation in the lower voltage distribution network, because of the absence

[40] The results and values in this report are presented in real 2016 Australian dollars.

[41] In Victoria, 88% of installed capacity is solar PV, 12% is dispatchable generation, and less than 1% is wind powered. The calculation method was fully applied to known pre-existing dispatchable generation systems installed across Victoria – this includes cogeneration and diesel backup systems. A similar calculation was applied to the areas in Victoria where small amounts of wind-powered distributed generation systems were installed (Ballarat North and Ballarat South ZSSs), so that the potential value from these systems were incorporated.

of publicly available data. Therefore solar PV may provide additional value that is not captured by this exercise.

FIGURE 4.2 NETWORK VALUE OF SOLAR PV, BY ASSET TYPE[a] (2017)



[a] The proportion of value attributable to each asset type is not fixed. It will vary in each measurement period based on the timing of network upgrade projects for each asset type of the network.

Data source: Jacobs

The size of network value is affected by:

- **Location** – The value varies based on the distributed generator's location within the network, specifically its proximity to areas of the network that are congested, or nearing congestion.
- **Time** – The value also varies according to the extent to which the electricity generation coincides with the periods of peak demand within the section of the network to which the generator is connected.
- **Asset life-cycle** – The value varies based on when in the network operator's cycle of upgrade projects the value is being measured. If the measurement is conducted on an annual basis, this means the value varies year-on-year, subject to the timing of network upgrade projects, as well as the supply and demand for energy in the area of the network to which it is connected.

- **Capacity –** The generation capacity of the distributed generation. For instance, there may be a minimum capacity needed to obtain material value. Furthermore, depending on the network configuration in a given location there may be a capacity above which additional distributed generation incurs network costs.
- **Optimisation** – 'Optimisation' refers to the extent to which the generation is optimised for delivery of grid services, which is largely a function of being both predictable and responsive to the needs of the network. The industry terms applied to these qualities are 'firm' and 'dispatchable'. A system that is highly optimised for network benefits is one that reliably produces output at the time it is most needed by the network.

The following sections outline the effect of each of these factors in more detail.

The analysis quantifies the value of the network benefits of distributed generation, but does not attempt to identify who is receiving that value. Some of the value we identify may already accrue to the investor in the distributed generation if that distributed generator has entered into an agreement to supply grid services to a network business. However, it is our understanding that such agreements are rare for small-scale distributed generators, and to the extent any exist, they are limited to a small number of trials.

THE NETWORK VALUE OF DISTRIBUTED GENERATION VARIES BY LOCATION

In Victoria, there are 224 zone sub-stations, 30 terminal stations and hundreds of sub-transmission feeders. Distributed generation may reduce network congestion at any number of these assets. Our analysis calculated the value at each of these levels of the network and its assets, and then expressed that value per zone substation.[42] This equates to using zone substations as the 'unit of analysis'.

The value is concentrated in a number of specific locations rather than being uniformly spread across the state. Our analysis of the Victorian network showed that the network value was markedly different even between neighbouring zone substations. This

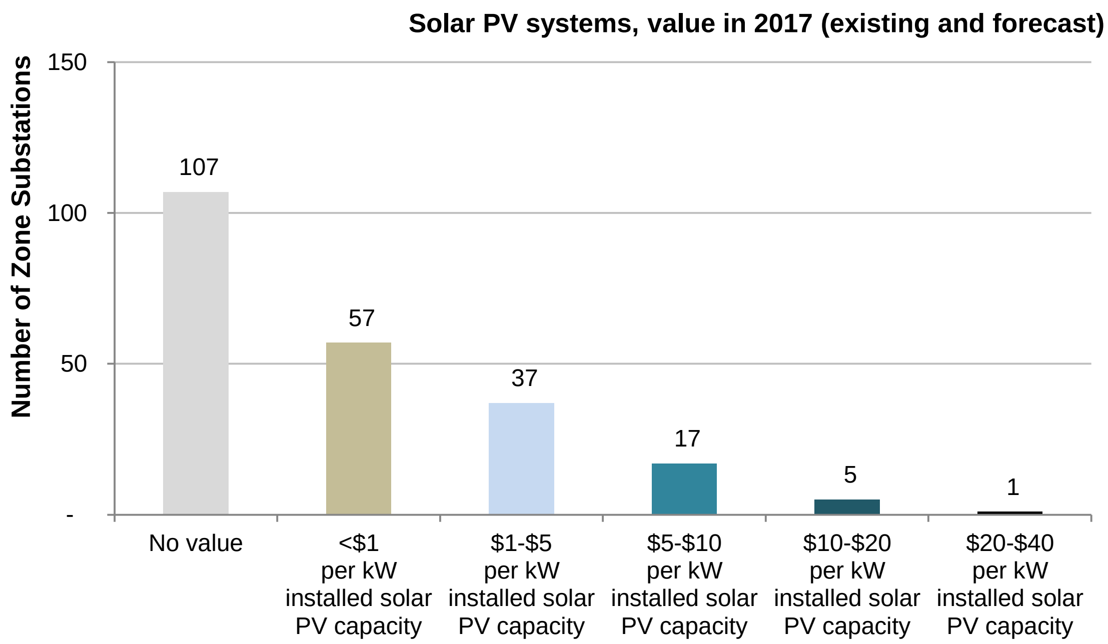
[42] The locational value of distributed generation in the low voltage portion of the distribution network was not calculated due to the lack of publicly available data.

pattern exists across the network. There may be considerable value at one network asset and zero value at the next.

As figure 4.3 shows, in the majority of locations, distributed generators will in 2017 provide no network benefits or will provide less than $1 per kilowatt (kW) of installed solar capacity of value. For solar PV, the value is estimated to exceed $10 per kW of installed solar PV capacity at only six zone substations. The maximum value provided by solar PV occurs at Barnawatha zone substation, in the north of the state, at a value of around $35 per kW of installed solar PV capacity.

This means that some but not all solar PV in Victoria provides network value. Network benefits are provided by those systems that are connected to a portion of the network that is congested, or nearing congestion. Figure 4.3 shows the number of zone substations that provide network value across a range of values.

FIGURE 4.3 ZONE SUBSTATIONS BY VALUE RANGE IN 2017
Number of ZSS by network value, solar PV systems ($/kW of installed solar PV capacity)

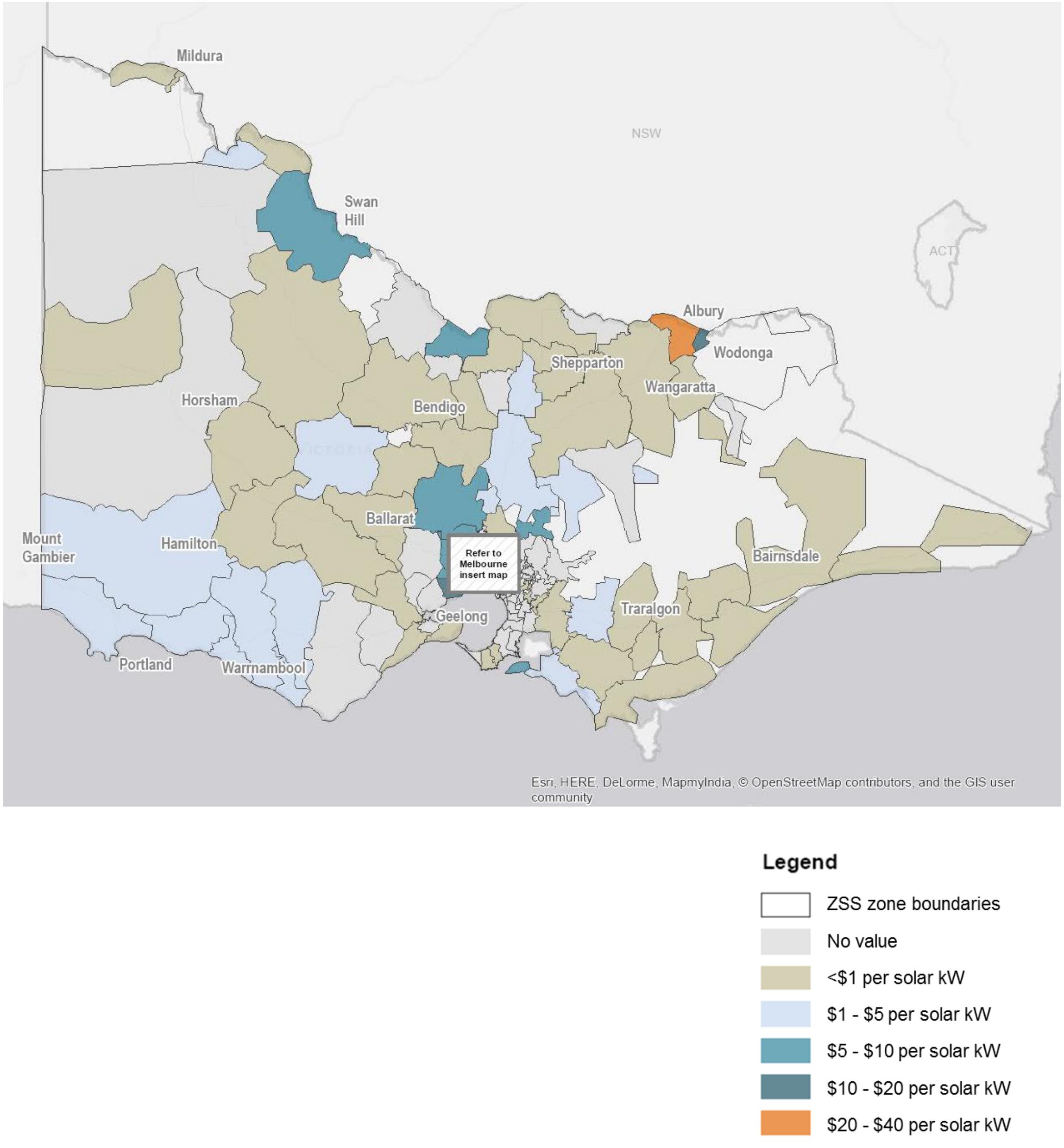


Data source: Jacobs

Higher value areas are located in various regional areas of Victoria (figure 4.4 and figure 4.5), and generally in the outer north and west of Melbourne (figure 4.6 and figure 4.7). For the majority of the Victorian electricity network, there is very low to no value provided from distributed generation in reducing network congestion.

FIGURE 4.4 NETWORK VALUE BY ZSS AREA IN VICTORIA (SOLAR PV)

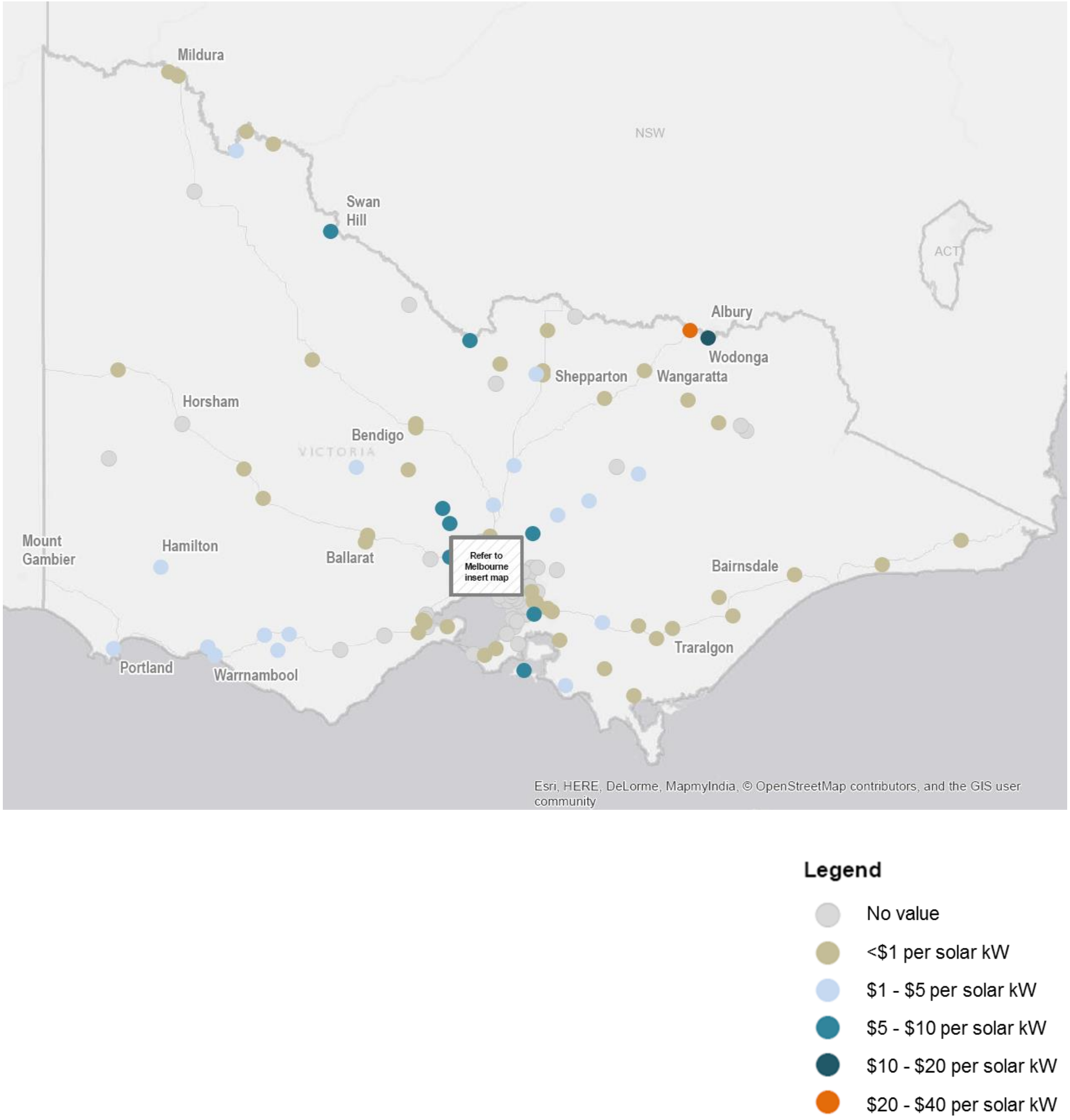
Value by ZSS for existing and forecast solar PV, for value ranges in 2017 ($/kW installed solar PV capacity)



Source: Jacobs

FIGURE 4.5 NETWORK VALUE BY ZSS LOCATION IN VICTORIA (SOLAR PV)

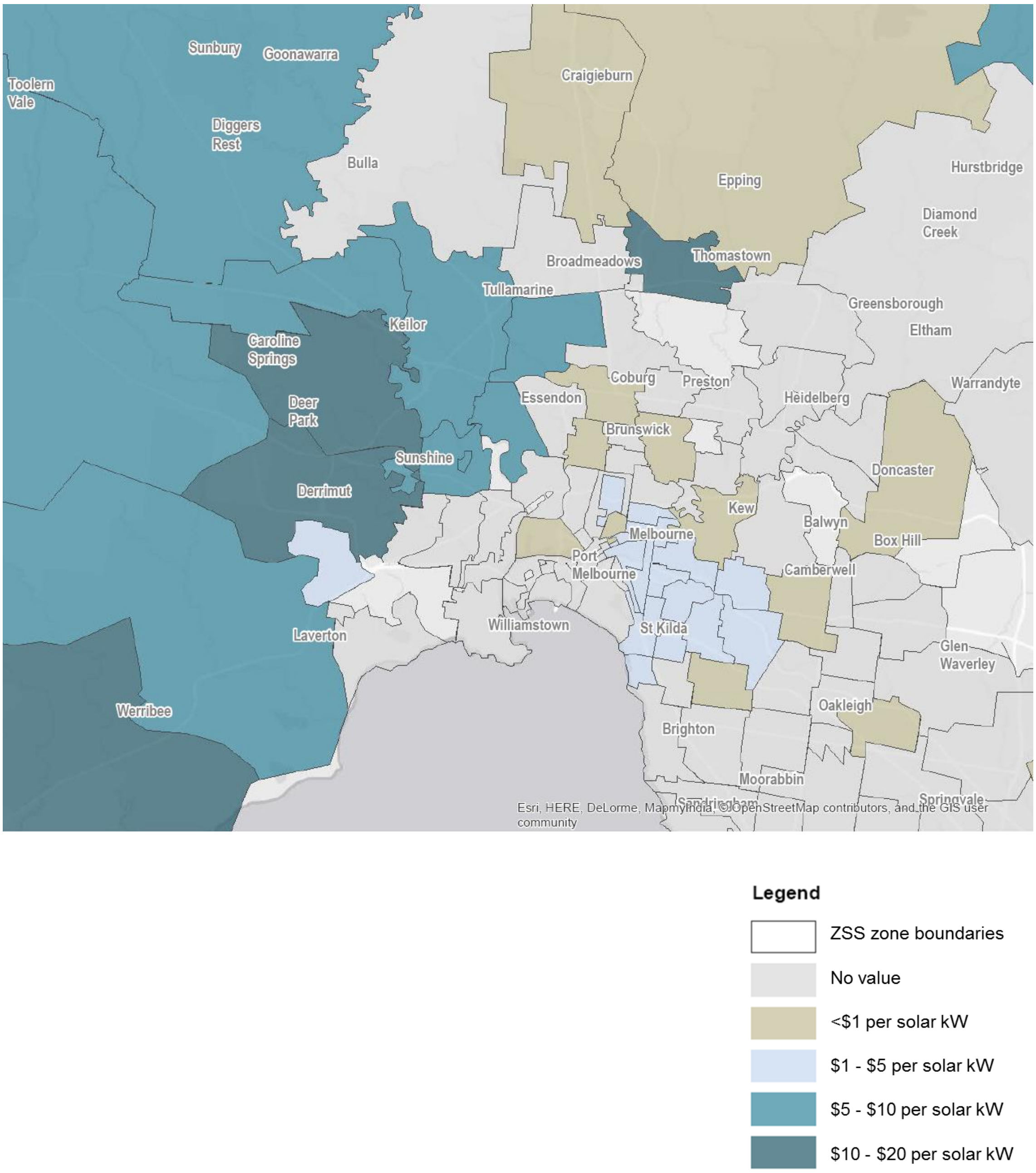
Value by ZSS for existing and forecast solar PV, for value ranges above $1 per solar kW installed capacity in 2017



Source: Jacobs

FIGURE 4.6 NETWORK VALUE BY ZSS AREA IN MELBOURNE (SOLAR PV)

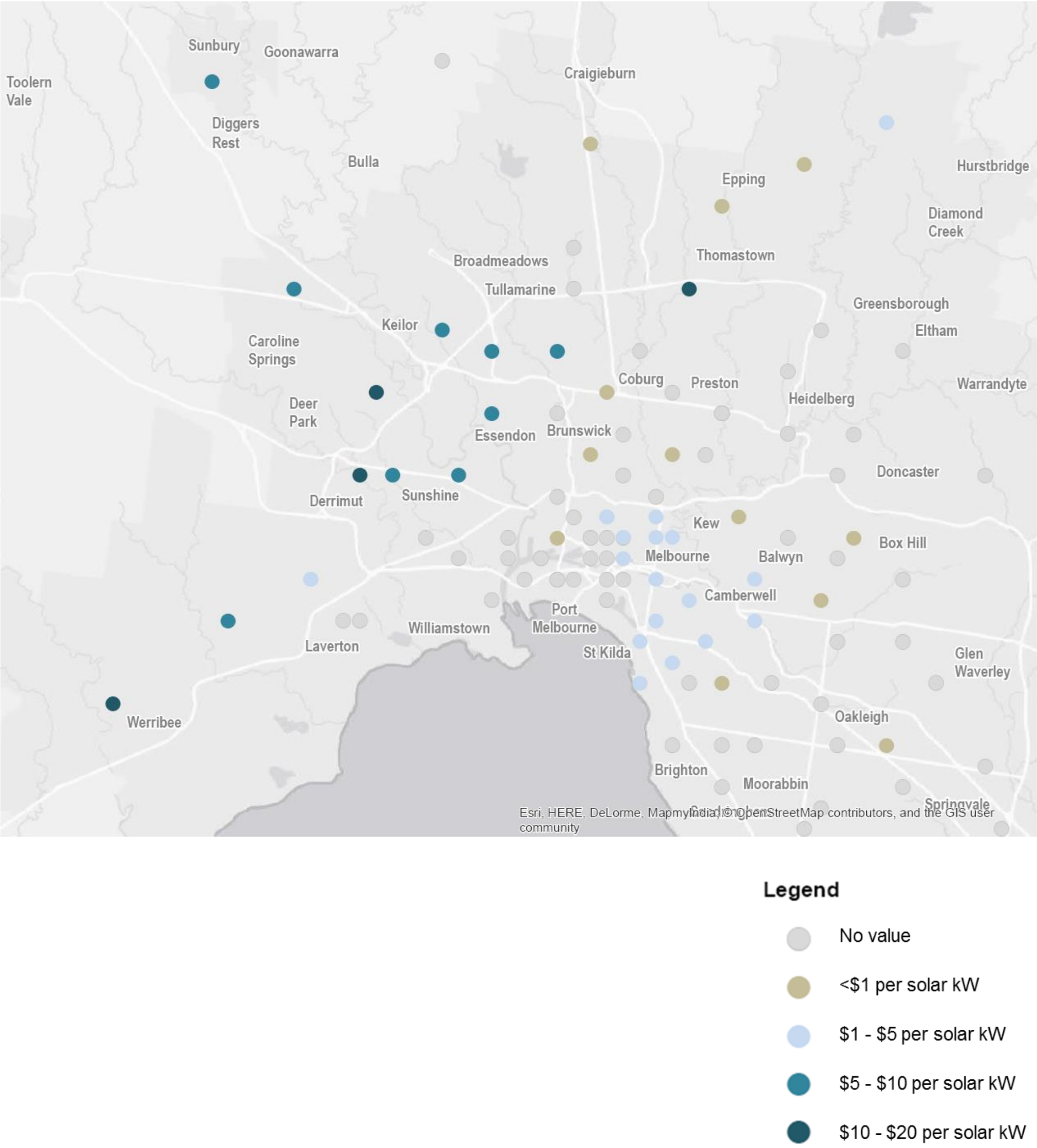
Value by ZSS for existing and forecast solar PV, for value ranges in 2017 ($/kW of installed solar PV capacity)



Source: Jacobs

FIGURE 4.7 NETWORK VALUE BY ZSS LOCATION IN MELBOURNE (SOLAR PV)

Value by ZSS for existing and forecast solar PV, for value ranges above $1 per solar kW installed capacity in 2017

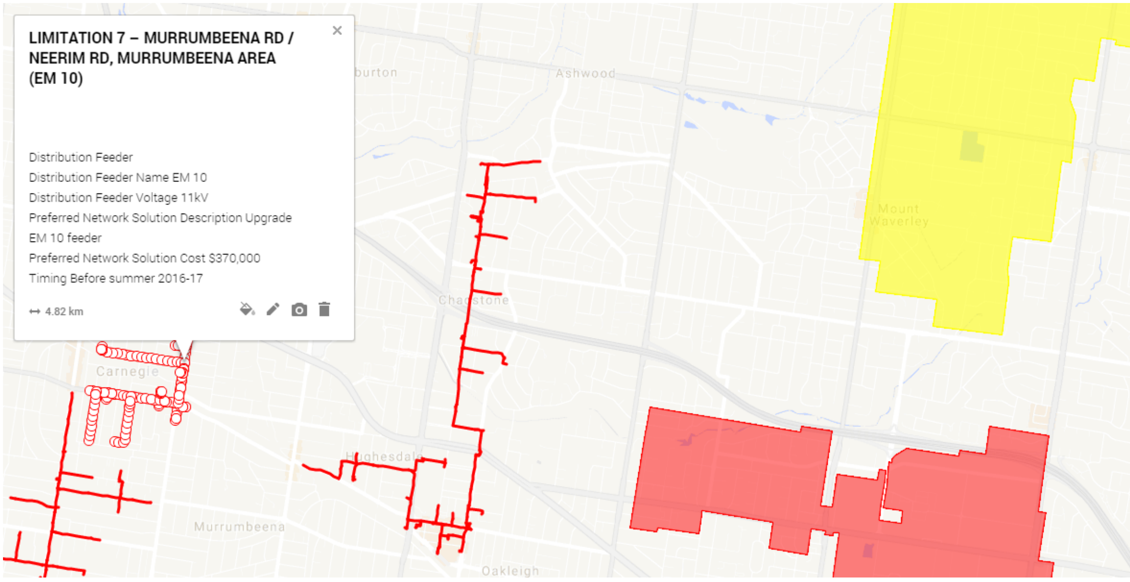


Source: Jacobs

Figures 4.4 to 4.7 only refer to network value at zone substations, sub-transmission feeders and transmission assets. The value in the low voltage portions of the network may be even more localised and granular. In congested sections of the low voltage network, this value may vary by distribution transformer and between sections of low voltage feeder (the type of assets often located at the street level).

Some network businesses have identified distribution level assets that require upgrading, but with limited publicly available data.[43] For example, United Energy developed a Network Limitations Map that identifies the location of required upgrades to distribution level assets. An excerpt of the map is shown in figure 4.8, showing an 11 kilovolt (kV) feeder requiring a network upgrade in 2016-2017 at a cost of $370,000. There remains the possibility that distributed generation could provide benefit at very local parts of the low-voltage network if that area is significantly congested.

FIGURE 4.8 EXAMPLE OF DISTRIBUTION LEVEL ASSET UPGRADES
Excerpt from United Energy Network Limitations Map 2015



Source: United Energy 2015, *Network Constraints Map,* www.unitedenergy.com.au/industry/mdocuments-library/

[43] It should be noted that network businesses are required to only provide detailed information (such as the information used for the purposes of this inquiry) at the zone substation level and above.

THE NETWORK VALUE OF DISTRIBUTED GENERATION VARIES BY TIME

Our analysis found that the network value of distributed generation in reducing network congestion is highly time dependent. To create value, the output of a distributed generator must coincide with peak network demand in the area of the network to which it is connected. While the network value of distributed generation may be high during network peak periods, for the remainder of the day the distributed generator will provide little or no network value.

In more specific terms, network value is time-dependent because the main driver of network value is 'energy at risk'. The amount of 'energy at risk' is a measure of the extent of potential congestion at each network asset, and as such it is what influences the timing of network augmentations and the amount of expected unserved energy.[44]

As we explain in chapter 3, 'energy at risk' is the amount of energy that won't be delivered if critical equipment fails at the zone substation (section 3.6.1). The capacity of a zone substation (or any network asset) in a scenario where the largest piece of equipment has failed is referred to as its N-1 capacity. A zone substation is at risk of being congested when the demand for electricity in the sections of the network served by the zone substation exceeds its N-1 capacity. The demand could also exceed the full 'N' capacity, often in cases where the network is exposed to weather variation in extreme days (such as a 1 in 10 years hot summer peak day) rather than an equipment failure.

The amount of 'energy at risk' varies each hour, based on the demand at each zone substation. Some zone substations will have no material 'energy at risk' because demand at that zone substation never exceeds the N-1 capacity and the probability of multiple simultaneous equipment failures is deemed to be highly unlikely. At other zone substations, the N-1 capacity will be exceeded on a daily basis. However, even in these instances, this will only occur at specific times, possibly only for a single hour or lesser duration.

[44] Expected unserved energy is equal to the 'energy at risk' multiplied by the probability of failure of the critical piece of network equipment which places that energy at risk. It may consist of a group of components for each mode of network failure that may cause supply disruption to customers, in which case it is calculated and summed over all the failure modes that may affect a location.

For distributed generation to reduce the energy at risk, and thereby produce value, its output must coincide with the times at which the N-1 capacity has been exceeded. That is, the generation must occur at the same time there is 'energy at risk'.[45] This is explained in more detail in box 4.1.

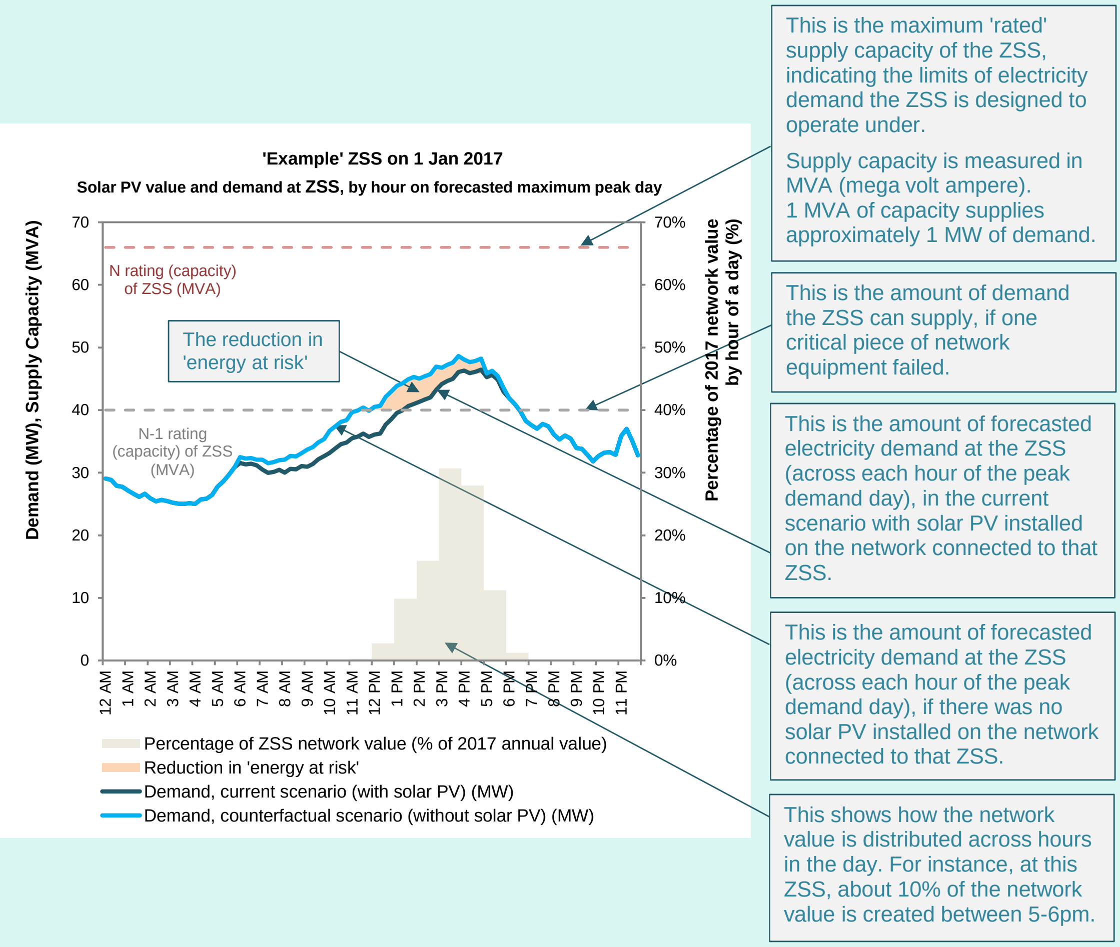
An additional layer of complexity is introduced by the fact the timing of peak demand varies throughout the network. In commercial or industrial areas, the peak may occur around the middle of the day, whereas in residential areas it may occur in the evening. This means there is no uniformity across the network regarding the time of the day at which distributed generation provides network value.

[45] Note that our method may in some cases underestimate the value created by solar PV through the reduction of expected unserved energy. This is because, in practical terms, it is unlikely to be possible to de-energise a portion of the network without disconnecting some solar PV systems. It may also not be able to disconnect the exact amount of load that is needed to meet the available capacity because in practice load is disconnected in discrete selectable blocks based on the distribution feeders supplied from the substation.

BOX 4.1 READING HOURLY DEMAND AND SOLAR PV VALUE GRAPHS

The following section provides graphs that demonstrate how the network value provided by distributed generation varies by time. These graphs provide examples of how distributed generation, in particular solar PV systems, can provide network value.

The figure below provides explanations of each component of the graph.



Distributed generation will provide value to the network when it reduces the amount of 'energy at risk'.[46] In the example above, distributed generation is providing value between the hours of 12pm and 6pm, because it is reducing the amount of energy that may be 'at risk' if the most critical piece of network equipment fails at that ZSS.

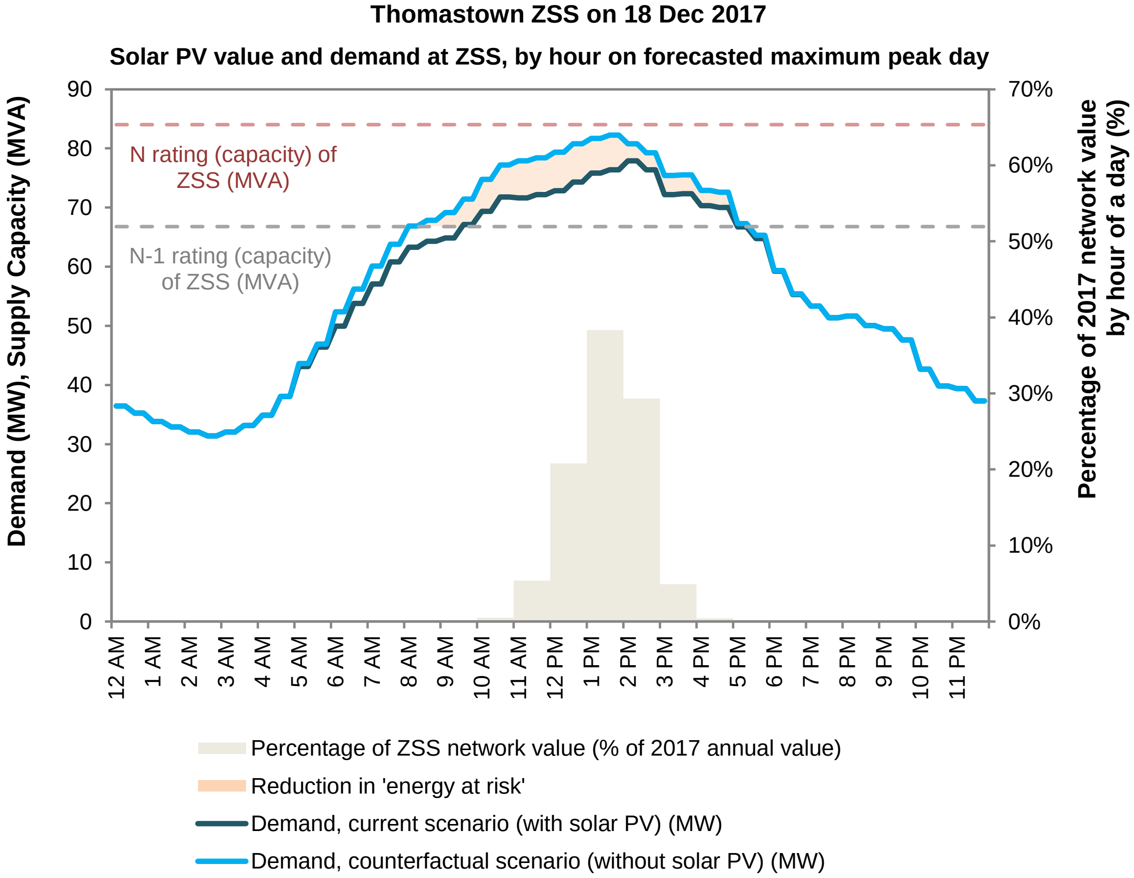
Source: ESC

[46] The 'energy at risk' in the example is the area between the electricity demand at the ZSS and its N-1 rating.

In the example of Thomastown ZSS, shown in figure 4.9, the amount of 'energy at risk' is determined by the amount of demand that exceeds the N-1 rating of the zone substation. The 'energy at risk' in a counterfactual scenario occurs between 8am and 5pm during that day. The extent to which distributed generation reduces 'energy at risk' also influences the extent of network value it provides.[47] The highest network value, occurring approximately between 1pm and 2pm, is where distributed generation is mostly reducing 'energy at risk'.

FIGURE 4.9 NETWORK VALUE OF SOLAR PV COMPARED TO ZSS DEMAND AT THOMASTOWN ZSS

For highest peak demand day, forecasted in 2017



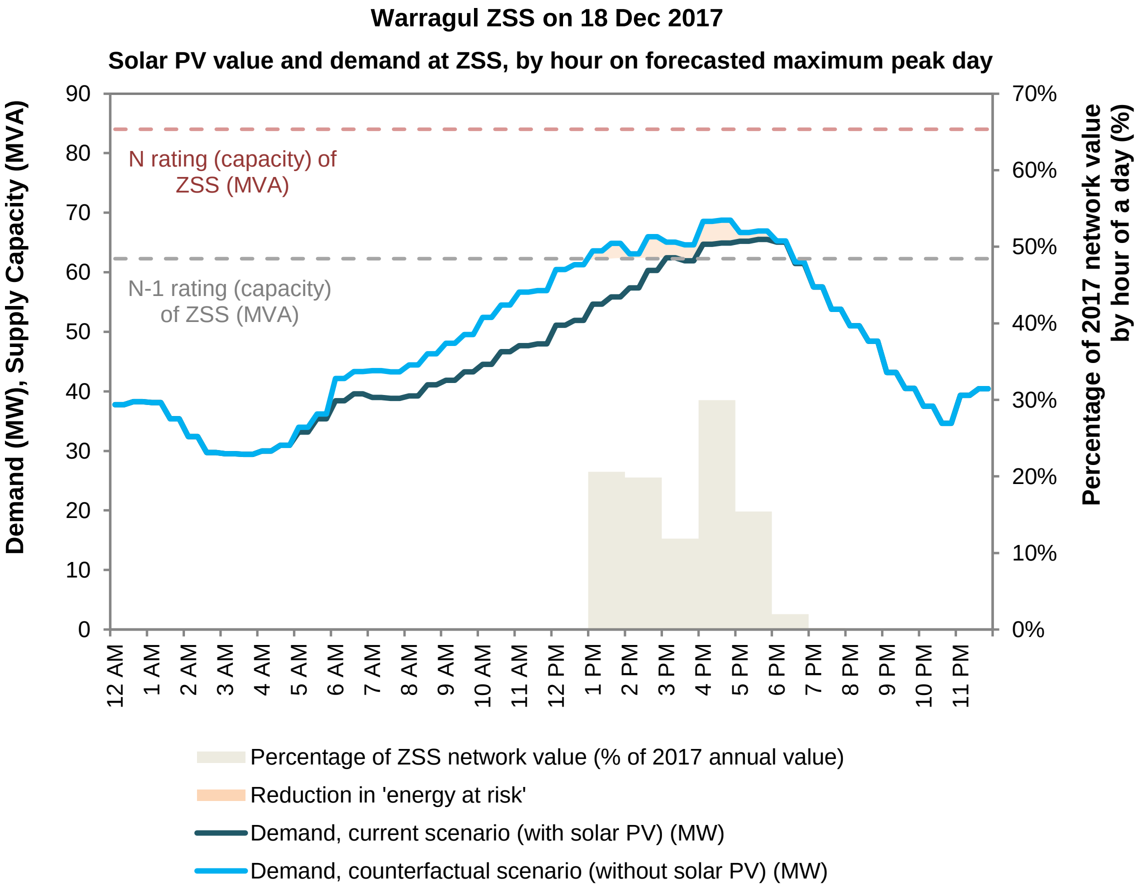
Data source: Based on Jacobs modeling

[47] It should also be noted that solar PV systems, in aggregate, could increase cyclic ratings on substation transformers. As shown in figure 4.9, solar PV systems will reduce the amount of zone substation load earlier in the day, which will lower the operating temperature of transformers prior to facing peak loads later in the day. Initial analysis has shown there may be improvements to cyclic ratings in the order of a 1%, but this would only be relevant to specific locations.

For comparison, figure 4.10 shows the zone substation at Warragul, where the period during which there is 'energy at risk' is more aligned to residential demand patterns. That is, the period of peak demand occurs later in the day, from 4pm to 6pm. In this example, the N-1 capacity is exceeded at a later period compared to Thomastown, from around 12pm to 6pm.

FIGURE 4.10 NETWORK VALUE OF SOLAR PV COMPARED TO ZSS DEMAND AT WARRAGUL ZSS

For highest peak demand day, forecasted in 2017

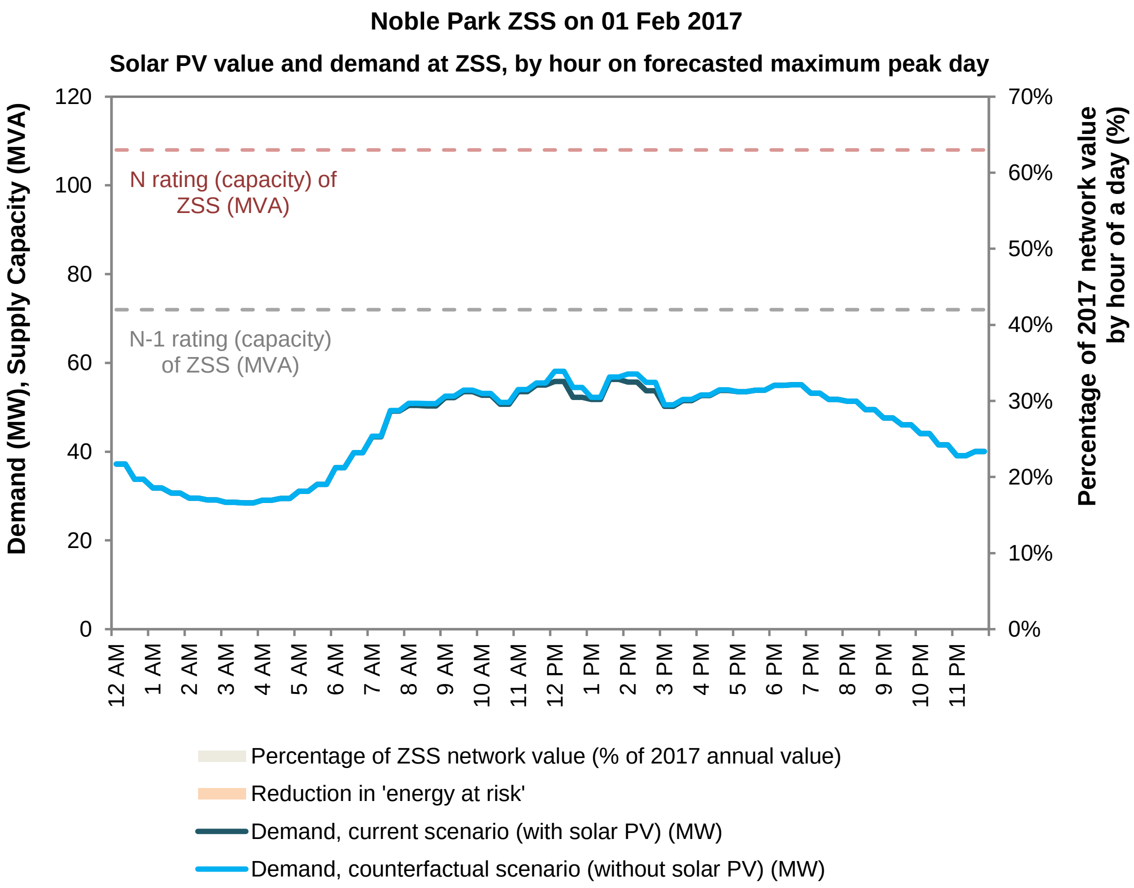


Data source: Based on Jacobs modeling

Lastly, figure 4.11 shows a zone substation (Noble Park) where, on this example day, demand does not exceed the N-1 capacity. This means that there is no material energy at risk in either the current or counterfactual scenario (without solar PV systems installed). As shown there is no assessed network value for the zone substation asset.[48]

FIGURE 4.11 NETWORK VALUE OF SOLAR PV COMPARED TO ZSS DEMAND AT NOBLE PARK ZSS

For highest peak demand day, forecasted in 2017



Data source: Based on Jacobs modeling

[48] This example shows only the network value relating to the zone substation asset. There may be value provided by distributed generation for sub-transmission and terminal station assets, which are not solely related to the demand profile of the zone substation.

For the majority of distributed generation systems in Victoria, which are solar PV systems, the higher network values occur when the electricity generation from solar PV coincides with the time of peak demand faced by the zone substation. This means that solar PV systems will not be able to provide material network value if a zone substation area experiences peak demand during the evenings. If the peak of any given zone substation occurs at night, solar PV will provide no value in that area.

NETWORK VALUE VARIES YEAR ON YEAR BASED ON ASSET LIFECYCLE

The network value of distributed generation varies based on when in the network operator's cycle of upgrade projects the value is being measured. The operator's investment profile is determined, at least in part, by the extent to which different parts of the network are nearing congestion. Our analysis indicates that as a part of the network (e.g. a zone sub-station) nears congestion, the network value of distributed generation rises. Once the operator has upgraded that facility, the network value can diminish — possibly to zero.[49]

If the availability of distributed generation (and the network value it delivers) leads to the deferral of planned network upgrade projects, this will prolong the period over which network value is positive. In other words, network value is an endogenous value. It depends on the network operator's upgrade plans which, in turn, depend on the availability of distributed generation at different points in the network which, in turn, depends on the price paid by network operators to the owners of distributed generation. This variation is caused by a minimum threshold of distributed generation that is needed to change the assessed timing of network projects. If the amount of distributed generation is small, it may only have a small effect on reducing expected unserved energy cost. A network upgrade may only be deferred by a larger amount of distributed generation capacity. The result of this interplay is that in most locations across the network, the value provided by distributed generation will shift considerably each year.

[49] The value will fall to zero only if there is no residual energy at risk without the distributed generation. The relevance of asset lifecycle to value over time was noted in submission by the Energy Networks Australia and Ausnet Services. Energy Networks Australia 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation - Proposed Approach Paper,* February, p. 3; AusNet Services 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 5.

To examine the extent of this variation, we applied the valuation method for another four years: for 2016 as well as 2018, 2019 and 2020. This enables us to compare the value across the network year-on-year.

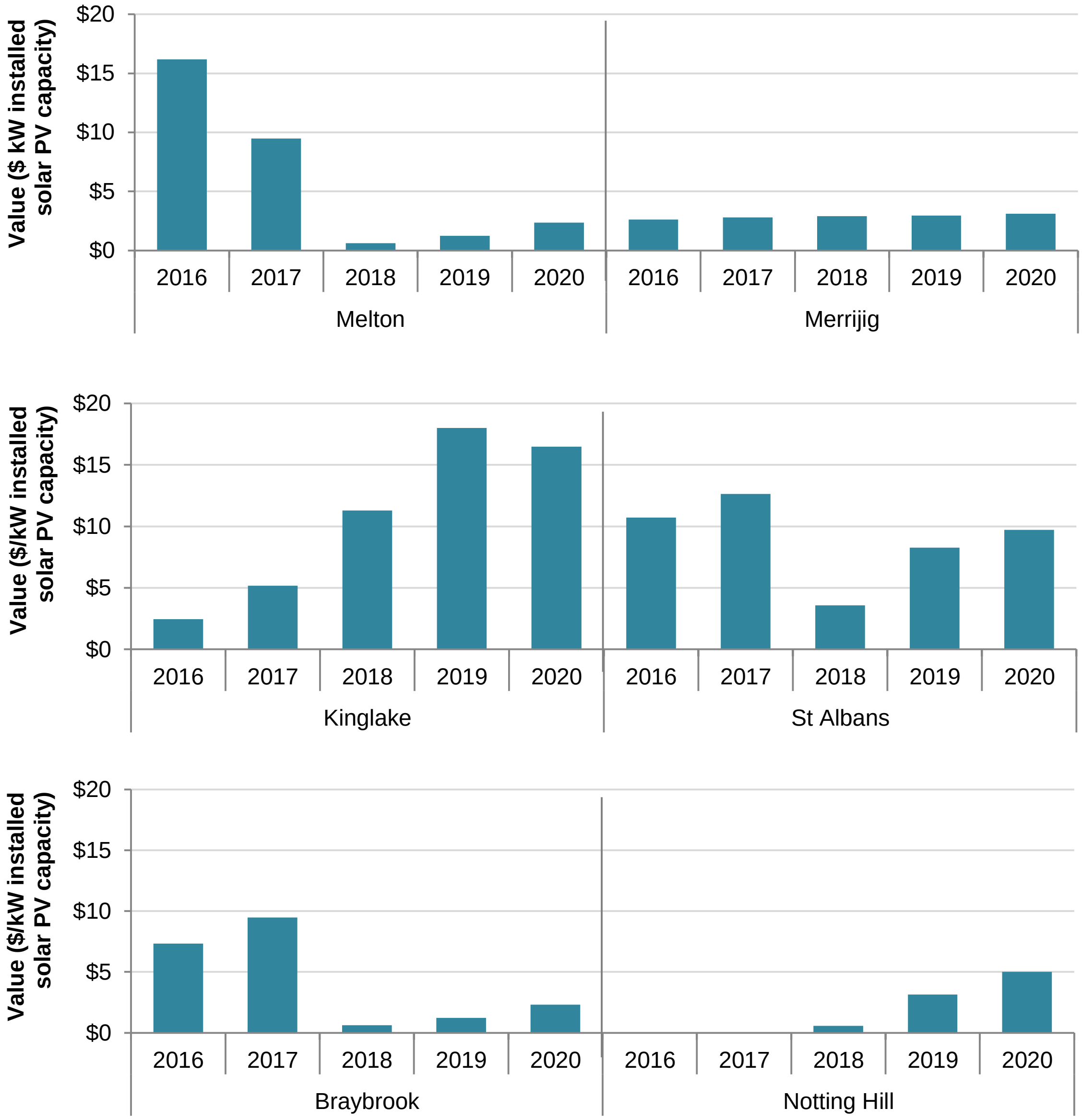
The results confirmed that, year-on-year, the value provide by distributed generation can increase or decrease sharply, changing by as much as 100 per cent or more between years. It also revealed that, as would be expected, the pattern of the variation is not consistent across the network. Between years, the value at one zone substation may spike, while at the neighbouring zone substation the value may drop or disappear.

The variability of network value each year is demonstrated by figure 4.12 for six different zone-substations in Victoria. In Melton, the network value calculated in 2016 and 2017 is around $10-15 per kW of solar PV installed capacity. However, this value drops sharply to almost zero in 2018. In contrast, at Merrijig, the value of solar PV remains relatively constant at around $8 per solar kW installed capacity between 2017 and 2020. The other four example zone substations show how these patterns of yearly value is not consistent across Victoria. The variability of total network value from solar PV across Victoria also changes each year, as shown in figure 4.13. It is worth noting that the values presented in future years (2018 to 2020) are less certain than the figures quoted for 2016 and 2017. Certainty decreases the further in advance the forecast is made.[50]

[50] Factors relating to network value such as demand growth, number of distributed generation systems and network project costs are less certain the further the forecast of value.

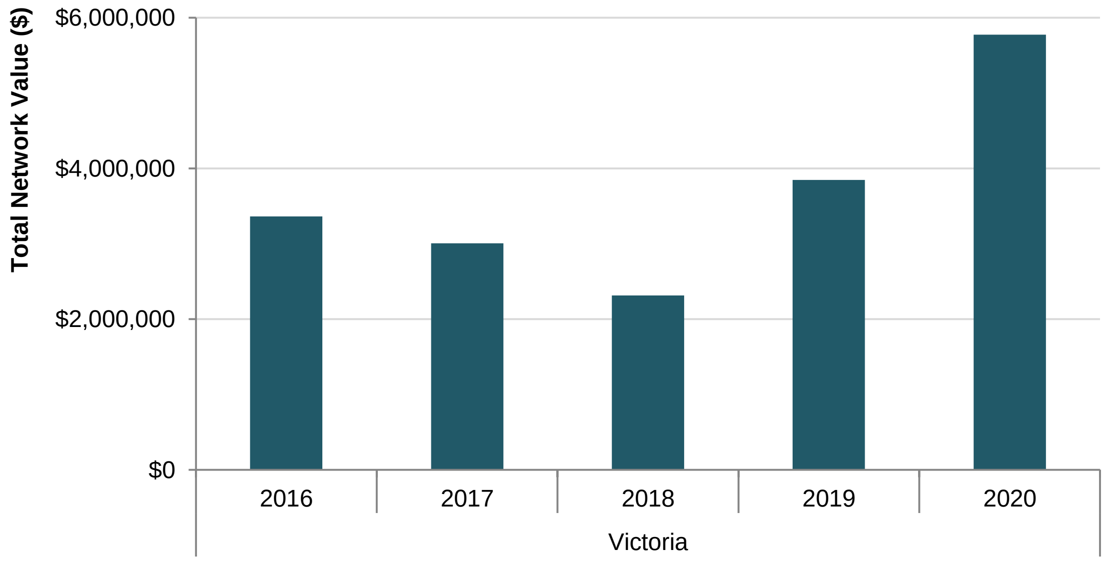
FIGURE 4.12 NETWORK VALUE, BY YEAR

Examples of network value by year ($/kW installed solar PV capacity) at six zone substations in Victoria



Data source: Jacobs

FIGURE 4.13 TOTAL ANNUAL NETWORK VALUE, BY YEAR
Examples of network value by year ($), total in Victoria



Data source: Jacobs

GENERATION CAPACITY INFLUENCES VALUE

Any reduction in network congestion will provide a benefit in the form of reduced expected unserved energy. However, the benefit of deferring network augmentation is only created where the reduction of network congestion reaches a threshold level.

That threshold varies for each network asset, but in keeping with the probabilistic planning method we explained in section 3.6.1, in each case it is defined by the point at which the saving in value of the expected unserved energy is greater than the cost of the planned augmentation project. In other words, to produce a benefit in this category, distributed generation must supply enough electricity at the appropriate times to make the network upgrade unnecessary for the time being.

Because the level of reduced congestion required to defer a network augmentation project is typically large, relative to residential solar PV system, this benefit is normally only produced by larger distributed generation systems, or by substantial numbers of smaller systems operating in unison.

‘FIRM’ SYSTEMS OPTIMISED FOR NETWORK BENEFITS ARE MORE VALUABLE

‘Firmness’ of generation is a key concept in the discussion of network value. Firmness is a shorthand means of referring to matters relating to the reliability of generation, which may include intermittency, predictability, and dispatchability.

Importantly, firmness exists along a spectrum. It is not a binary attribute. In other words, generation is not merely ‘firm’ or ‘not firm’. Rather, different electricity generators will have different degrees of firmness. No source of electricity generation is perfectly reliable and can be expected to be fully available at all times. However, sources of thermal and hydropower with availability exceeding 90% of the time and with failure rates less than 2% of the time are usually considered “firm” supplies in a power system context.

One means of influencing the firmness of a generator is through negotiated agreement. This may arise through a contract, for instance, between a network business and a supplier of distributed generation (or their agent, in an aggregation scenario), who is capable of delivering generation on demand. Distributed generation technologies that can be delivered ‘on demand’– sometimes referred to as controllable or ‘dispatchable’ generators – include technologies such as cogeneration plants, diesel engines and certain battery-connected systems. To the extent this contract is honoured, this output can be described as firmer than the output of an equivalent generator with whom no contract for supply has been struck.

Another factor that influences firmness is predictability. This factor applies particularly to solar PV, which is a broadly predictable source of electricity generation by virtue of its output being driven by two factors: system capacity and insolation (available sunshine). Both the effective system capacity and the insolation at the system’s location can be predicted based on publicly available weather forecast data.[51] Network

[51] As part of the valuation method used in this inquiry, Jacobs developed a typical generation profile of average solar PV systems in Victoria. Jacobs developed a method using a combination of 2015 hourly weather data from the Bureau of Meteorology for Melbourne and satellite data for areas outside of Melbourne, time-stamped modelled optimal generation data using the PVSys model for 2015, and factored against time-stamped gross outputs from 300 systems in the Ausgrid network area, NSW. This method enabled an aggregate solar PV generation profile to be derived for each location having regard to the varying efficiency and orientation of solar PV installations across many systems, as compared to an ideally oriented and new system.

businesses regularly incorporate forecasted output of solar PV in their annual planning processes on the basis of this predictability.

Firmness is relevant to the calculation of network value because that value arises primarily via the impact of distributed generation on the network planning process. Specifically, as explained above, network value is driven by changes in the level of ‘energy at risk’ at a given asset. When planning the network, the forecasted level of ‘energy at risk’ is the key driver of network augmentation decisions. Only generation that is sufficiently predictable can be incorporated into these forecasts.

However, as the previous sections illustrate, reliability alone is not sufficient to create network value. Rather, value is created primarily when the output of a distributed generator coincides with a period of network congestion (peak demand). In other words, the more responsive the output of a distributed generator is to the needs of the network – particularly in terms of timing – the greater the potential value it can produce. The systems with the greatest capability of being responsive are those that are fully dispatchable.

Some distributed generation can be relatively predictable, or firm, without being dispatchable. The output of solar PV (without batteries), for instance, is sufficiently predictable to be incorporated into the planning process, notwithstanding natural variations of weather.[52] However, the timing of its output does not always coincide with periods of network congestion. Furthermore, it cannot be controlled in order to alter the timing of its output. It is therefore inherently unresponsive.

On the other hand, a dispatchable distributed generation system, such as a gas turbine, has the capability to be highly responsive. For instance, if network congestion at a given zone substation occurs between 5pm and 7pm, the system can be programmed to run during this period. It may also be large enough to deliver enough generation to defer (or contribute to deferring) a network augmentation. However, without agreements (or potentially incentives) in place, it may not produce any output during this time and therefore may produce no value.

[52] Solar PV output may be affected by cloud cover on peak days, reflecting natural variations in weather, so the impact on peak demand must be considered together with the effect of the relevant weather variables on the underlying demand for electricity. These factors influence the ability of the network planner to rely on the solar PV generation and to include its effect on the assessed energy at risk.

When solar PV systems are supplemented with batteries and control systems (energy management systems), and thereby made dispatchable, the network value that previously accrued as a result of the predictability of standard PV may also change. This is because the output is now determined by the decisions of an operator as opposed to the more predictable interaction of system capacity size and insolation.

If the operator of this system does not align the output of the system in a manner responsive to the network's needs, the value that would otherwise accrue would be lost. This may occur, for instance, if during a period of network congestion the operator uses the electricity from the solar PV system to charge the battery instead of displacing local demand. In an alternative situation, the battery may have already been discharged earlier during a peak day, making it unavailable to support the network later when the peak demand arises. As a result, the system will not reduce the pressure on that section of the network at the time of congestion.

However, the inverse is also possible. A dispatchable solar PV and battery array could be controlled in such a way that it is highly responsive to the network, and thus produce considerably more value that would otherwise have occurred with a predictable but passive, or 'uncontrolled' system.

Distributed generation which bears the attributes of both firmness and dispatchability can be 'optimised' for network benefits.

To examine the additional value that 'optimisation' of distributed generation can deliver, we developed a variation on the counterfactual methodology we set out in chapter 3. Under this variation, we examined the value that would be provided by two identically sized 'additional increments' of distributed generation capacity.[53]

One increment was based on the generation profile of solar PV, while the other was deemed to be 'optimised'. That is, the second increment was assumed to predictably provide generation at the times when it was most needed by the network. We applied this method across the entire Victorian network.

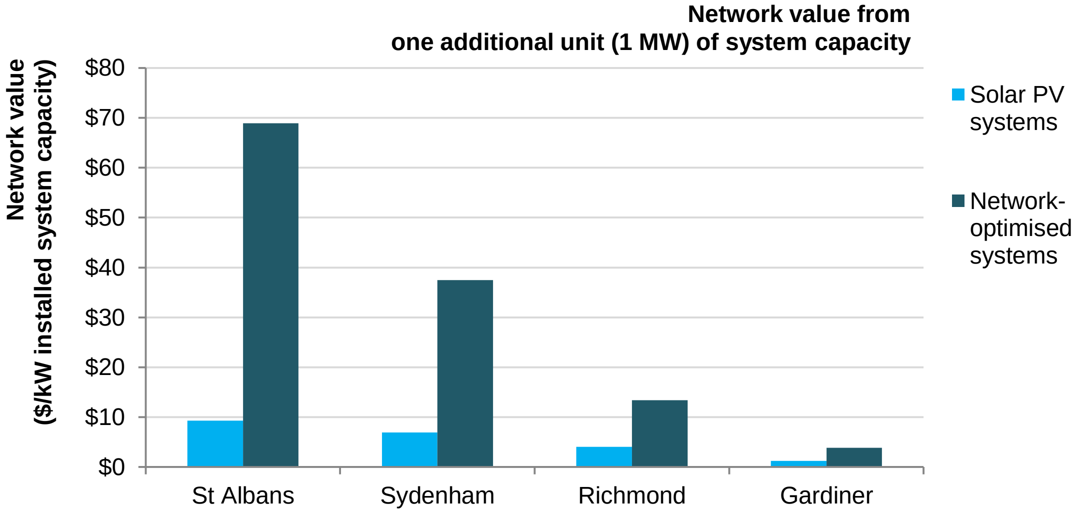
[53] The increment was 1 megawatt (MW).

The results showed that, across the state, 'optimised' distributed generation delivers more value for network operators than solar PV per unit of installed capacity. The difference in value between the two types of generation itself varied based on location. However, as a trend, optimised systems delivered on average around four times more value than solar PV systems. In some instances, the variation was much greater, with optimised systems up to twenty times more valuable.

To illustrate the modelled impact of network optimisation, figure 4.14 shows the comparison between solar PV and optimised systems at four different zone substations.

FIGURE 4.14 RATIO OF NETWORK VALUE OF NETWORK-OPTIMISED SYSTEMS COMPARED TO SOLAR PV SYSTEMS

Values based on an additional 1 MW of capacity, at various ZSS



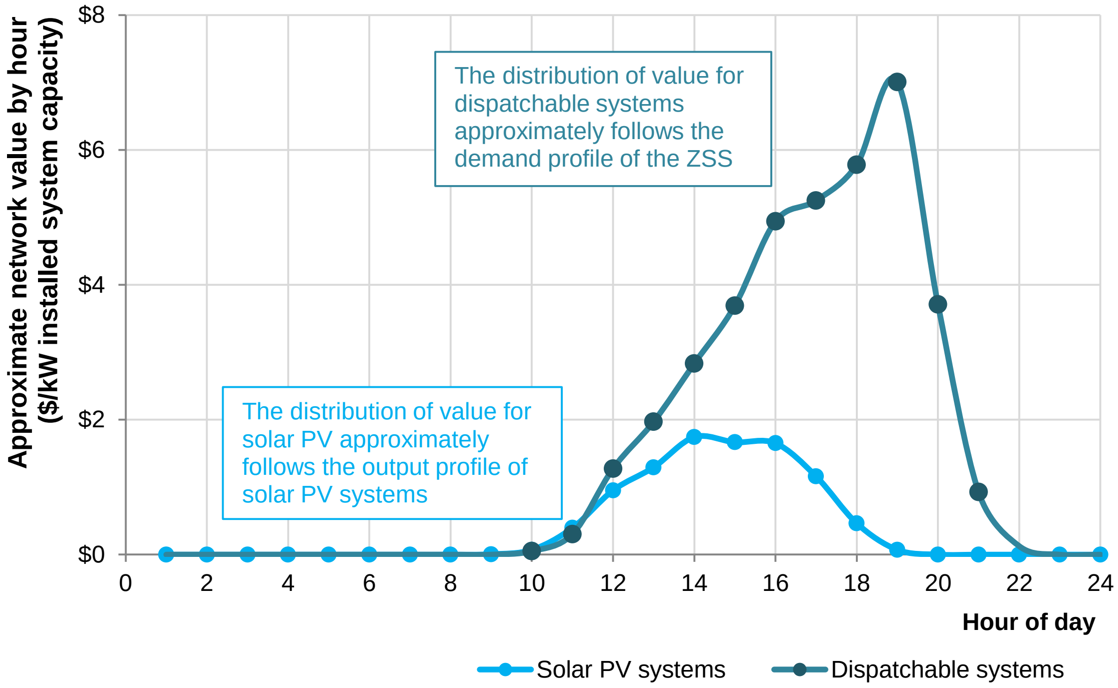
Data source: Jacobs

To further illustrate this variance, figure 4.15 breaks down the difference in value between solar PV and optimised distributed generation across 24 hours at an individual zone substation (Essendon). In the case of Essendon, the network value of solar PV generation is highest between 2pm and 4pm, and zero for the early morning and at night. The pattern of network value from solar PV systems follows the typical pattern of how much electricity it generates throughout a given day.

This is unlike the pattern of hourly network value from optimised systems, which could generate the same amount of electricity at any time of the day. Optimised systems provide value when most needed by the network (often when peak network energy demand is highest). In the example in figure 4.15, optimised systems can provide much higher network value compared to solar PV in the early evening at 6:30pm. This is primarily because most distributed generation in Victoria is solar photovoltaic (PV), which is not 'controllable' unless it is supplemented with additional technologies such as energy storage and energy management systems.

FIGURE 4.15 NETWORK VALUE, BY HOUR

Approximate total network value by hour in 2017 at Essendon ZSS, comparing solar PV and dispatchable systems ($/kW installed system capacity)



Data source: Based on Jacobs modeling

Our analysis indicated that controllable distributed generation can be significantly more valuable if it is optimised. The most value is likely to arise when the distributed generation system is controlled by a network business, whether directly or through third party arrangements such as contracted aggregation services, because this allows for the most precise optimisation of the system.[54]

If a greater proportion of Victoria's existing fleet of distributed generation was controllable and responsive to peak network demand – in other words, optimised for network value - its potential to provide value would increase.

4.3 ECONOMIC VALUE – OTHER NETWORK BENEFITS

In this section, we provide the results of our assessment the following potential network benefits of distributed generation:

- network support
- managing voltage regulation and power quality
- ancillary services
- islanding capability.

4.3.1 NETWORK SUPPORT

Network support is a form of grid service that provides an alternative to investment in additional network infrastructure. Under a network support arrangement, distributed generation or other forms of demand-side service can be procured by a network business to address a network issue, such as relieving network congestion in a constrained area of a network. Network support services can be deployed to relieve constraints in either the distribution or the transmission network.[55]

Network support facilities are typically located close to network assets that are nearing capacity, and are generally larger fossil-fuel based generators around 5-10 megawatts

[54] Appendix A provides a detailed summary of the values of solar PV and dispatchable generation at each of the Victorian substations analysed. In some cases, zero values arose due to lack of publically available data or in large single commercial entity sites where there is immaterial distributed generation installed.

[55] A specific Network Support Payment mechanism exists within the NER to facilitate payments to distributed generators for network support services rendered to the transmission network.

(MW) in capacity. Network businesses typically procure network support services on the basis that they meet defined technical standards such as availability and guarantee of service. Network support facilities defer the need to upgrade the constrained network asset by injecting electricity into the network downstream from a network constraint.

For example, AusNet Services have a network support agreement with NovaPower to provide up to 10 MW of electricity generation during network peak periods in Traralgon. The solution consists of gas-fired generators located close to the Traralgon zone substation.[56] In other cases, network businesses may engage network support agreements for highly specific and localised circumstances, such as responding to very specific demand patterns. The case study in box 4.2 describes a scenario of this nature in Bairnsdale. Based on our analysis and submissions to this inquiry, we have identified a number of other network support agreements currently in place across three of the five distribution areas in Victoria.[57]

One potential benefit of distributed generation is that it can reduce or avoid the need for network support facilities. This presumes that network support payments are in place or may be considered, and that the existence of distributed generation on the network in that area lessens the need, and therefore the cost, of those network support arrangements.

We acknowledge that distributed generation could also defer the need to procure network support services via the same means it can defer the need to upgrade network assets – that is, reducing network congestion. However, the benefit distributed generation provides in this case is already captured in our consideration of reducing network congestion in section 4.2. We were not presented with evidence that distributed generation influenced the scope and cost of network support services beyond that measured in the context of network congestion. As a result, we did not

[56] AusNet Services 2014, *Demand Management Case Study: Embedded Generation,* August.

[57] Citipower submitted that it made payments for network support services of $160,000 between 2011-14. Powercor submitted that it made payments for network support services of $40,000 between 2011-14: CitiPower and Powercor 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Proposed Approach Paper,* February, p. 9. AusNet services submitted that it had agreements for network support services in place with two distributed generators: AusNet Services 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Proposed Approach Paper,* February, p. 6.

identify a separate benefit that distributed generation provides with regard to network support arrangements.

BOX 4.2 NETWORK SUPPORT CASE-STUDY – BAIRNSDALE PROJECT

The Bairnsdale generation project is located in the AusNet distribution area. This network support facility provides generation in the form of two 40 MW gas turbines. The plant operates regularly to support the high network demand that occurs each night around midnight, because of a demand pattern that is unique to that area, based on hot water loads being switched-on at off-peak times.

In theory, a large amount of distributed generation at this location could reduce or remove the need to run these turbines, and save the fuel consumption associated with those gas turbines. However, for distributed generation to provide a benefit by reducing the requirement for this network support service its output would need to occur around midnight when output from solar PV is not available.

Source: Jacobs

4.3.2 MANAGING VOLTAGE REGULATION AND POWER QUALITY

Network businesses must also operate the network to meet certain power quality requirements. These include managing the voltage within their network to ensure it does not damage electrical equipment (referred to as voltage regulation) or cause annoyance to customers' electrical lighting (voltage flicker).

Fluctuations in voltage depend on customer loads (regardless of whether they have distributed generation systems) and the characteristics of the transformers and feeders conveying the electricity. These issues often occur in network areas under high load conditions, or where the load at that location exceeds the design specifications of supporting network equipment.

To minimise these effects, network businesses are required to operate the network at acceptable voltage levels – this requirement is known as voltage regulation.[58] Network businesses use a number of methods to maintain required voltage levels, such as adjusting transformer taps[59] or installing equipment such as capacitor banks[60] at substations.

Some stakeholders have noted that under certain conditions, distributed generation could potentially assist with voltage regulation, but only with the aid of advanced 'smart' inverters (see box 4.3), or if they are made highly responsive to the needs of network business. Citipower and Powercor stated:

> *...there may be network benefits in managing these voltage variations, but only if all solar PV inverters in a local area were controlled to adjust the power factor of each solar PV installation (so as to keep within a required voltage range).*[61]

The Energy Networks Australia provided another example where specific technologies, such as solar PV combined with battery storage, could reduce the need to manage voltage variations:

> *…reduced intermittency and day-time output potentially means less need for measures to manage voltage deviations and reverse control issues and therefore lower network management costs.*[62]

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[58] In technical terms, voltage regulation is the change in load voltage when the load is removed.

[59] Transformers are comprised of a number of coils (or windings) that dictate the supply voltage of the transformer. A transformer tap is a component of the transformer that can change the number of 'turns' in the coils of a transformer, which changes the supply voltage.

[60] Capacitor banks are used to store electrical energy temporarily, and are used to regulate voltage or high loads for customers.

[61] Citipower and Powercor 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 5.

[62] Energy Networks Australia 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 4.

BOX 4.3 'SMART' INVERTERS AND A NEW AUSTRALIAN STANDARD

In Australia, distributed generation systems (particularly solar PV systems) are typically installed with inverters that allow connection with the grid. These inverters are required to meet certain Australian standards. Since 9 October 2016, accredited inverter systems must now meet an updated standard, *AS/NZS 4777.2:2015 Grid connection of energy systems via inverters - Inverter requirements*.[63]

The main updates to inverter standards allow distributed generation system to have the capability to provide services to the network. This includes further new voltage and frequency set-points and limits to be compatible with requirements of network businesses.

The updated standards also require inverters to have Demand Response Mode (DRM) capabilities. DRM capabilities allow a remote operator to alter the inverter system to operate in a certain way, such as disconnecting from the grid, preventing generation of power, or increasing power generation. These functionalities for new inverters make it distinct from older generation inverters, and have been referred to as 'smart' inverters.

The updated standard requires inverters to have the capability for eight different modes of operation (referred to as DRM0 to DRM8). However, only one of the modes (DRM0) is required to be functional at the time of the installation. DRM0 allows a remote operator to disconnect the inverter form the grid. Disconnection from the grid may occur when the network is disrupted, when frequency and voltage levels are outside the set limits and when the DRM0 mode is activated (potentially by a network business).

Source: ESC

[63] Standards Australia 2015, *Grid connection of energy systems via inverters - Inverter requirements*, AS/NZS 4777.2:2015, October.

Beyond using solar PV-based systems, network businesses may also procure voltage control services from other types of distributed generation, known as synchronous generators. Synchronous generators, such as cogeneration plants, can be operated to provide or consume reactive power, which can assist network businesses by raising or lowering voltage levels in the network. [64]

In evaluating the extent to which distributed generation in Victoria provides this benefit, we note that voltage regulation can only be provided by very specific forms of distributed generation. Those systems must also be able to respond to the requirements of network businesses at certain times and locations. In box 4.4, we set out further information about voltage regulation requirements in Victoria, and the voltage control projects we have identified.

On the basis of the information presented, we formed the view that there was not sufficient evidence to support the claim that small-scale distributed generation is providing voltage regulation and power quality benefits in Victoria. However, we acknowledge that this may change as 'smart' inverters become more widespread and to the extent that distributed generation customers program those inverters to provide voltage regulation services. Indeed, the value of voltage regulation in distribution systems will increase as solar PV penetration rises, so there will be an increasing incentive for distributed generation to provide voltage control if only to secure its delivery to the grid.[65]

[64] The transfer of electricity in the network occurs through the production of magnetic fields – these fields are produced by reactive power. Reactive power is power where the current is completely out of phase with the voltage, which delivers no net energy to the customer. Reactive power effects voltage levels in a system, which can be useful for managing voltage regulation.

[65] Conversely, increasing penetration rates of distributed generation may also lead to higher grid management costs associated with bidirectional flows of electricity. Ernst & Young 2015, *Evaluation Methodology of the Value of Small Scale Embedded Generation and Storage to Networks*, Clean Energy Council, July.

BOX 4.4 CASE-STUDY FINDINGS – BENEFITS OF MANAGING VOLTAGE REGULATION AND POWER QUALITY

A very small number of zone substations in Victoria have voltage regulation issues at any time, demonstrated by the few voltage control projects identified as follows:

- 8 MVAr capacitor banks at four zone substations in the Jemena network area, costing approximately $2.2 million.
- Voltage regulators on two feeders in the Jemena network area, typically costing around $250,000.
- Two 6 MVA capacitor banks at two zone substations in the AusNet Services network area.

A typical 1 MW cogeneration plant with a 0.8 power factor could only provide 0.75 MVAr – this only provides a portion of the needs of the voltage control projects listed earlier. Jacobs estimated that the annualised cost of deferring or avoiding capital infrastructure for such voltage control projects would amount to less than $500,000 per year across the network in Victoria.

Appropriate technologies of distributed generation plants existing in Victoria, would only defer a small portion of this amount. These distributed generation plants will also be required in very specific locations and must be able to respond at certain times.

Source: Jacobs

4.3.3 ANCILLARY SERVICES

Ancillary services are services to maintain power safety, security and reliability of the grid.

The Australian Energy Market Operator (AEMO) procures such ancillary services to support the operation of the grid through a number of markets. These include markets for Frequency Control Ancillary Services (FCAS), Network Support Control Ancillary Services (NSCAS), and System Restart Ancillary Services (SRAS) markets.

Service providers can receive payments from AEMO for the availability and delivery of such ancillary services. However, these service providers must be capable of reliably dispatching these ancillary services, and capable of offering and bidding in specific markets – they must also register with AEMO in order to bid into any of these ancillary services markets. Payments to service providers can vary and change significantly, depending on the needs of the network.

Some stakeholders, such as the Clean Energy Council, suggested that we consider how distributed generation may be able to provide ancillary services:

> *Consideration should be given to the capability of small scale distributed generation and storage to provide high speed ancillary services like frequency management.*[66]

In this section, we discuss whether distributed generation provides, or can provide, benefits in form of ancillary services to AEMO.

FREQUENCY CONTROL ANCILLARY SERVICES (FCAS)

The National Electricity Market must be operated within a set frequency range of around 50 Hertz (Hz) in order to safely and reliably deliver power from larger generators to consumers.[67] However, frequency levels in the network can change quickly, depending on the balance of supply and demand – if electricity supply exceeds demand at any given time, frequency in the system increases (and vice versa).

AEMO manages frequency levels in the system by procuring specific services. For example, service providers could be procured to generate electricity or shed (reduce) loads very quickly (within 6 or 60 seconds) or after a delay (5 minutes). These services operate continuously as required and smooth the transition from one dispatch state to the next, according to the forecast demand and bids from generators.

AEMO operates eight separate ancillary services markets to procure these frequency control responses (referred to as FCAS) from service providers. In these markets, only specific types of service providers can deliver these services, such as those with fast-

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[66] Clean Energy Council 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 6.

[67] Australian Energy Market Operator 2016, *Fact Sheet: Frequency Control*, August.

responding dispatchable electricity generators, load-shedding[68] devices, or generator governors.[69] AEMO procures these services in increments of at least 1 MW.

SYSTEM RESTART ANCILLARY SERVICES (SRAS)

AEMO requires system restart ancillary services to enable parts of the network to be restarted following a partial or complete blackout.

In order to provide SRAS, service providers must be able to supply and energise a part of the network within one and half hours of a major disruption. Service providers must also provide capacity to meet 40 per cent of peak demand in that part of the network – often requiring large generators, such as power stations.

NETWORK SUPPORT AND CONTROL ANCILLARY SERVICES (NSCAS)

There are a range of other ancillary services that support the operation of the network (referred to as Network Support and Control Ancillary Services). AEMO procures specific services in three types of markets related to NSCAS:

- Network Loading Ancillary Service (NLAS), which are used by AEMO to control the flow of electricity between regions of the National Electricity Market (particularly across interconnectors) over short periods of time.[70] These services can be provided by either increasing generation levels or shedding load in targeted areas. NLAS markets generally require larger dispatchable generators, as compared to small-scale distributed generators.
- Transient and Oscillatory Stability Ancillary Service (TOSAS), which are used in the event of spikes in power flows, potentially due to short circuits and malfunctioning equipment. The services procured in this market require technologies that can quickly regulate network voltage or change power output, such as synchronous

[68] These are devices that may be attached to a customer's load or equipment to quickly disconnect that load from the network. These types of devices tend to be installed in industrial plant and machinery.

[69] A generator governor is a specific device on generation engines that limit the speed or amount of fuel required by the engine.

[70] NLAS is procured by AEMO at a national level, and is different to the local network support services procured by distribution businesses as discussed in section 4.3.1.

condensers, generators with power system stabilisers, and static VAR compensators[71].

- Voltage Control Ancillary Service (VCAS), which procure services to maintain voltage levels across the network within specific ranges. In these VCAS markets, services are provided by specific technologies like synchronous condensers and static reactive plant, which can provide and absorb reactive power, which impacts voltage levels.[72]

These services tend to be highly locational specific (depending on the need) and are often required outside of Victoria. For example, in 2014-15, AEMO only procured approximately $10 million in VCAS. At Murray Switching Station, Yass Substation, and transmission lines south of Sydney, 800 MVAr of reactive power absorption capability was procured from shunt reactors[73]. At Tumut and Murray Power Stations, reactive power generation and absorption were provided by 28 synchronous generators which operates in a special mode, specifically, at no load as synchronous condensers.

CONCLUSION

To provide any of the ancillary services described in this section requires a generator to have specific, often highly responsive, capabilities. These services are also typically required at a larger scale than could be provided by individual solar distributed generators. Whilst we acknowledge the possibility for technology to improve the capability of small-scale distributed generators to provide these types of services, advice provided to us by Jacobs Consulting indicates that Victoria's existing fleet of distributed generators is unlikely to be capable of participating in the ancillary services markets. As a result, we have not included ancillary services in our valuation of the network benefits of distributed generation.

There is no reason apart from cost why distributed generation based on solar PV with or without batteries could not provide voltage and frequency control services for

[71] Static VAR compensators are a specific combination of electrical devices that provide reactive power quickly, and are usually used on transmission level network assets.

[72] VCAS is procured specifically by AEMO at a national level. A further discussion on voltage regulation and procurement of these services by Victorian network businesses is discussed in section 4.3.2.

[73] Shunt reactors are specific devices used on high-voltage transmission lines, to absorb reactive power.

specific conditions if the inverters were suitably configured and controlled externally if needed.

4.3.4 ISLANDING CAPABILITY

'Islanding' refers the capability of premises, or section of the network, to remain powered when the rest of the network experiences a blackout. Distributed generation systems are typically deployed with 'anti-islanding' equipment to ensure that they de-energise during a blackout. This is primarily for safety reasons, so that crews sent to restore power can work without encountering live wires.

As a result, the majority of solar PV systems currently installed in Victoria can only generate electricity for a customer when there is a live connection with the grid. If there is a power outage during the day, these types of solar PV systems will be unable to generate electricity for that customer.[74]

However, some distributed generation systems can be fitted with equipment that allows the system to generate electricity for that particular customer, in the event of a blackout – equipment that allows 'islanding'. This can also occur at scale. A group of distributed generators and customers can also be 'islanded', which is typically referred to as a local micro-grid.

Facilities with islanding capability provide benefit to these customers, as they have access to power during grid outages. Stakeholders, such as the Clean Energy Council, stated that there may also be network reliability benefits as a result of islanding:

> *In an independent micro-grid or a system with islanding capability…, the electricity generated provides reliability and safety. There are both private and public benefits in reliability and safety.*[75]

[74] Most solar PV systems currently installed in Victoria are installed with inverters that require a live connection to the grid in order to generate electricity. These inverters have anti-islanding capabilities for safety reasons, preventing solar PV systems from exporting electricity to surrounding unpowered lines, which can be dangerous for workers who may need to maintain or work on these lines.

[75] Clean Energy Council 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Discussion Paper, Stage 2 – Network Value*, July, p. 3.

In our assessment, the possibility of islanding is analogous to the use of back-up generation with islanding capability by large commercial or industrial customers. The quantity of back-up generation currently installed in Victoria system is not accurately known, but it is estimated that around 100 MW of back-up generators are located in state hospitals.[76] These types of systems provide benefits to those who invest in them, but as they are private benefits they are outside the scope of this inquiry.

To the extent that the potential islanding benefits of distributed generation may lead to further environmental and social benefits, we examine this within the context of reducing bushfire risk in section 4.4.1, and customer empowerment in section 4.4.3.

4.3.5 CONCLUSION – ECONOMIC VALUE

The Commission reviewed a range of potential direct benefits for the management and operation of the network that may arise from distributed generation.

We found that distributed generation can create value by reducing network congestion. Our analysis to determine the extent of such network value in Victoria indicates that it varies by location, time of generation and peak demand, and by the ‘firmness’ of the generated electricity. It could also change significantly over time as network businesses invest in network upgrades.

We considered network value associated with reducing network congestion as being sufficiently material to justify investigation of whether the current regulatory framework adequately compensates distributed generation proponents (chapter 5), and whether regulatory reform is needed (chapter 6).

Distributed generation can also provide other benefits to the network, under specific circumstances. The quantity of these identified benefits is estimated to be immaterial for the purposes of this inquiry.

[76] There are currently no reporting requirements associated with back-up generation systems in Victoria.

4.4 ENVIRONMENTAL AND SOCIAL VALUE

In section 3.7, we set out our three-part test to assess whether distributed generation may provide environmental and social benefit and value in Victoria.

Where distributed generation leads to changes in the way the network is managed, this may cause flow-on, or indirect**,** social and environmental benefits. A number of submissions highlighted specific social and environmental benefits from distributed generation that they believe warranted further investigation. These specific benefits are:

- bushfire risk mitigation and reduction
- amenity and aesthetic benefits, and
- customer empowerment.

In this section, we present our assessment of these benefits.

4.4.1 BUSHFIRE RISK MITIGATION

Stakeholders suggested that distributed generation may facilitate a reduction in the risk of bushfire ignition, by limiting or avoiding the use of electricity assets on high fire risk days and at high fire risk locations. The reduction in bushfire risk potentially leads to safety benefits and reduced insurance premiums for network businesses.

In 2009, the Victorian Bushfires Royal Commission found that faults in live powerlines could ignite bushfires in high fire risk areas.[77]

Stakeholders such as the Clean Energy Council stated that distributed generation could avoid the need for powerlines and reduce bushfire risk:

> *Electricity grids are a bushfire safety risk. There are significant safety benefits when distributed generation avoids or reduces the need for additional overhead poles and wires.* [78]

[77] The review found that powerline faults could ignite bushfires either by; by an electric arc caused by electrical assets or clashing powerlines coming in contact with combustible material, or the flow of electric current through vegetation, an animal or other material comes into contact with a live electricity network asset. Bushfires can also be ignited through natural causes such as lightning, and human activity (indirectly or arson).

AusNet Services also agreed that distributed generation could assist the reduction in bushfire risk, stating:

> *It can be anticipated that communities could rely on standalone power systems on the critical fire risk days, with the local network de-energised, for example. Alternatively, permanent separation from grid supply may be optimal.*[79]

Stakeholders also referred to the Victorian Bushfires Royal Commission as a source of information regarding the role of distributed generation in bushfire mitigation. In 2011, the Powerline Bushfire Safety Taskforce (the Taskforce) reviewed options to reduce bushfire risk, particularly related to the electricity network in Victoria.[80] As part of its review, the Taskforce considered two mitigation options that incorporate certain technologies of distributed generation, which are:

- powerlines are temporarily turned off during high fire risk times, with distributed generation providing back-up power to customers, and
- customers are provided standalone power supplies, with the powerlines turned off permanently.

The Taskforce concluded that it would be more costly to use distributed generation technologies, compared to other options, in reducing bushfire risk, stating:

> *…there are more cost-effective options to reduce the bushfire risk associated with powerlines than to provide back-up generators to electricity customers in rural areas and to deliberately turn off powerlines temporarily on high fire risk days.*[81]

On the basis of the assessment of the Taskforce, we recognise that distributed generation may, in a theoretical sense, provide a means of reducing bushfire risk, albeit at potentially higher cost than alternative measures.

However, we were not provided with evidence indicating that the current fleet of distributed generators in Victoria has caused powerlines to be decommissioned,

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[78] Clean Energy Council 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Proposed Approach Paper,* February, p. 2.

[79] AusNet Services 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Proposed Approach Paper,* February, p. 10.

[80] Powerline Bushfire Safety Taskforce 2011, *Powerline Bushfire Safety Taskforce: Final Report,* September, pp. 74-78.

[81] Powerline Bushfire Safety Taskforce 2011, *Powerline Bushfire Safety Taskforce: Final Report,* September, pp. 76-77.

thereby leading to lower bushfire risk. Nor were we supplied with evidence the current fleet of distributed generators enables powerlines to be de-energised for the purposes of bushfire risk mitigation. We therefore were not able to conclusively state that Victoria's current fleet of distributed generators are providing this benefit.

Nonetheless, we recognise that distributed generation may be an increasingly viable means of undertaking bushfire mitigation, particularly as technology improves and costs reduce. The installation of bi-modal inverters, for instance, may more easily allow distributed generators to operate in circumstances where the grid itself has been de-energised. Particularly when installed with energy storage, this could allow distributed generation to be deployed in a remote area, thereby enabling the linking network to be de-energised during high fire risk days. This could provide a societal benefit if it was more efficient than other bushfire mitigation options, such as undergrounding wires.

The Commission did not identify any regulatory impediment to this value being realised. We therefore did not view the possibility of this benefit as warranting a regulatory intervention. Nor did we assess the merits of greater investment in distributed generation relative to other forms of bushfire risk mitigation available to network businesses.

4.4.2 AMENITY AND AESTHETICS BENEFIT

Some stakeholders, including the Clean Energy Council, suggested that distributed generation could provide amenity and aesthetic benefit by reducing the need to build poles and wires.

For existing poles and wires, these benefits would only be realised if such network infrastructure were removed completely, which could potentially occur if there were sufficient distributed generation installations to enable a local area to disconnect from the grid. The Commission has not been provided any evidence to suggest that rural or urban powerlines have been specifically decommissioned as a result of distributed generation.

New developments require new electricity connections, which could be supported by new electrical infrastructure such as poles and wires. Where a new development opts to be sourced by electricity from distributed generation sources, removing the need for poles and wires, the benefits of increased amenity and aesthetics accrue largely to the investor without the need for government intervention. As such, it is outside the scope of this inquiry.

4.4.3 CUSTOMER EMPOWERMENT

The Institute of Sustainable Futures considers that the 'islanding' capability of certain distributed generation technologies increases customer empowerment.[82] Environmental Justice Australia stated:

> *Victorians see benefit in using distributed energy to reduce their reliance on the grid, or go off-grid all together…*[83]

Distributed generation may be causally linked to increased empowerment for the investor. However, this benefit accrues directly to the owner/investor in distributed generation. That is, it is a private benefit and accrues to the investor without regulatory intervention and is outside the scope of this inquiry.

4.4.4 CONCLUSION – ENVIRONMENTAL AND SOCIAL BENEFITS

Distributed generation may provide a benefit if it provides a lower cost alternative to network projects that could be undertaken for the purposes of bushfire mitigation. This could occur in circumstances where deploying distributed generation in a remote area, and thereby enabling the linking network to be de-energised during high fire risk days, was a more efficient alternative to other bushfire mitigation steps, such as undergrounding wires. The Commission did not identify any regulatory impediment to this value being realised. We therefore did not assess the merits of greater investment in distributed generation relative to other forms of bushfire risk mitigation available to network businesses.

[82] Institute for Sustainable Futures 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Proposed Approach Paper,* February, p. 2.

[83] Environmental Justice Australia 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Proposed Approach Paper,* February, p. 7

The Commission did not identify any data that demonstrated the network effects of the distributed generation installed Victoria is giving rise to additional social or environmental benefits.

4.5 CONCLUSION

This chapter examined whether distributed generation provides benefits to the network, considering a range of potential economic, environmental and social benefits. A summary of our findings is described in table 4.1.

We found that distributed generation can reduce network congestion, and these benefits are highly variable but can be quantified and valued in Victoria.

We also considered a range of indirect environmental and social benefits of distributed generation. We recognise that distributed generation may be an increasingly viable means of undertaking bushfire mitigation, particularly as technology improves and costs reduce. The Commission did not identify any regulatory impediment to this value being realised. We therefore did not view the possibility of this benefit as warranting a regulatory intervention.

4.5.1 FINDINGS

Finding 1: Network value of distributed generation

Distributed generation can and does provide network value. The value is primarily derived from reductions in network congestion, which can lead to the deferral of network augmentation expenditure and reduce the quantity of expected unserved energy. Distributed generation can also provide other network benefits but these are not currently material with respect to calculating network value for the purposes of this inquiry.

Finding 2: Network value is highly variable

The size of the network value of distributed generation is affected by:

- **Location** - The value varies based on the distributed generator's location, specifically in terms of its proximity to areas of the network that are congested, or nearing congestion.
- **Time** - The value also varies according to the extent to which the electricity generation coincides with the periods of peak demand within the section of the network to which the generator is connected.
- **Asset life-cycle** - The value varies based on when in the network operator's cycle of upgrade projects the value is being measured. If the measurement is conducted annually, this means the value varies year-on-year, subject to the timing of network upgrade projects, as well as the supply and demand for energy in the area of the network to which it is connected.
- **Capacity** - The generation capacity of the distributed generation.
- **Optimisation** - 'Optimisation' refers to the extent to which the generation is optimised for delivery of grid services, which is largely a function of being both predictable and responsive to the needs of the network. A system that is highly optimised for network benefits is one that reliably produces output at the time it is most needed by the network.

Finding 3: 'Firm' distributed generation has significantly more network value than 'intermittent' generation

Distributed generation can provide significantly more network value when it is 'firm'. The greatest value is created when distributed generation can provide firm output in capacity increments that match the extent of the network congestion.

Finding 4: Technology can transform intermittent generation into firm generation

When intermittent distributed generation systems are supplemented with additional technologies – such as energy storage (batteries) and energy management technologies – they may be capable of operating as firm generators, which would increase their potential value. Technology also exists to coordinate, or ‘orchestrate’, multiple small-scale distributed generators in order to produce larger increments of firm generation and thereby maximise their network value.

Finding 5: Social and environmental benefits of network effects

Distributed generation may provide a benefit if it provides a lower cost alternative to network projects undertaken for the purposes of bushfire mitigation. This could occur in circumstances where deploying distributed generation in a remote area, and thereby enabling the linking network to be de-energised during high fire risk days, was a more efficient alternative to other bushfire mitigation steps, such as undergrounding wires. The Commission did not identify any regulatory impediment to this value being realised.

TABLE 4.1 SUMMARY OF NETWORK BENEFITS

Benefit category	Potential network benefit	Assessment summary	
Network Capacity	Reduced expenditure on network infrastructure	Quantifiable network value	Distributed generation can defer the need for network businesses to invest in new or upgraded infrastructure. This benefit is captured as part of the calculation of value in *reducing network congestion*. This network value varies by location, time of generation, asset lifecycle, generation capacity, and the extent to which the generation is optimised for network benefits.
Electricity Supply Risk	Reduced expected unserved energy	Quantifiable network value	Distributed generation can reduce the expected unserved energy in parts of the network, in the case where a critical piece of network equipment fails. This benefit is captured as part of the calculation of value in *reducing network congestion*. This network value varies by location, time of generation, asset lifecycle, generation capacity, and the extent to which the generation is optimised for network benefits.
	Islanding capability	Excluded	Distributed generation with islanding capabilities does provide benefits, in the event of a network outage. These benefits are private to the investor.

Benefit category	Potential network benefit	Assessment summary	
Grid Support Services	Network support	Non-material benefit with respect to calculating network value in this inquiry	Distributed generation can provide alternatives to current network support services, but this is highly localised to a very small number of ZSS areas.
	Managing voltage regulation and power quality	Non-material benefit with respect to calculating network value within this inquiry	Given there are very few voltage control projects required in Victoria, distributed generation is unlikely to provide significant network benefits. Also, the current distributed generation fleet is not designed to contribute any significant voltage control capacity.
		Future DG could provide benefit	Future distributed generation systems with 'smart' inverters could contribute to distribution system voltage control, which will increase in value as solar PV penetration rises.
	Ancillary services	Excluded	AEMO contracts specific resources to address network needs (ancillary services) that cannot be addressed by the current fleet of distributed generation.
Environmental and Social	Bushfire risk mitigation	Cannot be attributed to existing DG	We were not presented with evidence that the current fleet has caused a bushfire mitigation benefit, for instance through the decommissioning of powerlines.
		Future DG could provide benefit	Future distributed generation systems may be capable of contributing to bushfire risk mitigation, if lower in cost than alternative measures.
	Amenity and aesthetic benefit	Excluded	Distributed generation could provide increased amenity and aesthetics in new developments, which could avoid the need for above ground poles and wires. These benefits are private to the investors.
	Customer empowerment	Excluded	Distributed generation could give greater empowerment to investors, where the user has the ability to go off-grid. These benefits are private to the investor.

Source: ESC, Jacobs

5 REGULATORY FRAMEWORK

5.1 INTRODUCTION

This chapter sets out our analysis of the existing regulatory framework, as it relates to the network value of distributed generation of less than 5 megawatts (MW) in capacity.

It outlines the various regulations and mechanisms that exist at both the National and Victorian level that govern the interaction of distributed generation with distribution and transmission networks.

OVERVIEW

The primary purchasers of grid services are large, monopoly network businesses, which have access to more information than individual small-scale distributed generation proponents, who may often be residential households. In these circumstances, network businesses are likely to have considerable bargaining power. Conversely, procuring grid services from multiple small-scale providers may be challenging for network businesses, particularly from the perspective of risk allocation and transaction costs.

Some of these factors are acknowledged by the national regulatory framework that applies to monopoly network businesses and which contains:

- incentives for network businesses to appropriately apportion their expenditure between traditional network upgrade projects, such as upgrading the 'poles and wires', and non-network solutions, such as using grid services to defer upgrades of the existing network infrastructure
- requirements that network businesses provide a level of information about opportunities for the provision of grid services and

- processes network businesses must follow when deciding how to respond to network constraints, including undergoing a tender process before undertaking major upgrades of the network.

The regulator and the rule maker[84] for the national framework have identified ways in which the framework could be changed to improve how the market for grid services functions. Processes are underway at the national level to:

a. Develop and implement improved ‘demand-side’ incentive and allowance schemes, to take effect from 2021.[85] The new schemes are intended to better assist network businesses in identifying and selecting non-network solutions, including using distributed generation to defer network upgrades, where they are an efficient alternative to traditional network expenditure.
b. Potentially expand the information available to suppliers of grid services, including distributed generators, about the dollar value of reducing peak demand in specific locations around the network. If implemented, this information would be available on an annual basis from 2018 onwards.[86]
c. Potentially consider expanding the opportunities for suppliers of grid services to offer their services, as an alternative to traditional network expenditure, by requiring network businesses to conduct public tender processes when replacing some types of network asset.[87]

The framework is not orientated towards ensuring small-scale providers of grid services are able to efficiently participate in the market for grid services. As such, it does not contain any mechanisms designed to ensure network businesses calculate the network value of small-scale distributed generators on an individual basis, nor to ensure they make payments on the basis of that value.

[84] The Australian Energy Regulator (AER) and the Australian Energy Market Commission (AEMC).

[85] Demand Management Incentive Scheme (DMIS) and Demand Management Incentive Allowance (DMIA).

[86] The AEMC’s preferred rule within the draft determination in the Local Generation Network Credit (LGNC) rule change proceeding, which is described as a ‘system limitations report’.

[87] Australian Energy Market Commission 2016, *Replacement expenditure planning arrangements – Consultation Paper*, October.

5.1.2 STRUCTURE OF THIS CHAPTER

This chapter is divided into six sections:

5.1 Introduction

5.2 An examination of the Victorian State regulatory framework relating to the remuneration of distributed generation

- feed-in tariffs
- Electricity Industry Guidelines 14 and 15 and
- the Electricity Distribution Code.

5.3 An examination of the elements of the National regulatory framework that have a bearing on the remuneration of distributed generation

- NER Chapter 2: Small generation aggregation framework (SGAF)
- NER Chapter 5: Demand-side engagement strategy, distribution annual planning report (DAPR), Regulatory Test for Distribution (RIT-D)
- NER Chapter 5A: Connection regime and
- NER Chapter 6: Network price reform, capital expenditure sharing scheme (CESS) and efficiency benefit sharing scheme (EBSS), service target performance incentive scheme (STPIS), avoided transmission use of system costs (TUOS), network support payments.

5.4 Planned and potential changes to the National regulatory framework

- Demand Management Incentive Scheme (DMIS) and Demand Management Incentive Allowance (DMIA)
- local generation network credit (LGNC) rule change (and 'system limitations report')
- replacement expenditure (REPEX) planning arrangements rule change and
- demand response mechanism and ancillary services unbundling rule change.

5.5 The Commission's findings with regard to the regulatory framework

5.2 VICTORIAN FRAMEWORK

The relevant elements of the Victorian regulatory framework are:

- feed-in tariffs (FiT)
- Electricity Industry Guidelines 14 and 15 and
- the Electricity Distribution Code.

5.2.1 FEED-IN TARIFFS

Since 2004, there have been four separate feed-in tariffs (FiTs in Victoria and their policy objectives have evolved over time. Only one of these schemes, the minimum FiT, is open to new entrants.[88] The design of this FiT as it relates to the energy value of distributed generation was addressed through an earlier set of papers within this inquiry.[89] None of the Victorian FiTs reflect the network value of distributed generation in payments.

The minimum FiT was established as an outcome of the *Power from the People* review, completed by the then Victorian Competition and Efficiency Commission (VCEC) in 2012. In its final report, VCEC observed that:

> *…recovering the network value and paying it to the proponents of distributed generation is important to ensure there are incentives for the efficient incorporation of distributed generation into Victoria's electricity system.*[90]

However, VCEC also noted both the practical difficulties of identifying such a localised value, and the regulatory design challenges of reflecting such a granular value in a broad-based feed-in tariff. Consequently, when establishing the principles upon which the FiT would be set, VCEC recommended that the FiT be based exclusively on the wholesale value of the electricity produced by distributed generators.[91] As a result, the FiT does not include any provision for remunerating distributed generators on the basis of network value.

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[88] For a discussion of the other FiT schemes, see Essential Services Commission 2016, *The Energy Value of Distributed Generation - Distributed Generation Inquiry Stage 1 Final Report*, August, p. 15.

[89] Essential Services Commission 2016, *The Energy Value of Distributed Generation – Distributed Generation Inquiry Stage 1 Final Report*, August; Essential Services Commission 2016, *The Energy Value of Distributed Generation – Distributed Generation Inquiry Stage 1 Draft Report*, April; Essential Services Commission 2015, *The Energy Value of Distributed Generation – Distributed Generation Inquiry – Our Proposed Approach,* December.

[90] Victorian Competition and Efficiency Commission 2012, *Power from the People: Inquiry into Distributed Generation,* July, p. 85.

[91] VCEC recommended that the wholesale value be calculated in such a way that reflected the impact of line losses – that is, the electricity that is lost when it is transported through the system.

5.2.2 ELECTRICITY INDUSTRY GUIDELINES 14 AND 15

Until recently, the connection process for distributed generators in Victoria was governed primarily by two Victorian instruments: Electricity Industry Guidelines 14 and 15.[92] These Guidelines were developed by the Commission in 2004, and contained provisions relating to connecting and, in the case of Guideline 15, remunerating distributed generation for network value.

Guideline 15 contained three provisions that explicitly addressed the question of monetary transactions between network businesses and distributed generators for network value. These included provisions:

- Requiring that distributors must pass through a share of avoided distribution system costs to embedded generators. The guideline outlines how this should be calculated.
- Requiring that distributors must pass through the value of any Transmission Use of System (TUOS) charges they avoid due to the use of distributed generation. The guideline requires that the amount of avoided TUOS be calculated according to clause 5.5 of the National Electricity Rules (NER).
- Allowing distributors to be compensated by a distributed generator for failing to provide network support services as and when required.

However, the application of these Guidelines changed in July 2016 following the implementation of Chapter 5A of the NER in Victoria, which governs the connection of distributed generation[93] less than 5 MW in capacity.

The introduction of Chapter 5A meant that a number of the requirements of the Victorian regulatory framework contained within these Guidelines are now duplicated by the national regime. The Guidelines are scheduled for formal review following the conclusion of this inquiry.

[92] Essential Services Commission 2004, *Electricity Industry Guideline No.14 provision of services by electricity distributors*, Issue 1, April.

[93] Referred to in Chapter 5A as embedded generation.

An overview of Chapter 5A and its relevance to distributed generation is provided in section 5.3.3.

5.2.3 THE VICTORIAN ELECTRICITY DISTRIBUTION CODE

The *Victorian Electricity Distribution Code*[94] (the Code), with which all Victorian licensed distribution businesses are required to comply, places conditions on how the Victorian distribution business should engage with a distributed generator that requests a connection. The key facets of the Code as they relate to distributed generation include:

- distributors are required to ensure they are able to receive supply from a connected embedded generator in accordance with a connection agreement and
- distributors and embedded generators are required to negotiate in good faith to reach a connection agreement.

The Code also outlines the technical and safety standards that embedded generators connecting to the distribution system in Victoria must satisfy. The Code does not address the question of remuneration of distributed generation for network value.

5.3 NATIONAL FRAMEWORK

In addition to the mechanisms that apply exclusively within Victoria, distributed generators in this state are also affected by a separate, national regulatory framework known as the NER.

As regulated monopolies, the revenue that network businesses earn through building and operating the grid is determined by the Australian Energy Regulator (AER) through an approval process that occurs every five years.

This approval process occurs under Chapter 6 of the NER, which requires all network businesses operating in the National Electricity Market to submit proposals to the AER

[94] Essential Services Commission 2015*, Electricity Distribution Code*, Version 9, December.

outlining the revenue and expenditure they believe is necessary to operate their networks during the upcoming five year regulatory period. The AER assesses these proposals against a range of criteria outlined in Chapter 6 and makes a decision (determination) as to how much revenue the distribution business can collect during the regulatory period.

This approval process also determines how much network businesses will charge customers for using the network, as well as how they will apportion their approved capital between the different forms of expenditure required to manage the network. This can include upgrading the network's capacity ('augmenting' the network), replacing existing network equipment that is deteriorating, or it can include operating expenses such as paying the wages of staff and contractors. The framework that governs this process exists within the NER.

A central objective of the NER is ensuring that network businesses manage the grid in the most efficient way possible. To serve this objective, the NER contains an array of incentives, programs and regulatory process requirements aimed at ensuring that network businesses preparing to spend money on the grid always find and choose the most efficient option. The 'most efficient option' means the lowest cost means of achieving the levels of service, safety and reliability that network businesses are required to meet.

Sometimes, the most efficient option is to spend money on building new network infrastructure, such as adding a new transformer to a substation. In other circumstances, the most efficient option is not to change the network, but to change the way the network is used. Instead of expanding the capacity of the physical network to cope with greater demand for energy, this option entails reducing or 'reshaping' the demand. This option is referred to as 'demand-side management' or 'demand-side response', and can include things like paying energy users to reduce their demand during peak periods. It can also include offsetting demand using distributed generation.

In combination, the rules and mechanisms within the NER are designed to ensure that the right (efficient) amount of capital is allocated to demand response options. They also aim to furnish potential suppliers of grid services, including distributed generation, with a level of information about opportunities available for grid services. As well, they stipulate various processes network businesses must follow when deciding how to respond to network constraints, including a requirement to undergo a tender process before undertaking major upgrades of the network.

This section outlines the relevant sections of the NER that have a bearing on the remuneration of distributed generation for network value.

5.3.1 CHAPTER 2 OF THE NATIONAL ELECTRICITY RULES

SMALL GENERATION AGGREGATION FRAMEWORK (SGAF)

This framework establishes a Small Generation Aggregator as a new category participant within the National Electricity Market. This reduces the barriers for a third party aggregator in offering grid services to network businesses, which are associated with operating or investing in the grid. A 'third party aggregator' is an entity that aggregates the supply from a number of distributed generators and transacts through the wholesale market on their behalf. This mechanism provides a framework for small-scale generators to participate in aggregation schemes and potentially obtain financial benefit.

5.3.2 CHAPTER 5 OF THE NATIONAL ELECTRICITY RULES

DEMAND-SIDE ENGAGEMENT STRATEGY

Under Chapter 5 of the NER distribution businesses must develop and publish a demand-side engagement strategy that details the processes and procedures for a distribution businesses to assess non-network options as alternatives to network expenditure and for interacting with non-network providers. This provides greater transparency about how distribution businesses assess and consider non-network options (including distributed generation), and is intended to make it easier to engage with distribution businesses at an appropriate stage in the planning process.

DISTRIBUTION ANNUAL PLANNING REPORT (DAPR)

This places obligations on distribution businesses to annually plan and report on assets and activities that are expected to have a material impact on their network. This provides transparency on the planning activities and decision-making of distribution businesses and better enables non-network providers to put forward options (including distributed generation) as credible alternatives to network investment.

REGULATORY INVESTMENT TEST FOR DISTRIBUTION (RIT-D)

The RIT-D is a framework that requires electricity distribution businesses to consider a range of options where an investment in network augmentation is required above $5 million. Its purpose is to '…identify the credible option that maximises the present value of the net economic benefit to all those who produce, consume and transport electricity in the NEM'.[95] The framework requires distribution businesses to consider both credible network and non-network options, which might include demand-side management or specific distributed generation projects.

The RIT-D process is triggered when a distribution business identifies the need to augment its network, and the capital cost of the most expensive credible option to address the need is over $5m. Once the RIT-D is triggered the distribution business must follow a detailed process, laid down in guidelines produced by the AER, to determine how to proceed with the investment.[96] As part of this process the distribution business has to prepare a non-network options report. This report must include:

- a description of the identified need
- the relevant deferrable augmentation charge associated with the identified need and
- the technical characteristics of the identified need that a non-network option would be required to deliver:
  - the size of the load reduction or additional capacity
  - location and
  - the operation profile.
- a summary of the potential credible options to address the identified need, including both network and non-network options.

[95] NER, clause 5.17.1b, version 85.

[96] Australian Energy Regulator 2013, *Regulatory investment test for distribution (RIT-D) and application guidelines*, August.

Once published, stakeholders must have no less than three months to respond to the non-network report and submit alternative options.

Having assessed all the options identified and presented, the distribution business must publish a Draft Project Assessment Report that outlines and justifies the preferred option.

5.3.3 CHAPTER 5A OF THE NATIONAL ELECTRICITY RULES

Chapter 5A governs the connection of distributed generation systems[97] less than 5 MW (which is the threshold below which a generator is exempt from registering as a participant with the Australian Energy Market Operator (AEMO)). It provides for three different connection options:

- basic connection service – provided to a typical retail customer and to a micro-embedded generator[98] via a model standing offer
- standard connection service – for connections larger than for a micro-embedded generator, but for which there is a model standing offer and
- negotiated connection service – for connections not covered by either the basic or standard connection service.

Chapter 5A outlines the process and timelines that should be followed under each connection type.

Chapter 5A also provides the framework for determining the charges that network businesses can recover from a connecting customer. They allow, in certain circumstances, for a distribution business to recover extension and augmentation costs required to connect a distributed generator[99] to the network.

The connection costs that will be recovered from micro-embedded generators will be detailed in the relevant distribution business's model standing offer that will reflect the

[97] Referred to in Chapter 5A as embedded generation.

[98] A micro-embedded generator is defined as that which is connected via AS4777 inverter standards.

[99] Or a new customer who does not have generation, but which because of the additional demand (load), requires the DNSP to invest in network augmentation to service the customer.

connection policy of that distribution business. The connection policy of a distribution business, which is approved by the AER, must comply with the AER's connection charge guidelines and with the connection charge principles outlined in Chapter 5A. These outline that micro-embedded generators:

- can be required to make a contribution to the capital cost of an extension, which could arise when the distribution network is extended beyond the current boundary of the network and
- can be required to make a contribution to the capital cost of augmentation, but only if the service in question is not a basic connection service and a relevant distribution business threshold has been exceeded.

Distributed generators that are not classified as micro-embedded generators (but below the 5 MW AEMO registration threshold), can be charged for both the extension and augmentation costs related to their connection.

5.3.4 CHAPTER 6 OF THE NATIONAL ELECTRICITY RULES

Under Chapter 6 of the NER, all distribution businesses operating in the National Electricity Market must submit proposals to the AER outlining the revenue and expenditure they believe is necessary to operate their networks during the upcoming five-year regulatory period. The AER assesses these proposals against a range of criteria outlined in Chapter 6 and makes a decision (determination) as to how much revenue the distribution business can collect during the regulatory period. Chapter 6 also contains a range of mechanisms to encourage distribution businesses to consider non-network (demand-side) options in their revenue proposals. These are outlined below.

DISTRIBUTION NETWORK PRICING

Distribution businesses recover costs for their own distribution services through a charge for the use of the distribution system. These charges are known as Distribution Use of System (DUOS) charges. These charges are passed through to consumers by retail businesses. If a customer installs distributed generation this may lead to a reduction of these charges for that customer, but these contribute to the private benefit of distributed generation. They are not considered part of the external benefit of distributed generation.[100]

Under recent changes to Chapter 6, distribution businesses are now required to develop network prices that reflect the efficient cost of providing network services to individual customers. Each network tariff must be based on the long run marginal cost (LRMC) of providing the service.

Cost reflective network tariffs based on LRMC are intended to signal the cost incurred by distribution businesses in investing in their network to meet future demand. As these tariffs reflect the costs of increasing capacity at different locations across the network, they should more accurately reflect the network value caused by distributed generation reducing the need to build additional capacity.[101]

The main impact of this change is that network tariffs for all customers will now include a demand charge. This is calculated based on a customer's highest 30 minute demand during the peak charging window, which has been set for all Victorian distribution businesses at 3pm-9pm on weekdays. The charge applied to this demand is higher in the summer months (December – March) than in the non-summer months, reflecting the times when network demand is higher. The introduction of a demand charge will be matched by a reduction in the fixed component of a customer's bill.

In Victoria the transition to full LRMC network tariffs is being phased-in over the next few years. There are two elements to the transition:

- Demand charges will be introduced over time. In the first year of the new tariffs (2017), a percentage of the demand charge will be applied. This will increase over time. Citipower for example will apply 20% of the full demand charge in 2017, rising to 100% by 2021.

[100] Part of or all of value may be received where the distributed generator uses a portion of the generation energy to meet their own use of electricity. Network charges are thereby reduced according to the reduced purchase of electricity from the external network.

[101] However, the introduction of LRMC based cost reflective tariffs would nonetheless not account for all the value of the network benefits of distributed generation. The LRMC based cost reflective tariffs are intended to reflect the costs associated with meeting future demand (augmentation), and do not reflect the value of reducing expected unserved energy. As a consumption tariff, a cost reflective tariff of the structure would not reward the network benefits of electricity that is exported into the grid.

- Demand charges are being introduced for customers using less than 40 MWh a year, on an opt-in basis. That is, consumers cannot be automatically assigned to the new tariffs; they must actively make the choice to be assigned to the new LRMC based tariffs.

CAPITAL EXPENDITURE SHARING SCHEME (CESS) AND THE EFFICIENCY BENEFIT SHARING SCHEME (EBSS)

These schemes provide incentives for network businesses to further invest and operate networks more efficiently. If a network business identifies a non-network solution, such as distributed generation, as more cost effective than a previously planned (and approved) investment in typical network infrastructure, the schemes allow the network business to keep part of the cost savings. The intention of these mechanisms is to remove the distortions to incentives that would otherwise emerge as a result of the five yearly pricing determination process.

SERVICE TARGET PERFORMANCE INCENTIVE SCHEME (STPIS)

This mechanism provides distribution businesses with a financial incentive to maintain and improve service performance where customers are willing to pay for these improvements. It could encourage a distribution business to recognise any reliability and service quality benefits from distributed generation, and pay for them.

AVOIDED TRANSMISSION USE OF SYSTEM COSTS

Distribution businesses are required to pass through any TUOS costs that have been avoided as a result of distributed generation, i.e. where the energy supplied by distributed generation avoids energy supplied to the distribution network via the transmission network. This mechanism only applies to distributed generation with a capacity above 5 MW, meaning that it would not apply to the scale of distributed generation that is the subject of this inquiry.

NETWORK SUPPORT PAYMENTS

Distributed generation with a capacity above 5 MW can negotiate payments from distribution business and transmission network service providers (TNSPs) for providing specific network support services. These payments may be made by network businesses for services where distributed generation defers a specific shared transmission network asset, or for a service that contributes to reliability and security of a transmission network. This mechanism only applies to distributed generation with a capacity above 5 MW, meaning that it would not apply to the scale of distributed generation that is the subject of this inquiry.

5.4 CURRENT CHANGE PROCESSES

The Australian Energy Market Commission (AEMC) and/or the Australian Energy Regulator (AER) are currently considering a number changes to the national regulatory framework that is relevant to the interaction of distributed generation with electricity networks. In addition the AEMC is conducting a number of reviews into the operation of a number of elements of the National Electricity Market. These rule changes and reviews are outlined below.

5.4.1 DEMAND MANAGEMENT INCENTIVE SCHEME (DMIS) AND INNOVATION ALLOWANCE (DMIA)

The AER is required to develop and publish the incentive scheme and set an innovation allowance to fund innovative projects that have the potential to deliver ongoing reductions in demand or peak demand. The innovation allowance will provide distribution businesses with funding for research and development in projects that have the potential to reduce long-term network costs. Projects may incorporate distributed generation solutions as part of this scheme. The AER is in the process of developing the detail of the DMIS and DMIA. They are scheduled to be applied in the next regulatory period that begins in 2021.

5.4.2 LOCAL GENERATION NETWORK CREDIT (LGNC) RULE CHANGE[102]

The AEMC has recently published its final decision on the LGNC rule change proposal.

[102] Australian Energy Market Commission 2016, *Local Generation Network Credits – Final Rule Determination*, December.

Their final decision confirms the position outlined in their draft decision to not proceed with the LGNC. Instead, and as proposed in their draft decision, the AEMC have made a final rule that places obligations on electricity distribution network businesses to provide better information on opportunities to adopt alternatives to 'poles and wires' investment.

The new rule requires distribution network businesses to publish an annual 'system limitation report' in conjunction with each distribution businesses' annual planning report (DAPR). This system limitation report will include information on:

- the name or identifier and location of network assets where a system limitation or projected system limitation has been identified during the forward planning period
- the estimated timing of the system limitation or projected system limitation
- the proposed solution to remedy the system limitation
- the estimated capital and operating costs of the proposed solution and
- the amount by which peak demand at the location of the system limitation or projected system limitation would need to be reduced in order to defer the proposed solution, and the dollar value to the distribution business of each year of deferral.

The rule will be implemented so that the first system limitation report is prepared and published by 31 December 2017.

5.4.3 REPLACEMENT EXPENDITURE PLANNING ARRANGEMENTS RULE CHANGE PROPOSAL[103]

This is a rule change, proposed by the AER, to improve the reporting and planning requirements in relation to replacement capital expenditure (REPEX). The rule change applies the current requirements in relation to augmentation expenditure (annual planning reports (APR), RIT-D and regulatory investment tests for transmission (RIT-T)) to replacement expenditure. If implemented this would mean that distribution and

[103] Australian Energy Market Commission 2016, *Replacement expenditure planning arrangements – Consultation Paper*, October.

transmission businesses would need to consider non-network options when proposing to replace existing network infrastructure, as well as augmentations.[104]

The AEMC has published a consultation paper on the proposed rule change with a draft decision to be published by 13 April 2017.

5.4.4 DEMAND RESPONSE MECHANISM AND ANCILLARY SERVICES UNBUNDLING RULE CHANGE[105]

The AEMC has made a final decision in relation to the rule change proposed by the Council of Australian Governments (COAG) Energy Council. The final decision confirms the position outlined in the draft decision not to implement the demand response mechanism but to allow for the unbundling of ancillary services from the provision of energy.

The final decision confirms the AEMC view that a specific demand response mechanism for the electricity wholesale market is not needed. The AEMC observed that demand response for wholesale energy market purposes is already happening in the National Electricity Market and that there are no barriers to the continued proliferation of demand response of this kind. (This is distinct to demand response that is delivered for network purposes). They concluded that the costs of implementing the demand response mechanism would outweigh the benefits.

Under the final rule:

- Parties, such as retailers and third-party service providers will be able to register as a market ancillary service provider. A registered provider will be able to offer a customer's load, or an aggregation of loads into FCAS markets.
- A market ancillary service provider does not need to be the customer's retailer. In practice, this may mean that whilst a customer has a retail supply contract with one

[104] G Strbac et. al. 2016, *Delivering future-proof energy infrastructure*, National Infrastructure Commission UK 2016, February.

[105] Australian Energy Market Commission 2016, *Demand Response Mechanism and Ancillary Services Unbundling Rule Change – Final Determination*, December.

retailer, the same customer may also have a separate contract with a market ancillary service provider (who maybe another retailer) to provide ancillary services.

The new rule commences on 1 July 2017.

5.4.5 CONTESTABILITY OF ENERGY SERVICES RULE CHANGES[106]

The AEMC is currently considering a number of rule changes put forward by the COAG Energy Council and the Australian Energy Council. The rule changes are focussed on improving the competition and contestable provision of a range of energy services, provided by behind-the-meter technologies (including distributed generation). The proposed rule changes are seeking to:

- amend the NER to promote the development of competitive markets for new technologies which are capable of providing multiple services/revenue streams in both contestable (wholesale electricity market) and regulated natural monopoly markets (network services to distribution businesses)
- clarify which elements of Distribution Services are contestable and non-contestable by introducing a new Contestable Services classification
- exclude distribution businesses from direct investment in behind-the-meter assets and
- reduce the threshold when a RIT-D is triggered to $50,000, from the current $5m.

The AEMC published a consultation paper in December 2015, with a draft determination or options paper due to be released 1 September 2017.

[106] Australian Energy Market Commission 2016, *Contestability of Energy Services Rule Changes – Consultation Paper*, December.

5.4.6 AEMC ELECTRICITY NETWORK ECONOMIC REGULATORY REVIEW[107]

In August 2016, the COAG Energy Council tasked the AEMC to monitor developments in the electricity market, including the increased uptake of decentralised energy, and to provide advice on whether the economic regulatory framework for electricity transmission and distribution networks is sufficiently robust and flexible to continue to achieve the national electricity objective in light of these developments.

The AEMC is required to publish the findings of its review every year on 1 July. The first annual monitoring report is due to be published on 1 July 2017. The AEMC have published an Approach Paper to inform the development of the monitoring report.

5.4.7 AEMC DISTRIBUTION MARKET MODEL PROJECT

The AEMC is undertaking a Distribution Market Model project to explore how the operation and regulation of electricity distribution networks may need to change in the future to accommodate the increased uptake of distributed generation. This project is exploring whether any new roles, price signals and market platforms are required to optimise the development, deployment and use of distributed energy resources, including distributed generation.

5.5 CONCLUSION

The national framework is fundamentally geared towards ensuring that network businesses pursue the most efficient outcome when planning investments in their network. This extends to ensuring they have the right incentives to consider non-network options, including distributed generation.

It also contains mechanisms that are designed to provide a level of information to potential suppliers about grid service opportunities. Another mechanism is designed to

[107] Australian Energy Market Commission 2016, *Electricity Network Economic Regulatory Review – Approach Paper*, December.

ensure network businesses undergo a tender process before undertaking major upgrades of the network.

The framework is not orientated towards ensuring small-scale providers of grid services are able to efficiently participate in the market for grid services. As such, it does not contain any mechanisms designed to ensure network businesses calculate the network value of small-scale distributed generators on an individual basis, nor to ensure they make payments on the basis of that value.

To the extent that small-scale distributed generation has the potential to provide material value in the market for grid services – which could be realised to the benefit of all customers, through lower network charges, if it led to a more efficient operation of the network – there may therefore be potential to explore regulatory reform options that serve an enabling role for the participation of small-scale grid services providers, including distributed generation, in that market.

Chapter 6 examines the extent to which this potential exists, and explores the question of how it may be realised.

6 ACCESSING THE NETWORK VALUE OF DISTRIBUTED GENERATION

6.1 INTRODUCTION

This chapter sets out our proposed reform direction to enable the participation of small-scale distributed generation in a market for grid services.

OVERVIEW

Distributed generation is one of a number of means through which network value can be delivered. Other demand-side measures, such as demand response, may also give rise to network value. The potential network benefits provided by all these forms of demand-side measures can be collectively described as 'grid services'.

Because of the focus of this inquiry, we have centred our analysis on the value of the grid services provided by distributed generation. But some measures implemented for the purposes of remunerating distributed generation for the provision of grid services could be designed in such a way that did not preclude the remuneration of other means of delivering grid services.

Technology now exists that can effectively transform intermittent distributed generation, such as solar photovoltaic systems (PV), into firm generation and thereby make it considerably more valuable to networks. Such technology includes energy storage (batteries), 'smart' inverters, and energy management systems.

Technology is also emerging that enables the coordination of large numbers of small-scale distributed generators. These technologies enable multiple systems to be bundled, or 'orchestrated', in order to deliver grid services at the times and in the locations that they have the greatest value.

A regulatory framework exists at the national level to incentivise monopoly network businesses to appropriately apportion their expenditure between traditional network upgrade projects and non-network solutions. That framework is not geared towards providing opportunities for small-scale grid service providers, such as distributed generators, to participate in the market for grid services.

Unlike other jurisdictions in the National Electricity Market, Victoria has advanced metering infrastructure (AMI), or 'smart meters'. Smart meters allow grid services to be deployed more easily and at lower cost than is possible under traditional metering.

The penetration of smart metering within Victoria raises the possibility that opportunities exist in Victoria for the further development of an established market for grid services that may not presently exist within the other jurisdictions of the National Electricity Market.

So that small-scale providers of grid services in Victoria, including distributed generation, have adequate opportunities to participate in the market for grid services, we believe it important to identify the attributes of a market in Victoria to emerge.

Because of the characteristics of network value, a broad-based feed-in tariff (FiT) is unlikely to be an appropriate tool to achieve this purpose. The value of the grid services that distributed generation can provide is too variable – between locations, across times, and between years – to be well suited for remuneration via a broad-based FiT. Instead, a market in Victoria could better remunerate grid services provided by distributed generation.

6.1.1 STRUCTURE OF THIS CHAPTER

This chapter is divided into four sections:

6.1 Introduction

6.2 Distributed generation as a 'grid service'

- discussion of what constitutes a high value grid service and
- examination of circumstances in which distributed generation constitutes a high value grid service.

6.3 Examples and relevant developments

- international and Australian research into a market for grid services.

6.4 A market based approach

- the market for grid services in Victoria and
- a network value feed-in tariff?

6.5 Conclusion

6.2 DISTRIBUTED GENERATION AS A 'GRID SERVICE'

Our analysis of the Victorian electricity network demonstrates that distributed generation can and does provide network value. Distributed generation can create this value primarily through reducing network congestion. This may defer network augmentations and reduce the amount of expected unserved energy.

However, distributed generation is one of a number of means by which network congestion can be reduced. Other demand-side measures, such as demand response, may also give rise to network value.

The potential network benefits provided by all these forms of demand-side measures can be collectively described as 'grid services'. 'Grid services' is the term used to describe the full suite of services that electricity networks require in order to run safely, reliably and efficiently. All current and potential network benefits of distributed generation are associated with various types of grid service, from deferring network augmentation projects by reducing congestion through to assisting with ancillary services such as frequency control.

Because of the focus of this inquiry, we have centred our analysis on the value of the grid services provided by distributed generation. But measures implemented for the purposes of remunerating distributed generation for the provision of grid services could be designed in such a way that did not preclude the remuneration of other means of delivering grid services.

6.2.1 HIGH VALUE GRID SERVICES

Our analysis in chapter 4 demonstrated that distributed generation provides significantly more value when it is ‘firm’ and responsive. In most instances, firm generation that was optimised for the purposes of network benefits was several orders of magnitude more valuable than ‘intermittent’ solar PV. In the year we examined (2017), the value of firm distributed generation at some substations was more than twenty times greater than the value of standard solar PV.

Historically, firm grid services were exclusively provided by larger, fossil-fuel based generators such as diesel generators or gas turbines. These systems could be controlled to dispatch generation when required by the network, subject to ‘ramp up’ times. They could also provide dispatch in sufficiently large capacity increments. (If 7 megawatts (MW) of additional capacity is required to defer a network upgrade, providing only 6.5 MW can mean the deferral value does not materialise because the deferral threshold is not reached and the upgrade project proceeds as scheduled.)[108]

By contrast, intermittent distributed generators such as wind and solar PV systems rely upon the presence of sun and wind, respectively, in order to generate electricity. They cannot provide certainty of dispatch, which limits their ability to provide grid services to networks. Furthermore, because Victoria’s fleet of solar PV is comprised largely of small-scale systems – the average system size is currently 3 kilowatts (kW) – these systems are individually unlikely to be capable of providing grid services on a scale that makes them capable of creating material network value.[109]

These factors have led to some stakeholders forming the conclusion that small-scale intermittent distributed generation such as solar PV is an inherently unviable source of utility-scale grid services.

[108] However, in this scenario there may still be value through reductions in the expected amount of unserved energy.

[109] The average system encompasses all existing solar PV. Estimates are from Jacobs Consulting for AEMO, published in June this year, indicate that the average size of systems being installed today across the NEM is 4.5 kW. Jacobs Consulting 2016, *Projections of uptake of small-scale systems*, Australian Energy Market Operator, June, p.10.

6.2.2 TRANSFORMING SOLAR PV INTO FIRM GENERATION

However, this status quo appears to be shifting, as new technology expands opportunities for intermittent solar PV systems – currently the dominant form of distributed generation in Victoria – to become controllable, and therefore capable of providing firm generation that is responsive to network needs.

Such technologies include energy storage (batteries), ‘smart’ inverters and energy management systems. Some of these technologies are not new – various forms of energy storage have been in use for decades,[110] but they are becoming increasingly economic for small-scale distributed generation owners to purchase and install.[111]

ENERGY STORAGE

There are many varying estimates of the timing and scale of energy storage (battery) uptake in Australia. Estimates of the pace and extent of this expansion vary considerably. Jacobs Consultancy projects that the installed battery storage capacity within the National Electricity Market will grow from negligible levels today to around 1,000 MW by 2020, of which around 300 MW will be located in Victoria.[112]

Other estimates are significantly higher. Morgan Stanley estimated in June 2016 that by 2020 installed battery capacity (residential) in the National Electricity Market will be ‘about four times’ higher than that forecast by Jacobs.[113]

Issues surrounding battery storage remain to be addressed, including those relating to safety, installation and operating standards, as well as standardised communications

[110] Australian Energy Market Commission 2015, *Integration of Energy Storage: Regulatory Implications*, December.

[111] The scope of technology change and integration with the network is a broader scope than is covered in this inquiry. Currently, a number of studies nationally and internationally are exploring these technology changes and the operation of the future grid (for e.g. G Strbac et. al. 2016, *Delivering future-proof energy infrastructure*, National Infrastructure Commission UK 2016, February, pp. 20-24; Energy Networks Australia, CSIRO 2015, *Electricity Network Transformation Roadmap – Interim Program Report*, December; and New York Department of Public Service 2016, *Staff Report and Recommendations in the Value of Distributed Energy Resources Proceeding,* October).

[112] Jacobs Consulting 2016, *Projections of uptake of small-scale systems*, Australian Energy Market Operator, June, p 29.

[113] Morgan Stanley 2016, *Australia Utilities – Asia Insights: Solar & Batteries*, June, p. 6. Note that Morgan Stanley reports an uptake of batteries of approximately 6 GWh in the NEM by 2020, compared to Jacobs reported uptake of round 6.9 GWh in the NEM by 2037.

protocols and regulatory implications.[114] Nonetheless, it is reasonable to assume that this technology will become more widely available.[115]

ENERGY MANAGEMENT SYSTEMS

Energy management systems are used to monitor, control and optimise the energy output and consumption of customers' generation and appliances. Such systems often rely on cloud-based software that enables customers to remotely manage or monitor their energy generation, consumption and transactions.

When deployed in combination, energy storage and energy management systems can equip solar PV owners with the ability to store their excess solar energy and then dispatch it into the grid at the time of their choosing. If this dispatch is actively responsive to the needs of the network, it may have considerable network value. In other words, the combination of these technologies can effectively transform intermittent solar PV into firm, dispatchable generation.

For instance, a residential customer who owns a solar PV array and battery might use an energy management system to automatically purchase energy from the grid when prices are low, and during that time store the energy produced by their solar panels. When the price of energy increases, the energy management system might automatically switch to using the energy stored in the customer's battery, or if the 'export tariffs' were sufficiently high the system may begin exporting energy from the battery directly into the grid. The system may also be programmed to supply energy to the grid when it is most needed by the network; that is, to provide grid services.

Energy management systems can also be used to control appliances within the home, such as air conditioners and refrigerators, in response to changes in the price and availability of energy, or conditions within the grid.

[114] For a discussion of regulatory implications in the context of contestability of energy services rules within the national framework, see Australian Energy Market Commission 2015, *Integration of Energy Storage: Regulatory Implications*, December.

[115] Australia has been earmarked as an early adopting market globally for energy storage due to the high penetration of solar and the prevalence of wholesale value based feed in tariffs that are typically significantly lower than the retail price for energy.

SMART INVERTERS

As of early October 2016, an updated Australian Standard applies to newly installed solar inverters. Inverters are devices that convert the direct current (DC) output of solar PV units into alternating current (AC) electricity that can be used by customers and/or exported into the grid, along with an increasing range of other functions such as power factor correction and voltage regulation. Inverters installed in Australia after 9 October 2016 must be capable of additional functionality, including functions related to demand response.[116] Further information is provided in box 4.3.

COORDINATION OF DISTRIBUTED GENERATION

Our analysis of network value within the Victorian grid demonstrated that the greatest value occurs when the quantity of generation is matched to the needs of the network. To reduce congestion in a way that produces the greatest value may require larger quantities of generation capacity than small-scale distributed generators can provide individually. However, this value can be unlocked by multiple smaller systems acting in unison.

Technology is emerging that enables multiple distributed generation systems to be coordinated, or 'orchestrated', in order to collectively deliver output in the locations, and at the times, where it has the greatest value.[117] By pooling their output, multiple small units may collectively reach the capacity thresholds required by the network to deliver augmentation project deferrals.

Conceivably, pooled distributed generation may be capable of being more responsive to network needs than conventional fossil-fuel based distributed generation. When

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[116] Standards Australia 2015, *Grid connection of energy systems via inverters - Inverter requirements,* AS/NZS 4777.2:2015, October.

[117] Large scale coordination of distributed energy resources, including distributed generation, is sometimes referred to as a virtual power plant (VPP). The NER contains a mechanism – the Small Generation Aggregation Framework – that is specifically designed to enable aggregation. The mechanism creates a new market participant who is entitled to participate in the wholesale market on behalf of a fleet of aggregated distributed generators. This mechanism is sometimes incorrectly cited as explicitly enabling the provision of aggregated grid services. However, this result is incidental. Unlike participation in the energy wholesale market, the provision of grid services does not require a particular legal standing or the attainment of a minimum capacity threshold defined by regulation. To the extent the Small Generation Aggregator Framework has a bearing on the provision of aggregated grid services, it is through its potential to incentivise the aggregation of distributed generators for energy trading purposes, which creates a 'ready-made' unit of distributed generation whose capabilities might also be deployed as grid services.

compared with traditional sources of grid services, orchestrated distributed generation may be able to deliver ramp up rates of seconds rather than minutes or hours. A fleet of distributed generation may also provide higher reliability of service as they are made of many contributing installations that are independent. Additionally, it may be capable of producing near to real time provision of ancillary services such as frequency control.[118]

DEMONSTRATION PROJECTS

All additional technologies come at a cost, and there remains uncertainty as to how quickly these new technologies will become mainstream. The pace of deployment will depend on factors such as the cost of the new technologies and the structure of electricity consumption tariffs.[119]

However, a small but growing number of companies in Australia have developed market-ready energy management systems for use within households and businesses.[120] The maturity and capabilities of these technologies is currently being illustrated in Victoria through demonstration projects that are proceeding with the assistance of grants and allowances.

Network provider United Energy has partnered with new energy technology company Greensync to defer capital investment on the Mornington Peninsula using a mix of demand-side measures, including coordinated distributed generation.[121] The capital investment by United Energy would otherwise be required to upgrade the network to meet infrequent high demand that occurs during the summer holiday period. The Community Grids Mornington Peninsula project will proceed with a pilot over the

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[118] There have been various trials nationally and internationally on co-ordinating distributed energy resources for the needs of the network. See UK Power Networks 2015, *Flexible Plug and Play, Closedown Report,* August.

[119] In general, the more cost reflective customer consumption tariffs, the greater the likely uptake of energy storage and associated technologies. If customers are exposed to the higher prices during peak periods, they have a greater incentive to invest in technologies, such as batteries, that will enable them to avoid drawing energy from the grid during those periods.

[120] A recent survey completed on behalf of the Australian Energy Market Commission identified 21 such companies presently active across the NEM. Oakley Greenwood 2016, *Current Status of Demand Response in the NEM: interviews with Electricity Retailers and Demand Response Specialist Service Providers*, Australian Energy Market Commission, June.

[121] Community Grids Mornington Peninsula project received $554,886 in grant funding from the Victorian Government as part of the Government’s New Energy Jobs Fund.

summer of 2016/17, the results of which will inform the project itself, commencing in late 2018.

United Energy has used funds available via an allowance scheme[122] to trial a number of distributed energy resource projects[123] for the purposes of deferring augmentation at seven constrained substations.[124] Separately, network provider Citipower has used funding made available via the same scheme to conduct a residential storage trial in targeted areas within their network. In a similar vein, AusNet Services has used the mechanism to trial battery storage in residential settings, which it used as the basis of a pilot 'mini grid' encompassing 16 houses at Mooroolbark, a suburb in Melbourne.[125]

The examples listed above are instances in which investment has been led by network businesses. However, future investment in these technologies is likely to be driven, in part, by the decisions of energy customers rather than those of traditional energy businesses such as network providers.[126] We therefore consider it appropriate, in the context of the technology changes occurring in the industry, to examine whether small-scale distributed generators will have adequate opportunities to monetise the grid services they are capable of providing, now and into the future.

6.3 EXAMPLES AND RELEVANT DEVELOPMENTS

A number of regulators, research bodies and businesses in Australia and internationally have been investigating and trialling technologies, platforms and systems that resemble a market for grid services. Whilst there is no single model in the world that represents a market for grid services, there are a range of studies and systems that examples of certain elements of the market. In this section, we describe

[122] The Demand Management Incentive Allowance (DMIA) scheme.

[123] Such as the Virtual Power Plant (VPP) Project, as described in United Energy 2016, *Demand Management Incentive Scheme Report – 2015*, July, p. 2.

[124] United Energy 2016, *Submission to the Australian Energy Markets Commissioner on the Local Generation Network Credits Rule Change*, February, p. 3.

[125] Residential battery trial funded via the DMIA.

[126] Energy Networks Australia & CSIRO 2015, *Electricity Network Transformation Roadmap – Interim Program Report*, December.

some examples related to a market for grid services from an international and Australian perspective.

6.3.1 INTERNATIONAL EXAMPLES

Given the significant differences between electricity markets in New York State, the UK and Australia, it is not the Commission's intention to advocate for the adoption of a distribution system operator model in the Victorian context or more broadly in the National Electricity Market. Such a proposal would need to be part of a much larger discussion about the future of electricity networks, and touches on key debates currently underway about ownership models, contestability[127] and ring-fencing,[128] which are not within the primary focus of this inquiry.

However, these examples illustrate the types and scope of reforms that are being considered in other jurisdictions, elements of which may have implications for the remuneration of small-scale distributed generators as providers of grid services.

NEW YORK – REFORMING THE ENERGY VISION

The potential of increasingly dynamic markets for grid services is receiving increasing attention, particularly in light of pioneering reforms being implemented under the auspices of New York State's Reforming the Energy Vision (REV) reform package.

The REV is a far-reaching set of reforms aimed at reshaping the traditional utility model for the purposes of ensuring cost-effective and reliable electricity supply in an increasingly decarbonised future. A central element of the REV is the conversion of network operators into 'distribution system operators', charged with managing the grid as a platform over which multiple agents transact and procure energy related services, including the types of grid services that we have discussed in this report.

[127] In early September 2016, the AEMC received a rule change request from COAG Energy Council to clarify energy service classifications for the purposes enabling contestable provision of services from emerging technologies. The AEMC is consulting on the rule change, Australian Energy Market Commission 2016, *Contestability of Energy Services Rule Changes – Consultation Paper*, December. This follows a rule change approved by AEMC last November which initiated processes to expand contestability in metering services, Australian Energy Market Commission 2015, *Expanding competition in metering and related services – Rule Determination*, November.

[128] Ring-fencing refers to the practice of 'separating business activities, costs, revenues and decision making within an integrated entity associated with a regulated monopoly service, from those that are associated with providing services in a competitive market.' The AER has released an electricity distribution ring-fencing guideline, Australian Energy Regulator 2016, *Electricity distribution: Ring-fencing guideline*, November.

CALIFORNIA – EMERGING PLATFORMS AND INNOVATION PILOTS

California has been attracting a variety of new businesses, innovative commercial models and platform-based solutions related to the electricity industry. Many of the more innovative businesses and models seek to better integrate distributed generation and other energy resources together with the electricity grid.[129] For example, an energy utility[130] in California is using a platform that can draw on different technology providers to help manage the electricity network (shown in box 6.1).

BOX 6.1 CALIFORNIA – PLATFORM-BASED PILOT AND TRIAL

Pacific Gas and Electric Company (PG&E), a major Californian energy utility, is trialling a platform-based approach to integrating distributed energy resources (DER) into the electricity grid. The approach is known as a DER Management System (DERMS). DERMS uses software to monitor, optimise and deploy distributed generation systems (and other similar devices) in response to network congestion and other needs of the grid.

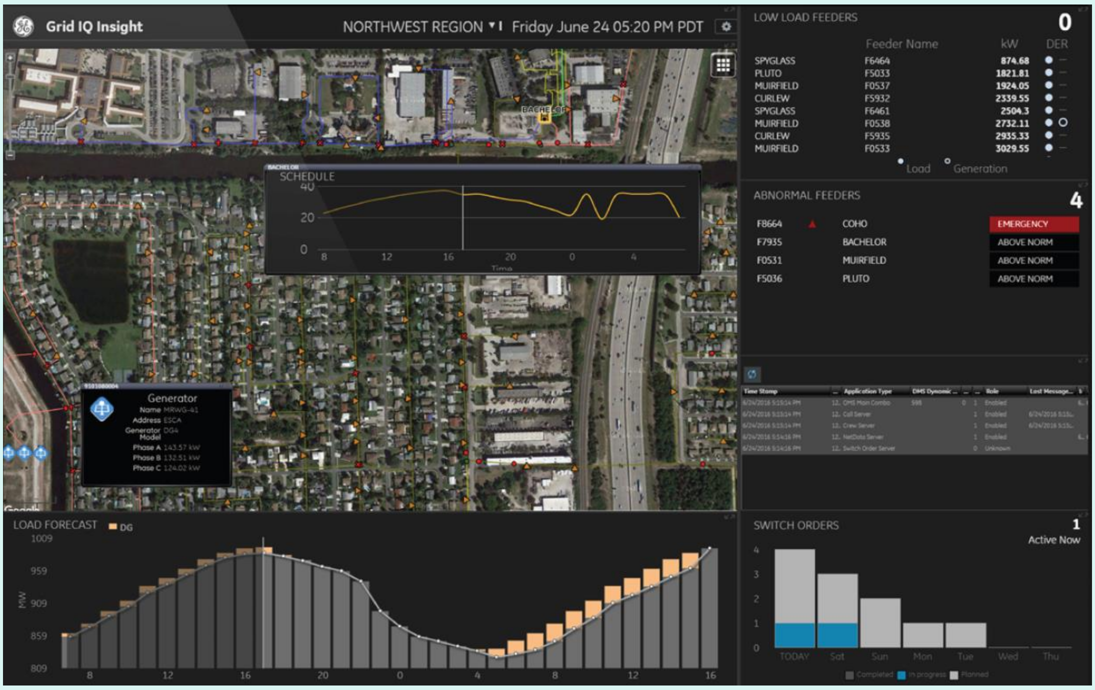
DERMs need to be sophisticated enough to operate with dynamically responding distributed assets. This is opposed to what is traditionally done by network businesses, which is to operate the network using centralised control. These DERMS will also need to help simplify these complexities for energy utilities.

The trial uses General Electric's Grid IQ Insight software as a platform between PG&E (the energy utility) and two intermediaries; Green Charge Networks and Solar City. Grid IQ is a platform that helps the energy utility facilitate and contract each intermediary to deliver services that helps PG&E operate and optimise the DER installed in the network.

[129] In the US and in accompanying literature, the term often used to collectively describe small-scale generation systems and demand management devices is Distributed Energy Resources or DERs.

[130] In the US, energy utilities are generally both a network business and energy retailer who sells energy directly to customers. Unlike in Australia, energy utilities in the US can capture the benefit streams related to both network and wholesale energy value, and internally manage any trade-offs between these two benefit streams. The issue of the interactions between these benefit streams are described further in section 7.4.5.

FIGURE 6.1 GRID IQ INSIGHT PLATFORM INTERFACE



Source: General Electric 2016, *Grid IQ Insight – Translating Data to Actionable Intelligence for Empowered Decision Making*, October

The two intermediaries each have their own technology platforms, capable of monitoring and orchestrating their fleet of customers' DER systems to deliver a suite of grid services. Under this pilot, the intermediaries will integrate their separate systems and platforms into the common Grid IQ Insight platform.

The trial does not describe how payments for grid services would be determined and paid for. However, intermediaries already have payment and benefit sharing arrangements with their customers. Typically, the intermediaries can offer their customers technology bundles that include solar PV systems, batteries, and smart inverters for participation in the pilot. The intermediaries can also provide services to customers such as maintenance, financing, or providing energy analysis advice. The addition of grid services might involve an additional payment from the utility to the intermediary, which could be shared with end customers.

Source: Research undertaken by ESC

UK NATIONAL INFRASTRUCTURE COMMISSION – A DISTRIBUTED SYSTEM OPERATOR

The potential emergence of a 'distributed system operator' (DSO) model, and associated markets, to replace elements of the existing utility model is also being examined in the United Kingdom (UK). In a report issued in March 2016, the UK National Infrastructure Commission took the view that the establishment of distributed system operators 'should be treated as a priority'.[131] Energy UK, the trade association for the UK energy industry, has indicated the likely need to make such a transition.[132]

In explaining its position, the UK National Infrastructure Commission identified the potential that this model held for accessing additional value from resources such as distributed generation. In citing the benefits that may emerge, the report states:

> *A DSO with a clear idea of what the local network needs at each moment in time will be able to purchase or procure these services to manage its system, creating revenue streams and market signals to suppliers. It is currently difficult to put together a commercial business case for local level storage and demand flexibility measures, as their benefits are diffused across different parts of the system. This change will also incentivise the development of new and innovative business models, and save money for consumers by reducing or deferring the need for costly physical enhancements to the grid.*[133]

These three international examples highlight how different jurisdictions across the world are beginning to research, pilot and test the nascent markets of grid services. The particular emphasis of international work is on integration of DER, including distributed generation systems, using technological and market platforms.

6.3.2 CURRENT DEVELOPMENTS IN AUSTRALIA

Investigation into the applicability of these concepts are already advancing in the Australian context, such as is occurring under the auspices of the Electricity Network Transformation Roadmap project, a partnership between the Energy Networks Australia and CSIRO. In its Interim Program Report last year, the project considered a

[131] National Infrastructure Commission UK 2016, *Smart Power*, March, p. 70.

[132] Energy UK 2016, *Pathways for the GB Electricity Sector to 2030*, February, p. 15.

[133] National Infrastructure Commission UK 2016, *Smart Power*, March, p. 68.

number of future scenarios, including one in which network providers operate as ‘enabling platforms’, facilitating transactions through which distributed generators would be remunerated for providing energy and grid services.[134]

More recent work from the Roadmap project, released in October 2016, emphasised the benefits associated with facilitating grid services transactions between network businesses and small-scale operators, including residential customers. The report, prepared by Energeia, noted:

> *With the increase of new technologies in the energy system, early opportunities for buying and selling grid services are best served through agreements between customers and service providers to allow for dynamic and locational network orchestration of distributed energy resources where they can provide a lower cost solution to a traditional distribution service expenditure, to either augment or replace the existing grid.*[135]

The examples discussed in this section illustrate the emerging thinking about how grid service providers, including distributed generators, might be remunerated in the context of improving technological capabilities, more precise pricing arrangements, and potential shifts in the orientation of the commercial models of network businesses.

6.4 A MARKET BASED APPROACH

When we discuss the market for grid services, we refer to the arena in which network businesses transact with providers of grid services. In a market for grid services, the primary purchasers of these services are large monopoly network businesses. By virtue of this status, network businesses have access to more information than individual small-scale distributed generation proponents, who may often be residential households. In these circumstances, it would also be expected that network businesses will have greater bargaining power. Conversely, procuring grid services from multiple small-scale providers may be challenging for network businesses,

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[134] Energy Networks Australia & CSIRO 2015, *Electricity Network Transformation Roadmap – Interim Program Report*, December, p. 12.

[135] Energy Networks Australia & CSIRO 2016, *Unlocking Value for Customers: Enabling New Services, Better Incentives, Fairer Rewards*, October, p. 3.

particularly from the perspective of consumer education, risk allocation and transaction costs.

Some of these factors are acknowledged in the national regulatory framework, which incentivises monopoly network businesses to appropriately apportion their expenditure between traditional network upgrade projects, such as upgrading the ‘poles and wires’, and non-network solutions, such as using grid services to defer upgrades of the existing network infrastructure. The objective of these incentives is to ensure the grid is built and managed in the most efficient way.

The national framework is orientated towards efficient capital expenditure, and providing at least some opportunities for grid service providers to engage with network businesses. For instance, when undertaking large network upgrades (greater than $5 million), network businesses must run a tender process into which grid service providers may bid.[136]

Chapter 5 showed that the national framework is not geared towards providing opportunities for small-scale grid service providers, such as distributed generators, to participate in the market for grid services.

6.4.1 THE MARKET FOR GRID SERVICES IN VICTORIA

Although the Australian energy market shares a common national framework, each jurisdiction has unique features that reflect the varying pace of reform, different ownership arrangements, and various models of supply chain integration.

Unlike other jurisdictions in the National Electricity Market, Victoria has almost full penetration of advanced metering infrastructure, or ‘smart meters’. Smart meters allow grid services to be deployed more easily and at lower cost than is possible under traditional analogue metering. This is because smart metering enables near to real-time remote monitoring of electricity flows to and from customers. Providers in Victoria can therefore provide accurate and timely grid services without the need to install additional metering infrastructure.

[136] See discussion of the Regulatory Investment Test – Distribution (RIT-D) in section 5.3.2.

In Victoria, the adoption of smart metering is more advanced and widespread than any other state. High penetration rates of smart meters could help enable the provision of grid services in Victoria, as stated by Energy Networks Australia in the context of its Electricity Network Transformation Roadmap project:

> *…Victoria is well advanced compared to other states in terms of having smart meter functionality that will advance development of future products. This will provide opportunity for Victorian businesses to develop and trial important elements…in a way that contributes to integrated transformation on a national scale.* [137]

So that small-scale providers of grid services in Victoria, including distributed generation, have adequate opportunities to participate in the market for grid services, we believe it important to identify the attributes of a market in Victoria to emerge. We describe these in detail in chapter 7.

6.4.2 A NETWORK VALUE FEED-IN TARIFF?

The feed-in tariff (FiT) is an instrument that already exists to make payments to small-scale generators on the basis of the value of the energy they produce. We have considered whether this instrument could be used to enable small-scale distributed generation to participate in the market for grid services. However, we found the value of the grid services that distributed generation can provide is too variable – between locations, across times, and between years – to be well suited for remuneration via a broad-based FiT.

A key characteristic of network value is its variability across locations, across the hours of the day, and between years. It varies by location because it manifests in specific, localised sections of the grid rather than across the grid as a whole, or even across geographic regions. Chapter 4 showed that the network value was markedly different even between neighbouring zone substations in Victoria.

This pattern exists across the Victorian network. There may be considerable value at one network asset and zero value at the next. The value in the low voltage portions of

[137] Energy Networks Australia 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December, p. 4.

the network – which we did not examine because of the absence of publicly available data – may be even more localised and granular.

Network value is also highly dependent on the time of generation. As we showed through our reports during the first stage of this inquiry, the *energy* produced by distributed generation always has a wholesale market value, even if it fluctuates between higher and lower values over the course of the day (in keeping with movements in the electricity wholesale market).

By contrast, to provide *network* value, the output of a distributed generator must coincide with peak network demand in the area of the network to which it is connected. While the network value of distributed generation may be high during network peak periods, for the remainder of the day the distributed generator will provide little or no network value.

An additional layer of complexity is introduced by the fact that the timing of peak demand varies throughout the network. In commercial or industrial areas, the peak may occur in the middle of the day, whereas in residential areas it may occur in the evening. This means there is no uniformity across the network regarding the time of the day at which distributed generation provides network value.

This variation across time and location makes it difficult to express network value through a broad-based FiT. In order to ensure payments to distributed generators accurately reflect the network value they are providing, it would be necessary to construct a tariff structure that reflected the variable nature of that value across time and locations.

This would require a tariff with many location zones, each with a unique time of use structure. Conceivably, the resulting tariff structure could produce different time of use structures for each zone substation in Victoria (of which there are over 220). Establishing such a structure would be costly and complex, and would produce an outcome that was expensive and difficult to administer for network businesses and regulators alike. The exercise would also need to be repeated each year.

Alternatively, the variability of value could be dealt with by 'averaging' the values to reduce the number of location zones and time blocks to a manageable number, so they could reasonably be reflected in a broad-based FiT. However, averaging across time and locations would result in payments being made to distributed generators who were providing no network value.

Equally, those distributed generators that could potentially provide very high levels of network value would receive payments that were significantly lower than the level of benefit they cause.

In short, if a broad-based network value FiT was calculated with sufficient granularity to reflect the underlying network value, it would be disproportionately complex and costly to implement. If it were made simple enough to implement, it would be inadequately reflective of value and could lead to payments to distributed generators who were not providing benefits while, at the same time, not sufficiently rewarding those who were.

This conclusion aligns with the view of the then Victorian Competition and Efficiency Commission (VCEC), in its 2012 inquiry into feed-in tariff arrangements in Victoria, that network value was fundamentally different in character to energy value.[138] The conclusion also aligns with the position taken by the Australian Energy Market Commission (AEMC) in its final determination on a rule change proposal to introduce Local Generation Network Credits (LGNC), another tariff-based instrument.[139]

Even if the issue of time and location variability could be resolved, there remains the issue of year-on-year variability. Victoria's current 'energy value' FiT varies each year based on changes in the wholesale value of electricity. These annual variations are relatively minor when compared to the annual variability of network value, which can spike by orders of magnitude, or be reduced to zero, from one year to the next.[140]

The impact on investment of introducing such 'peaky' incentives into a FiT, and whether there might be unintended effects, is not clear. For example, incorporating high network values in specific high-value locations into a FiT may cause a surge of

[138] Victorian Competition and Efficiency Commission 2012, *Power from the People: Inquiry into Distributed Generation,* July, p. XXXVIII.

[139] Australian Energy Market Commission 2016, *Local Generation Network Credits – Final Rule Determination*, December.

[140] The extent of this annual variability can be influenced by the method used to calculate the value. Some methods apply smoothing functions which mitigate the sharpness of variation. However, even calculation methods that include smoothing functions necessarily produce values that reflect the underlying driver of value, which is the timing of network augmentation projects. This means values retain a high degree of annual variation under any method.

investment in distributed generation at that location, only to have the value collapse in the following one to two years due to either the constraint being deferred by the surge in investment or because the network augmentation project eventually becomes necessary and proceeds.

This may prove difficult for individual investors in distributed generators to comprehend or accept, particularly if they have made an investment decision of the basis of the FiT payment that was available in ‘year one’. This situation also shows that annual prices are not necessarily a useful indicator of long-term value and individual investors could make uneconomic investments as a result.

Finally, a FiT is by design a limited means by which to remunerate network value because it is paid on the basis of exported electricity – that is, excess energy that is exported by the distributed generator back into the grid – whereas the network value of distributed generation is driven by the entire capacity of the system. Rewarding distributed generators for only the portion of their generation that is exported means some portion of the value they provide would not be remunerated.

For these reasons, the Commission has formed the view that a broad-based FiT is unlikely to be an appropriate means by which to remunerate network value for distributed generation. It is nonetheless desirable that distributed generators are remunerated for the network value they create. We have therefore taken a broader view to this question and sought to explore other means of ensuring appropriate remuneration for network value occurs.

Chapter 7 discusses the potential of a market to allow distributed generation to participate and be remunerated for providing grid services.

6.5 CONCLUSION

The potential network benefits or ‘grid services’ provided by distributed generation and other demand-side measures can have value. A regulatory framework exists at the national level to incentivise monopoly network businesses to appropriately apportion their expenditure between traditional network upgrade projects and non-network solutions. That framework is not geared towards providing opportunities for small-scale grid service providers, such as distributed generators, to participate in a market for grid services. Because the characteristics of network value, a broad-based feed-in tariff (FiT) is unlikely to be an appropriate tool to achieve this purpose. That value is too variable – between locations, across times, and between years – to be well suited for remuneration via a broad-based FiT.

Changes in technology could increase the value of grid services provided by distributed generation, for example, by transforming intermittent distributed generation into firm generation, or by co-ordinating large numbers of small-scale distributed generators. In Victoria, unlike other jurisdictions in the National Electricity Market, the large penetration of smart metering raises the possibility for further development of a market for grid services that could provide adequate opportunities for small-scale providers, including distributed generation.

6.5.1 FINDINGS

Finding 6: Sources of grid services

Reducing network congestion is a form of ‘grid service’. Network congestion can be reduced by a number of means, of which distributed generation is only one. Measures implemented for the purposes of remunerating distributed generation for the provision of grid services could be designed in a way that does not preclude the remuneration of other means of delivering grid services, such as demand response.

Finding 7: A market for grid services

Distributed generation in Victoria could be remunerated for its network value through a market for grid services, assuming the market for grid services provided adequate opportunities for the participation of small-scale grid service providers, including distributed generation.

Finding 8: A broad-based feed-in tariff is unlikely to be an appropriate mechanism to remunerate network value

A broad-based feed-in tariff is unlikely to be an appropriate mechanism to support the participation of small-scale distributed generation in a market for grid services. If a network value FiT was calculated with sufficient granularity to reflect the underlying network value it would be disproportionately complex and costly to implement. If it were made simple enough to implement, it would be inadequately reflective of value and could lead to payments to distributed generators who were not providing benefits while, at the same time, not sufficiently rewarding those who were.

Finding 9: Opportunities for the grid services market in Victoria

For reasons including but not limited to the roll out of advanced metering infrastructure, there may be opportunities in Victoria for the earlier development of an established market for grid services that are not currently available in other jurisdictions. Such a market could provide adequate opportunities for small-scale grid service providers, including distributed generators, to be remunerated for the grid services they are capable of providing.

7 A MARKET FOR GRID SERVICES

7.1 INTRODUCTION

This chapter explains the concept of a market for grid services and describes the market attributes that would enable participation by small-scale distributed generators. The chapter also discusses some of the key issues related to the development of the market for grid services in Victoria.

7.1.1 STRUCTURE OF THIS CHAPTER

This chapter is divided into five sections:

7.1 Introduction

7.2 A market for grid services

- what are grid services?
- transacting grid services via a market and
- market participants.

7.3 Remunerating small-scale distributed generation through a market for grid services

- a description of the attributes of a market for grid services to enable the participation and remuneration of owners of small-scale distributed generation systems in providing grid services and
- a description of the pathway and drivers for a market for grid services to emerge.

7.4 Key issue areas

- a discussion of key issues that may emerge as the market for grid services evolves

7.5 Conclusion

7.2 A MARKET FOR GRID SERVICES

Network businesses use a range of services to build and maintain the grid. These include services to help manage congestion within the network, as an alternative to expanding the network itself, as well as a range of services for ensuring the network can operate safely.

Under certain circumstances, small-scale distributed generation can already provide some of these services. For instance, our analysis has shown that small-scale solar PV systems can assist with reducing network congestion. If distributed generation system owners invest in battery storage and energy management technologies, they may be able to provide higher value services. This includes exporting power into the grid in response to real time signals from the network to help avoid a looming constraint.

This section briefly describes a market arrangement that could be used to coordinate and remunerate grid services from small-scale distributed generators.

7.2.1 WHAT ARE GRID SERVICES?

In chapter 4, we demonstrated that distributed generation in Victoria can and does provide network value through reducing network congestion.[141] We also identified that there are other potential network benefits that distributed generation could provide. In presenting these results, we noted that distributed generation is only one way these network benefits could be provided. Other demand-side measures, such as demand response, may also give rise to network value. The network benefits and services provided by all these forms of demand-side measures can be collectively described as 'grid services'.

The full suite of grid services includes any service that electricity networks need in order to run safely, reliably and efficiently. This may include:

[141] The benefit of reducing network congestion includes the potential to defer network augmentations and reduce the amount of expected unserved energy.

- **Managing congestion –** reducing network congestion at all (or varying) levels of the network, including the low voltage distribution network. Grid services that manage congestion can provide value by deferring the need to expand the network.
- **Supporting the network** – providing system-wide ancillary services, such as voltage regulation, frequency response or system inertia, and system restart services, or providing these services in specific subregions of the network.

  These ancillary services are critical to the safe and stable operation of the network. Frequency, voltage and available capacity throughout the grid are constantly changing. These dynamic features of the grid need to be kept within tightly defined boundaries to maintain a balanced, reliable and stable network.

Standard rooftop solar photovoltaic (PV) systems can, in some circumstances, assist with managing congestion in the network even when operating 'passively' – that is, simply generating electricity in response to insolation (sunshine) patterns. But in most cases, to provide grid services with genuine value to the network, solar PV systems and other forms of distributed generators must alter the way they operate.

For example, distributed generation systems might be programmed to take certain actions in response to grid conditions (e.g. turn on, turn off, charge, discharge, or change output in response to system frequency). Alternatively, they may be held 'in reserve' to provide electricity generation when needed or they may be directly controlled by a third-party. Table 7.1 provides some examples of how a distributed generation system can be operated to provide grid services.

TABLE 7.1 EXAMPLES OF POTENTIAL GRID SERVICES FROM DISTRIBUTED GENERATION SYSTEMS

Distributed generation system type	Configuration of system	Example of grid service that could be provided
Passive solar PV system	Passively generate electricity	By generating electricity in a predictable way, passive solar PV systems can, in some circumstances, help reduce network congestion by reducing demands on the network during peak periods.
Solar PV system and battery with smart devices	Passively generate electricity	Help reduce network congestion in some circumstances (as above).
	Programmed to stored electricity held in reserve	Increases potential network capacity when the risk of network congestion is high.

Distributed generation system type	Configuration of system	Example of grid service that could be provided
	Programmed to be controlled by a third-party to discharge stored electricity at a given time	Can be optimised to respond to grid conditions, and effectively increase network capacity at time of risk of network congestion. Can also be programmed to support the grid by responding to excessive system voltage deviations.
Solar PV system with smart inverter	Configured to manage local voltage in response to signals	Provides continuous voltage control.
Battery system with Variable VAR inverter	Configured to manage local voltage in response to signals	Provides continuous voltage regulation or frequency regulation (ancillary services).
	Maximum discharge of stored electricity at given times	Supports the grid by responding to excessive system voltage deviations.

Source: ESC

7.2.2 TRANSACTING GRID SERVICES VIA A MARKET

A market, in its broadest sense, is an arena where there are transactions between buyers and sellers for certain products or services. The term 'market' refers to a wide range of commercial arrangements. Markets can be small, such as farmers markets that form in response to the local needs of buyers and sellers with limited external coordination. Others are large and complex, such as the National Electricity Market, which is designed and highly-structured, established pursuant to legislation and regulations, covering a large number of transactions, and managed by an independent market operator.

In the broadest sense, a market for grid services is a place where network businesses transact with providers of grid services. This notion – of competitive markets in which new energy technologies provide different forms of electrical services – is gaining traction within Australia and in some overseas jurisdictions, such as California, New York State, and the UK. In each case, appropriately equipped distributed generation – along with other types of distributed energy resources – is envisaged to have a role.

In some visions, small-scale distributed generation systems located in customer premises are directly orchestrated by networks (or their ring-fenced affiliates) through technology platforms (see box 7.1). At the simplest level, controls can be built into inverters to provide basic grid services such as local voltage control and power shutdown in response to high system frequency. In others, intermediaries such as aggregators or retailers bundle multiple small providers together and manage their interaction with the grid. Still other visions see a role for sophisticated market design, including a role for an independent mechanism, such as a billboard or auction, or market facilitator.

BOX 7.1 WHAT ARE PLATFORMS?

'Platforms' is a term frequently used to describe the overall system used to deliver an internet-based service. Platforms are increasingly being used to coordinate resources in novel and useful ways, which were too expensive, complicated or unreliable to use in the past. For example, eBay has allowed the exchange of millions of items which would otherwise have not been used or sold.

In the energy industry, platforms are being considered for the coordination of small-scale devices and distributed generation in a cost-effective manner. These platforms are sophisticated enough to co-ordinate the actions of many different devices in real-time. This could encompass optimising and controlling a fleet of distributed generation of various brands and types. Platforms can also consider data from weather forecasts, device status, customer preferences and market conditions to constantly control distributed generation systems.

Beyond merely optimising the operation of multiple distributed generators, more sophisticated platforms would be capable of facilitating market interactions. This form of platform focuses on providing an arena for the trade of goods and services, such as Amazon, Gumtree, Airtasker, and Uber. These platforms connect willing buyers and sellers at low cost and tend to increase the number of participants in a market.

Market platforms could play a similar role in the market for grid services. For example, platforms could range from bulletin boards posting requests for grid services, to complex platforms involving dynamic transactions occurring between buyers and multiple sellers.

Source: ESC

To the extent a market for grid services can be said to exist at all in Victoria, it is currently highly restricted in scope to a few players and sees very few transactions. One early sign that the market may be beginning to emerge has arisen via a mechanism within the national regulatory framework that applies to large network upgrades (the regulatory investment test for distribution (RIT-D) process). In this case, with some assistance of government grants a new energy technology company (GreenSync) is undertaking a project to deliver a grid service that defers a traditional network upgrade project on the Mornington Peninsula for two years.[142] This project is now the subject of an Australian Renewable Energy Agency (ARENA) funded pilot to trial a prototype market platform for transacting grid services (box 7.2).

BOX 7.2 DECENTRALISED ENERGY EXCHANGE (DEX) PROJECT

ARENA is funding a pilot project to trial a market-based solution to provide grid services in Canberra and Mornington Peninsula in Victoria. GreenSync will develop a prototype platform – a decentralised energy exchange (deX) – to be a marketplace between small-scale providers of grid services and network businesses (United Energy and ActewAGL).

The marketplace will be an Australian first to dynamically reveal prices of grid services in local network areas. Suppliers of grid services will include residential and small businesses premises with batteries and rooftop solar.

In Victoria, the pilot will focus on co-ordinating small-scale providers of grid services to reduce peak demand. The Victorian and Australian Capital Territory Governments will also be part-funding the pilot and participating in a reference group for the project.

Source: Australian Renewable Energy Agency 2017, *World first marketplace to maximise value of renewables*, February

[142] United Energy 2016, *RIT-D Report, Lower Mornington Peninsula Supply Area, Final Project Assessment Report,* June 2016.

A small number of other businesses, such as Reposit Power or AGL New Energy, have been contracted directly by network businesses to deliver specific types of grid services. These examples demonstrate the emerging capacity of appropriately equipped distributed generation to provide grid services, and the nascent stage of a market for commercial transaction of those services.

7.2.3 MARKET PARTICIPANTS

We have identified four broad types of participants in a market for grid services:

- **Buyers –** The primary purchasers of grid services are large monopoly network businesses.
- **Sellers (including distributed generators) –** Sellers would include individuals or businesses that can reliably provide grid services.

  Distributed generation owners could participate in the market as a seller by entering into a contract directly with network businesses. Others may wish to indirectly participate in the market by contracting with an intermediary. For any individual, their mode of interaction with the market would be influenced by their preferences, including their motivation to personally engage with the technical requirements associated with supplying grid services.
- **Intermediaries –** It is likely that intermediary businesses will emerge to manage the exchange between small-scale providers of grid services and network businesses. Intermediaries could include aggregators, energy services companies or retailers.

  Aggregators are a growing type of business in the electricity industry (although only a small number are currently active in Victoria). These businesses enter into contracts with large numbers of customers, including those who own distributed generation, and ‘aggregate’ their grid services.

  This aggregation process makes it easier for large network businesses to scope and purchase grid services, particularly where dealing with thousands of small providers would be expensive or difficult.

  Similarly, retailers could engage their customers and offer retail products in return for utilising their distributed generation systems to deliver grid services.

- **Market facilitators –** As transaction volumes increase, a more formal structure may be necessary to coordinate and organise the transactions. In a highly developed market, a dedicated market facilitator may be capable of lowering transaction costs and standardising transactions and agreements for grid services. A market facilitator could manage transactions, publish listings of grid services to be transacted, or set the rules for participating in the market. Multiple market facilitators could be required across different locations.

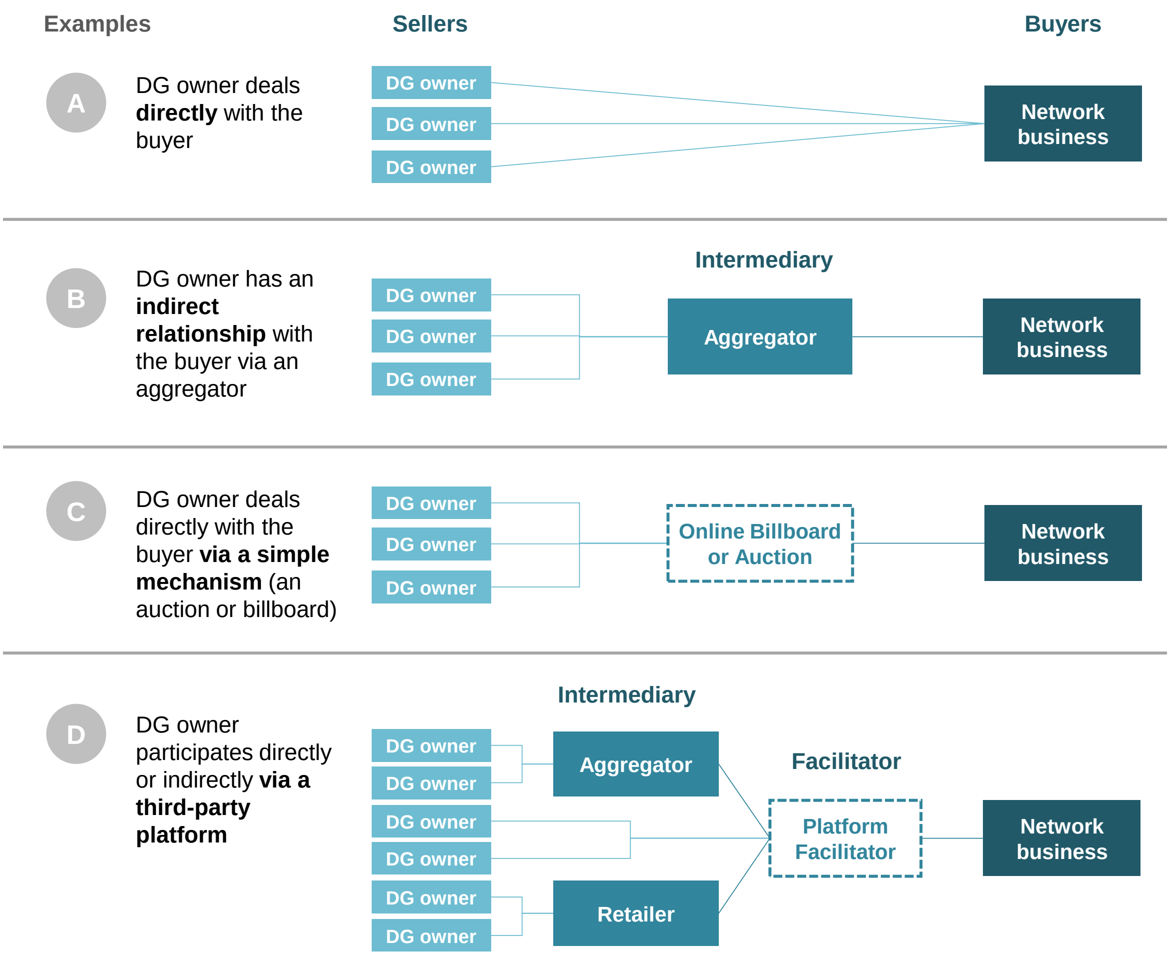
Relations between market participants may take many forms, subject to the market structure that emerges. In figure 7.1, we illustrate four potential models. The list is not exhaustive – many more structures may be conceivable.

Figure 7.1 illustrates some of the many ways in which contractual relationships between participants in the market for grid services could be organised. Small suppliers selling to monopsony purchasers (network businesses) are just one possibility. The emerging availability of functioning platforms provides growing opportunities for different ways to organise transactions and organise participation in the electricity network.

As we show in figure 7.1, in the future instead of small-scale distributed generators operators selling grid services to a large distributor, they may instead be able to coordinate through aggregators, participate in online billboards or auctions, or participate directly or indirectly via third party platforms. We saw in chapter 6 that different approaches are being trialled or considered in New York, California and the UK.

Issues that need to be considered in Victoria, in a context of far-reaching technical change, include which of these or other market design options would yield the best system outcomes and realise value for distributed generators, what can be learnt from international research and trials, and whether commercial incentives are strong enough to promote the development of new structures.

FIGURE 7.1 EXAMPLES OF POTENTIAL CONTRACTUAL RELATIONSHIPS BETWEEN PARTICIPANTS IN A MARKET FOR GRID SERVICES



Source: ESC

7.3 REMUNERATING SMALL-SCALE DISTRIBUTED GENERATION THROUGH A MARKET FOR GRID SERVICES

This inquiry is focused on examining effective remuneration of the network value of distributed generation in Victoria. In chapter 6 we found that it was not desirable to remunerate distributed generation for its network value using a broad-based tariff. Rather, we proposed that distributed generators could be effectively remunerated for their network benefits via an efficient market for grid services.

In this section, we consider five attributes such a market would need in order to be amenable to participation by small-scale distributed generators:

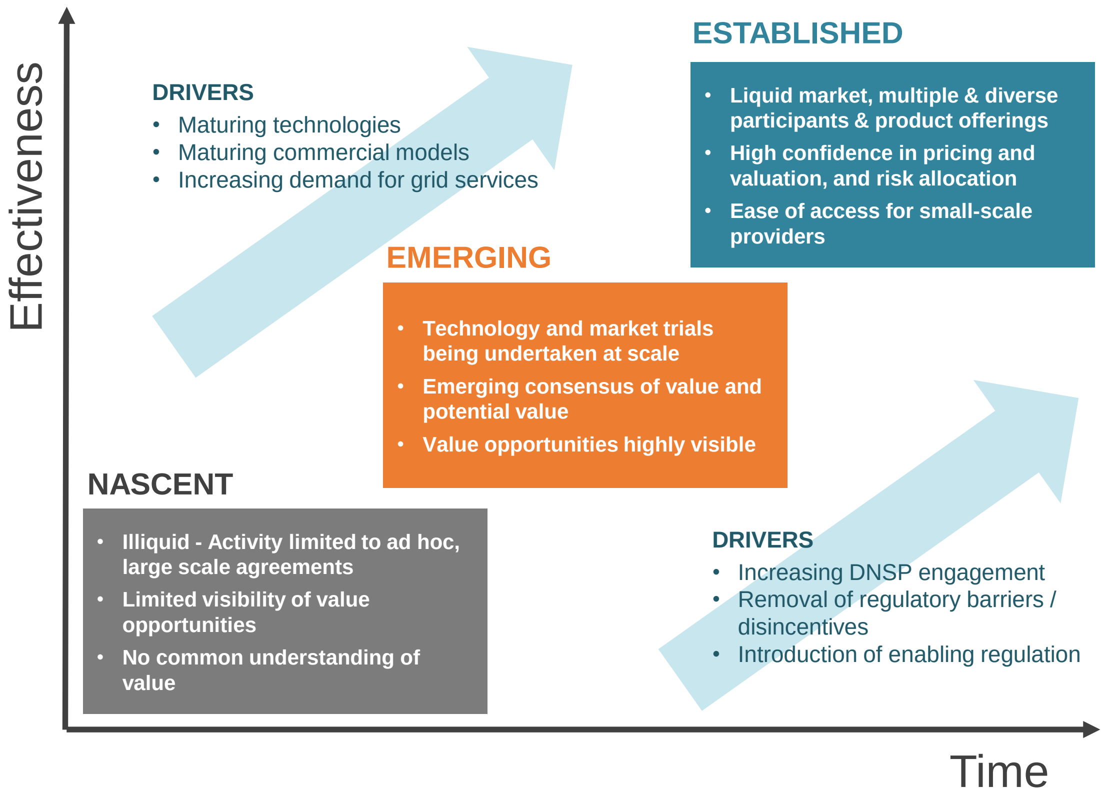
- **Information** – Small suppliers of grid services must be able to easily source information about the potential network value of their investment. Information about the obligations and risks of entering into agreements to provide grid services, must also be easily accessible. They must also be able to compare offers.
- **Access** – Small suppliers who are willing to meet the obligations of providing grid services should have genuine opportunities to participate in the market. The contractual basis of market exchanges should be clear and comprehensible.
- **Payment** – Small suppliers should have confidence that the prices offered to them are reasonable. Reliable and efficient settlement of transactions will be needed.
- **Protections** – The provision of grid services should not undermine the existing customer protections of a distributed generation owner (who is also an energy customer). The provision of grid services should not impose unnecessary privacy or cyber-security risks on the customer or society at large.
- **Efficiency** – There should be sufficient competition to provide the small supplier with options with regard to how their grid services are tendered. The market should not produce 'local monopolies' that deliver negative or perverse outcomes. Transactions costs that can be cost effectively reduced should be minimised.

7.3.1 PATHWAY TOWARDS AN ESTABLISHED MARKET

Our analysis indicates the market for grid services is likely to evolve in stages. (Whether this evolution will occur organically or requiring policy or regulatory intervention is one focus of our proposed way forward in chapter 8). In figure 7.2, we set out the main stages through which we expect the market to develop, as well as the main drivers influencing that development.

Given the small number of grid service transactions presently occurring in Victoria, our assessment is that the market is presently in the nascent stage. However, there are signs that, under the right circumstances, the market will soon begin to start shifting into the 'emerging' stage.

FIGURE 7.2 PATHWAY FOR A MARKET FOR GRID SERVICES



Source: ESC

Drivers of the market for grid services can be grouped into three categories:

- Maturing technology and commercial models
- Increasing demand for grid services and
- Regulatory changes.

Each of these is discussed below.

MATURING TECHNOLOGY AND COMMERCIAL MODELS

Technology and commercial models drive the emergence of the market for grid services primarily by enabling the provision of those services where previously they were technically impossible or commercially unfeasible. Technology drivers include falling prices (for battery storage, for instance) or improving functionality.

For instance, improved energy storage and energy management systems allow small-scale distributed generators to translate their passive systems into more dynamic, responsive assets that can actively provide congestion management services. Improved control systems allow multiple grid service providers to be harnessed together, meaning these services can be more easily delivered at scale (see section 6.2.2).

In tandem with technology improvements, maturing commercial models are also assisting small-scale distributed generators to become grid service providers. This includes new third-party aggregator models, discussed above, which can coordinate fleets of distributed generation systems to provide large scale grid services. New energy technology businesses are also beginning to adopt internet-based technology platforms to allow them to form new commercial relationships – including with appliance manufacturers – to support to the delivery of grid services.

INCREASING DEMAND FOR GRID SERVICES

Demand for grid services can be expected to grow as areas of the network become more congested over time. This may occur in localised sections of the network where customer demand for electricity during peak times increases. Alternatively, network businesses may have an increased need to procure ancillary services to assist with managing voltage or frequency issues caused by the increasing numbers of solar PV systems connecting to the grid.

REGULATORY CHANGES

Finally, regulatory changes may both proactively enable the emergence of the market for grid services, or alternatively, regulations that presently inhibit its emergence may be reformed. In the period since we completed our Stage 2 Draft Report in October 2016, a number of reviews and regulatory change processes commenced within the national regulatory framework (see section 5.4). The outcomes of these regulatory processes are likely to have a bearing on the evolution of the market. Principal among them are:

- An Australian Energy Regulator's (AER) review of mechanisms designed to encourage network businesses to source solutions from grid service providers when managing the network, and also to encourage greater research and development into these types of solutions (DMIS and DMIA mechanism).
- A project being conducted by the Australian Energy Market Commission (AEMC) into potential 'distribution market' models, which is examining the potential for market based approaches to managing the distribution network, potentially including small-scale providers of grid services.
- Rule change requests submitted to the AEMC by the Council of Australian Governments (COAG) Energy Council and the Australian Energy Council, both of which focus on issues germane to the evolution of the market for grid services. The rule change requests seek to clarify the definition of certain energy market participants who may be involved in providing grid services, with the aim of increasing the contestability of energy service provision.
- A rule change request submitted to the AEMC by the AER which proposes to expand the RIT-D to include network replacement projects (the mechanism is currently limited to network augmentation projects).

Subject to the outcomes of these regulatory reviews, they may support the emergence of a market for grid services by increasing the level of distribution business engagement in the market. However, the nature of the regulatory processes may mean that their impact will not be felt for some time. For example, given the AER is scheduled to publish a revised DMIS and DMIA in September 2017, any changes are likely to only take effect from 2021 in the next network pricing determination period.

7.4 KEY ISSUE AREAS

For the market for grid services to emerge, a great deal of commercial and technological detail needs to be addressed. This section describes the main areas in which additional research, trials, and policy and regulatory attention are required.

We categorised these issues into the following areas:

- Information
- Access (including risk allocation)
- Market design (including pricing and payment mechanisms)
- Technical factors and
- Customer protections.

We describe these issues in more detail in the following sections.

7.4.1 INFORMATION

Participants in a market for grid services require access to timely and accurate information to inform their investment decisions and to allow them to accurately price their offers of grid services. Energy Australia noted the current lack of transparent information about network constraints as a relevant consideration, stating:

> *We consider that the single greatest barrier to creating a more effective market for grid services is the lack of transparency around network constraints, and the opportunities which exist for investment to address them. Addressing this issue would ensure that the most efficient response to any particular constraint is deployed.*[143]

To allow the market for grid services to develop, information is needed so that:

- Participants (both buyers and sellers) can clearly understand the nature of services being requested and offered, including the terms and conditions upon which they are made available. For small-scale providers of grid services, this information needs to be sufficiently 'intuitive'. Considering the increasing role of information technology in the development of this market, it may also be necessary for information to be presented in a machine readable format.
- Third-parties, especially intermediaries, can examine the value of grid services and identify and develop commercial opportunities.

[143] Energy Australia 2016, *Submission to the Essential Services Commission Inquiry into the true value of distributed generation – Draft Report, Stage 2 – Network Value*, December, p. 4.

- Participants can reasonably determine how risk is allocated between buyers and sellers.

The AEMC is currently making changes to the availability of information about network constraints. From December 2017, network businesses will be required to publish annual 'system limitation reports', which will provide additional information about the location of network constraints and the estimated cost of remedying them. This will make it easier for sellers to identify opportunities to offer grid services.

However, the information contained in the reports will not reference the entire network. Constraints within the low voltage distribution network, for instance, will not be included. Although some network businesses have begun publishing this information, including United Energy, in most areas of Victoria there is currently no way of easily obtaining information about network constraints in the medium or low voltage network.

7.4.2 ACCESS

The key matters relating to market access for small-scale providers of grid service are:

- Clear and reasonable technical requirements and
- Clear and reasonable contractual arrangements, including those relating to service obligations and risk allocation.

TECHNICAL REQUIREMENTS FOR MARKET ACCESS

Managing the electricity network is a complex, technical undertaking. Network businesses must also operate the grid under rules that require them to maintain power quality within strict parameters to ensure electrical equipment can be used safely. It is only reasonable, therefore, that network businesses set technical criteria that must be met by any device or service that connects to the network in order to supply grid services.

However, it is equally important that technical requirements are not used by network businesses to unreasonably prohibit small-scale distributed generators (or other providers) from gaining access to the market. Equally, it is important that such requirements are made available in a way that is clear and comprehensible.

Additionally, connection requirements should not be used to unreasonably engineer favourable commercial outcomes for network business. This may apply to the connection of new generation solar inverters, which can be programed to deliver grid services (such as assisting with power quality). One concern raised by stakeholders was that network businesses may require inverters to be programed to deliver this service as a minimum connection standard, thereby effectively sourcing grid services from a customer for free.

CONTRACTUAL ARRANGEMENTS FOR MARKET ACCESS – OBLIGATIONS AND RISK

To become a supplier of grid services, an entity (who may be a regular energy consumer) will enter into a commercial contractual arrangement, either directly with a network business or with an intermediary. In doing so, the supplier will agree to take certain actions in order to deliver the grid services. This basic arrangement will apply even if these actions are effectively pre-programmed via an energy management system and don't require the supplier to 'press the button'.

For instance, the agreement may be to automatically discharge their battery in response to signals sent from the network or from an intermediary. In more sophisticated arrangements, the agreement may stipulate that the supplier's battery will only respond to the network business' signal under certain circumstances – such as if the operator consents via a smart phone app, for instance.

The nature of these agreements is likely to be highly varied. Indeed, one of the key areas of innovation in this space is how such arrangements are structured and executed.

In all cases, however, these contractual arrangements will encompass at least two factors: the service obligations of the supplier and the allocation of risk between supplier and purchaser, including the risk of non-delivery.

For the market for grid services to evolve in a manner that is suitably open to the participation of small-scale suppliers, the service obligations will need to be clear and reasonable. Put differently, suppliers of grid services must be clear on what they're 'signing up for'. This will be particularly germane to agreements that involve third party access to a supplier's home appliances, such as air-conditioning units, which have traditionally not been subject to external control in Victoria.[144]

In managing the grid, one of the key factors that network businesses must confront is the risk that, during a peak period, there will not be sufficient network capacity to meet demand for electricity. Network businesses operate under regulated performance targets that require them to manage this risk effectively. Traditionally, network businesses have managed this risk by building up the network to ensure it has sufficient capacity to cope even during the highest demand periods in any given the year.

For network businesses to instead rely on grid services to ensure the network can cope efficiently during peak demand is a significant departure from the traditional approach. It raises important questions about who bears the risk – for instance, in a circumstance in which the network business has engaged grid service suppliers to help manage network congestion – if the network becomes overloaded during a peak demand event.

It is therefore reasonable that any agreement to source grid services would entail an allocation of risk between the parties, and that network businesses would seek to protect themselves from risk of non-delivery leading to failure to meet their regulated performance targets.

However, it is equally important that this risk is allocated in a reasonable and transparent way. This extends to ensuring that risk allocation is not used to effectively close off opportunities for small-scale providers to participate as suppliers of grid services – by requiring suppliers to bear all risk of the network not being capable of meeting peak demand, for instance. It also includes reasonable consequences (including penalties) for non-delivery of services.

[144] Manipulating the thermostats of air-conditioning units to reduce their impact on peak demand is a form of demand response, which is another form of grid service that small scale suppliers might provide, alongside the services provided by their distributed generation unit. Note that air-conditioning units have been subject to direct load-control in places like Queensland, and hot water services in Victoria.

7.4.3 MARKET DESIGN (INCLUDING PRICING AND PAYMENT MECHANISMS)

Market design refers to how the market is structured, as well as the rules or conventions that define the interactions between parties. A market design may be externally imposed via regulation – as in the case of the electricity wholesale market – or it may emerge through the actions of private entities.

In figure 7.1, we set out, at a basic level, some of the potential market structures that may emerge in this context of grid services. We also noted that this is an area of considerable uncertainty. The final market structure will be influenced by the customer preferences, the evolution of commercial models and technologies, and the nature of commercial opportunities – in short, many of the unresolved issues discussed above. Where relevant, it may also be shaped by the policy priorities of governments and regulators.

This uncertainty notwithstanding, there are three key questions that are particularly germane to the long term evolution of the market:

- the need for independent market facilitation
- the nature of the pricing and payment mechanisms that underpin transactions in the market and
- issues associated with low levels of competition.

INDEPENDENT MARKET FACILITATION

Some discussions of the market for grid services posit the need for an independent market facilitator. This concept is often couched in terms of whether the grid will eventually require a 'distribution system operator' (DSO). Although models vary, the role of such a facilitator may be broadly analogous to the role played by AEMO within the National Electricity Market.

In the grid services context, a market facilitator might be charged with facilitating transactions of buyers and sellers of grid services across a dedicated platform, market clearing and price discovery functions, settlement services, and monitoring participant conduct.

Whether the market for grid services requires independent facilitation, and what roles a facilitator has, are important questions for the long term evolution of the market. However, they go to more fundamental questions about the wider evolution of the utility models that underpin our current electricity system – such as those being explored through the AEMC's Distribution Market Model project – and thus are beyond the scope of this review.

Being long term considerations, these questions do not need to be resolved prior to contemplating smaller 'no regrets' steps to support the emergence of the market. However, they should be kept in mind as the market continues to evolve.

PRICING AND PAYMENT MECHANISMS

As this inquiry has demonstrated, identifying and measuring the network benefit provided by small-scale distributed generators (and other forms of grid service provider) is a technically complex undertaking. Given this complexity, a key issue for the success of a market for grid services is establishing a credible mechanism for pricing the services traded.

This entails ensuring that prices compensate the value being provided, taking into account both the benefits and costs involved in the supply of grid services by small-scale distributed generators.

Notionally, if the market is sufficiently liquid – insofar as the range of buyers and sellers is concerned – then it would be competitive enough to produce efficient prices. However, there are good reasons to doubt that this expectation is reasonable in this context, particularly in the short term.

To facilitate efficient transactions, a market for grid services must overcome a number of impediments and complexities, including:

- **Information asymmetry** – Network businesses are likely to have considerably richer information about value opportunities, particularly on a technical level, than small-scale grid service suppliers. Conversely, information about a small-scale supplier's willingness to supply a service may be hidden from the network business.
- **Coordination complexities –** Inherent in the notion of a market for grid services that includes small-scale suppliers is the challenge of coordinating a large number of actors.

- **Policy/regulatory complexity** – Small-scale suppliers of grid services are likely to also be energy customers who, on the 'other side' of their interactions with network businesses, will be paying network charges for the energy they consume. The type of network tariff they are on will influence whether they are imposing a net benefit or cost on the network when they supply grid services. Meanwhile, network businesses are subject to a complex array of regulations that influence their ability and incentives to procure grid services**.**
- **Monopoly purchasers** – In any given geographic area, there is, ultimately, only one purchaser of grid services: the region's monopoly distribution network service provider (network business). Their position as the sole buyer may allow network businesses to develop an undue ability to influence prices in their favour.[145]
- **Technical complexities –** Determining the full scope of the value of the grid services provided by any given distributed generator is a technically complex task, requiring deep knowledge of the operation of network infrastructure and the planning process.
- **Lumpy capital –** A primary form of grid service is likely to be the management of network congestion. In this context, the value is derived from the deferral of network upgrade projects. Because the capital investment requirement for these upgrade projects is large and indivisible, it is challenging to apply traditional investment criteria, in which marginal benefits are compared with marginal costs, to estimate the value of these services into the future.

Given these complexities, consideration should be given to whether specific market mechanisms – such as specifically designed auctions – should be put in place to structure the process of revealing prices and facilitating settlement. This may be necessary to ensure that these complexities and impediments are overcome in an efficient way.

Short of a designed pricing mechanism, the methodologies that underpin network businesses' approach to pricing should be transparent in order to build confidence of parties engaged in the market.

[145] In economic terms, a monopoly purchaser is referred to as a monopsony.

INADEQUATE COMPETITION BETWEEN GRID SERVICE PROVIDERS

We have identified two issues that may emerge if there is insufficient competition in the grid services market.

The first issue is the potential for 'local monopolies' to emerge in the intermediary market. In this scenario, a small number of intermediaries gain access to large portfolios of distributed generation systems in a given geographic area. Once these fleets are 'recruited' to a given intermediary, particularly if the recruitment process has involved the installation of proprietary hardware, it may prove costly for any other intermediary to establish themselves in that area.

This may be exacerbated if the network business and intermediary invest in technologies to enable the interoperation of their systems on the basis of proprietary communication protocols. The search and switching costs involved in changing supplier may mean the intermediary enjoys advantages that allow it to extract additional value from both ends of the grid services supply chain.

The second issue arises as a result of the manner in which opportunities for grid services are advertised to the market. The regulatory framework is increasingly geared towards requiring network businesses to publish information about looming constraints, as well as the estimated cost of responding to the constraint.

In a highly competitive market for grid services, multiple suppliers would vie to provide the congestion management services required to defer the network upgrade. In this scenario, competitive pressures would ensure that the network upgrade was deferred at the lowest possible cost, as the grid service suppliers would seek to outbid their competitors.

This can be compared to a scenario in which only one grid service provider – an intermediary, for instance – is capable of supplying network businesses the solution to the constraint. This is essentially a bilateral monopoly situation, the outcome of which is difficult to determine and may not lead to efficient outcomes.

While this issue may be an inevitable part of the market's evolution, it may indicate the value of supporting the emergence of a diverse set of suppliers of grid services.

7.4.4 TECHNICAL FACTORS

One driver of the market for grid services is technological, particularly for the control and coordination of multiple distributed generators. Improving technologies allow operations to occur cheaply and easily that were once too complex or expensive to contemplate.

As these technologies evolve, challenges of interoperability are likely to emerge. For instance, different distributed generators may be controlled by different proprietary software. Intermediaries may develop technology platforms through which to coordinate multiple distributed generators, thereby establishing another layer of software systems. These platforms may also be expected to link to platforms developed by technology or electronics companies – such as those designed for control of the 'internet of things' enabled appliances like refrigerators or air-conditioners. And some or all of these technologies may be required to interface with the information and communications technology (ICT) systems of network businesses.

In the context of this diversity of ICT systems, ensuring systems can efficiently interact – that is, ensuring they are sufficiently interoperable – may emerge as a challenge.

This is a common issue in the ICT industry, particularly as new technologies are emerging. Typically, it is resolved through the development of standards, which establish a set of common specifications to which all industry members adhere. An example of a standard is Universal Serial Bus, or USB, an industry standard that defines the connection protocols for a common form of computer cable.

Standards can be established via formal, government endorsed standards setting processes, such as those managed by Standards Australia. For instance, a standard currently used by network businesses is AS/NZ4755, which describes a protocol for simple control of demand management enabled devices.[146]

[146] Standards Australia 2016, *Demand response capabilities and supporting technologies for electrical products - Demand response framework and requirements for demand response enabling devices (DREDs)*, AS/NZS 4755.1:2016, August.

Alternatively, standards can emerge through industry consensus, and may be subject to patent or be 'open' and therefore available for any entity to use without incurring cost.

Whichever form the relevant standards take, for the market for grid services to emerge efficiently – and for the full value of the new technologies to be realised – it will be necessary for standards to be established. This will apply particularly to any application programming interfaces (APIs) that are used to facilitate communication across platforms.

7.4.5 CUSTOMER PROTECTIONS, ENTITLEMENTS AND OPPORTUNITIES

Small-scale providers of grid services are, in many cases, likely to be energy customers who have installed specialised equipment in their homes, whether solar PV and battery systems, 'internet of things' enabled appliances such as 'smart fridges', or potentially electronic vehicles. This means their interaction with the network businesses will be simultaneously as a customer (as a purchaser of electricity that travels through the network) and a supplier (as a provider of services for the management of the grid).

As energy customers, individuals are entitled to a range of protections under the Energy Retail Code. As customers make the investments necessary to engage in the market for grid services as suppliers, it will be important to ensure their customer protections are not undermined. It is also important to ensure their ability to participate effectively in the electricity retail market, or to derive other revenue streams from their investment, is not impaired.

We have identified four main scenarios in which customers' interests may be undermined if safeguards are not developed. These scenarios relate to the following:

- Retaining access to customer protections
- Retaining ability to participate effectively in the electricity retail market
- Optimising revenue potential of distributed generation systems and
- Privacy and security risks.

Each of these issues is discussed below.

RETAINING ACCESS TO CUSTOMER PROTECTIONS

There is around 930 MW of small-scale distributed generation capacity currently installed in Victoria.[147] Many of these distributed generation systems are owned and operated by household or residential electricity customers. In a market for grid services, it is likely that a majority of distributed generation owners will participate via a third-party intermediary.

Current relationships between industry parties and customers are afforded protection under existing consumer protection regimes. All consumers are generally protected under the Australian Consumer Law, and Victorian energy customers are afforded protections under the Energy Retail Code.

In a future market for grid services, intermediaries could offer new types of energy products to potential distributed generation investors, and the treatment of these products within current regulatory frameworks is unclear. The potential risks for distributed generation owners (who are also electricity customers) may include inadequate protections relating to those in financial difficulty, or facing unregulated marketing of new energy products (particularly products that have costly or lengthy contractual obligations).

Protections are critical in building confidence of participants in the market, particularly for small-scale providers such as distributed generation owners. The importance of customer protections was recognised in the latest Financial System Inquiry, which remarked that:

> *A market economy operates more effectively where participants enter into transactions with confidence they will be treated fairly... This includes providing consumers with clear information about risks; competent, good-quality [services] that takes account of their circumstances; and access to timely and low-cost alternative dispute resolution and an effective judicial system*.[148]

[147] Small scale distributed generation refers to systems with a capacity of less than 100 kilowatts (kW). The data are Commission estimates based on Victorian data for eligible small-scale solar PV, wind and hydro under the Small-scale Renewable Energy Scheme from the Clean Energy Regulator 2016, *Postcode data for small-scale installations*, March, and additional data provided by Victorian distribution network service providers (DNSPs) for the purposes of this inquiry.

[148] Australian Government 2014, *Financial System Inquiry – Final Report,* November 2014, p. 6.

It is likely that consumer protection frameworks will need to be updated in line with innovation and emerging energy markets, such as the market for grid services, to preserve customer confidence in the changing industry. An examination of current customer protection frameworks will identify whether small-scale providers of grid services require additional or different customer protections. The Commission's early work on the energy licensing framework review have also addressed aspects of these issues to some extent. Other organisations such as the Consumer Action Law Centre have also considered the potential issues related to consumer protections in an evolving energy market.[149]

RETAINING ABILITY TO PARTICIPATE EFFECTIVELY IN THE ELECTRICITY RETAIL MARKET

In one potential scenario, energy retailers fulfil the role of intermediaries within the grid services market. Within their wider product offering, retailers may package up energy services, energy technologies and distributed generation. In the process the retailer may defray some of their costs by establishing the customer as a supplier of grid services and mediating the relationship with the retailer.

Depending on how the grid services contract is set up, the customer may find themselves locked into a long-term agreement with their network – mediated by the retailer – that effectively ties them to their retailer. This would effectively preclude that customer from participating freely in the electricity retail market for the duration of the grid services contract.

OPTIMISING REVENUE POTENTIAL OF DISTRIBUTED GENERATION SYSTEMS

Many of the technologies that allow distributed generation systems to provide grid services are also able to provide other benefits across other markets. The ability to capture and deliver all of these benefit streams is known as 'benefit-stacking'. Benefit streams might include data capture and analysis, enhanced appliance services and reduced energy costs (or managing wholesale energy price risk).

[149] Consumer Action Law Centre 2016, *Power Transformed – Unlocking effective competition and trust in the transforming energy market*, July.

For example, an intermediary business could co-ordinate a fleet of solar PV and battery systems whilst capturing a range of benefit streams simultaneously. The intermediary could receive payments for each benefit stream, such as managing wholesale energy costs fluctuations,[150] and providing grid services at the request of a network business. In this example, the intermediary is able to stack a range of benefits together and receive a payment for each.

The ability of customers, or their agents, to effectively 'stack' the benefits of their distributed generation system may be impaired in some scenarios. For instance, network businesses (or their ring fenced affiliates) may develop relationships directly with customers and engage them to supply grid services. However, a customer's ability to capitalise on the other revenue streams opportunities may be limited if their agreement with the network business obliges them to prioritise the provision of grid services over other services (such as energy trading).

The failure to optimise and benefit-stack could lead to an inefficient economic outcome for the energy supply chain as a whole. The current regulatory framework in Australia does not facilitate benefit-stacking in Victoria, particularly for energy-related benefit streams. Network businesses are prevented from selling energy and so cannot directly capture wholesale market energy benefits. The converse is generally true for retailers, being unable to capture grid services benefits.[151]

A related issue is where one participant may be able to 'free-ride' from the actions of another. For example, a fleet of co-ordinated battery systems in a network congested area could respond to high wholesale prices to reduce energy costs. But this could reduce network congestion and potentially provide a free grid service to a network business. 'Free-riding' may discourage sellers from participating in the market for grid services.

It is therefore important to consider what market arrangements will best allow full optimisation of distributed generation systems, from both an individual customer and system wide perspective. An independent market facilitator whose remit is to transact

[150] A potential way to manage wholesale energy price risk is for aggregators to discharge batteries when NEM prices are high.

[151] There are exceptions, such as where a DNSP reaches a deal with an intermediary to provide grid services.

services between energy market, ancillary services, network and customer preferences could be the foundation for a market structure that keeps benefit streams transparent and available for transaction.

PRIVACY AND SECURITY RISKS

A market for grid services is likely to involve new technology, particularly involving the internet and the conveying of large amounts of data (even at a personal or household level) between market participants. It is also likely that internet-based platforms will be used to co-ordinate large fleets of individual distributed generation systems or devices.

Managing cyber security will grow in importance as internet-based platforms develop. For instance, at a network-wide level, the intentional manipulation of a fleet of distributed generation systems simultaneously could result in black-outs or even state-wide grid instability. The market for grid services will need to develop with a view to manage the vulnerability of critical infrastructure to criminal activity.

Additionally, smart devices installed with distributed generation systems are likely to record large amounts of data and store it to remote servers, potentially outside of Australia. The increasing access to such data can expose customers to risks relating to data privacy and security. For instance, the criminal hacking of distributed generation systems and its associated data could create serious nuisances for individuals.

7.5 CONCLUSION

The market for grid services is a term that describes the arena in which network businesses sources and transacts the services required to manage the grid. As technology improves, small-scale distributed generators will be increasingly capable of providing these services. This chapter has briefly explored the potential evolution of such a market in Victoria, and the attributes it would need in order for small-scale distributed generators (and other small-scale providers of grid services) to participate effectively. It also identifies some of the issues that will need to be resolved as the market evolves.

8 PRACTICAL STEPS

8.1 INTRODUCTION

Building on our analysis from chapters 4 through to chapter 7, this chapter presents a proposed way forward with regard to supporting the development of a market for grid services in Victoria.

8.2 PROPOSED WAY FORWARD

A fully developed market for grid services may be many years in the future. At this stage it may be too early to identify specific regulatory reforms that are necessary to enable its emergence. However, Victoria is well placed to become a leading jurisdiction in this area, largely because one of the key enablers – widespread penetration of advanced metering infrastructure (AMI) (smart meters) – is already in place. If the right steps are taken, Victorian distributed generators may be amongst the first to access, on an effective and efficient basis, remuneration for the network value of their investment.

The scale of this endeavour should not be underestimated. Developing a fully mature market for grid services involves efficiently integrating thousands of small distributed generators – possibly tens of thousands – into the management of the grid. The technical challenges of this alone are significant, to which myriad commercial and regulatory challenges are added. Our analysis leads us to conclude that the development of a market for grid services warrants careful and sustained analysis, consultation and planning. It is not a minor reform, but rather a material step towards ensuring the ongoing energy industry transformation unfolds in an efficient and equitable manner.

Various processes occurring at the national level are investigating reforms that may assist with the emergence of the market for grid services. Some commenced or were publically announced following the release of our Stage 2 Draft Report in October 2016. Significant among those are the Australian Energy Market Commission's Distribution Market Model project, rule change requests on the contestability of energy services and demand response and network support, and the Network Transformation Roadmap project being delivered by Energy Networks Australia and CSIRO. These processes and developments may address some of the issues we have identified in this report, although their outcomes and their timing are uncertain.

For such a market to emerge that enables participation by small scale operators, a great deal of commercial and technological detail needs to be addressed. This includes how regulated entities would participate in such a market. We are not confident that a market of this nature will emerge without some external assistance, but nor are we certain that this won't be the case. Some elements may need external assistance while others may not. A work program aimed at facilitating the emergence of a market should proceed in carefully sequenced stages so as not to preclude the opportunity for a market to emerge of its own accord. It should also account for developments in the national framework.

Progressing the development of market for grid services in which small-scale operators can engage will require a work program consisting of the following elements.

- A focus on promoting the availability of appropriate information for all existing and potential market participations – including information about the opportunities to supply grid services – taking into account the need to ensure the relevant information is available in the appropriate form and at an appropriate time. In the context of the information asymmetry that currently exists between network businesses and small-scale distributed generation owners, consideration should be given to balancing the need for clear, simple, location-specific information against costs to network businesses of providing that information.
- A review of the means by which customers can access the market for grid services as suppliers, including the reasonableness and clarity of the technical and contractual requirements for participation, and the associated allocation of risk between parties. As part of this review, consideration should be given to the question of whether standardised arrangements are warranted.

- An investigation of the design of potential market mechanisms, including auctions, to ensure prices are revealed in a robust and efficient manner and account for the benefits provided by distributed generators, in the context of network tariff arrangements. Such mechanisms could be designed in such a way as not to preclude the participation of all forms of demand side participation, and could be designed to be scalable and thus inform the development of similar mechanisms at a national level. Consideration should be given to ensuring such mechanisms do not preclude efficient ‘stacking’ of revenue streams from distributed generation, including the revenue derived from sales of energy, and the risks of inadequate competition.
- A focus on promoting the establishment of technical standards to support the interoperability of relevant technologies, such as solar photovoltaic (PV) systems, energy storage devices (batteries), energy management systems, inverters, appliances, and platforms. Such standards may be supported via a formal Australian Standards process or may be supported to emerge via the coordination of private actors within the market.
- A review of existing customer protections to ensure customers are empowered to provide grid services while maintaining their ability to participate in the retail market in an effective and efficient way. Privacy and cyber security risks associated with a data-driven market should also be considered.
- Facilitation of grid services market trials and pilots in Victoria in order to progress the practical deployment of grid services market elements and mechanisms. Pilots could be focused on advancing understanding – for commercial operators, policymakers and regulators – of key elements of the market, such as platform development and interoperability issues, product specification (including ancillary services based products, such as coordinated voltage control), pricing mechanisms, customer interactions, and associated risks.

Finding 10: Proposed way forward

Progressing the development of a market for grid services in which small-scale operators can engage will require a work program consisting of the following elements.

- A focus on promoting the availability of appropriate information for all existing and potential market participations – including information about the opportunities to supply grid services – taking into account the need to ensure the relevant information is available in the appropriate form and at an appropriate time.
- A review of the means by which customers can access the market for grid services as suppliers, including the reasonableness and clarity of the technical and contractual requirements for participation, and the associated allocation of risk between parties.
- An investigation of the design of potential market mechanisms, including auctions, to ensure prices are revealed in a robust and efficient manner and account for the benefits provided by distributed generators, in the context of network tariff arrangements.
- A focus on promoting the establishment of technical standards to support the interoperability of relevant technologies, such as solar photovoltaic (PV) systems, energy storage devices (batteries), energy management systems, inverters, appliances, and platforms.
- A review of existing customer protections to ensure customers are empowered to provide grid services while maintaining their ability to participate in the retail market in an effective and efficient way.
- Facilitation of grid services market trials and pilots in Victoria in order to progress the practical deployment of grid services market elements and mechanisms.

APPENDIX A – TABLE OF RESULTS

This appendix presents an extract of the results from the valuation method applied in this inquiry. It inventories the value of the forecast benefit of reduced network congestion caused by distributed generation in Victoria in 2017, presented by zone substation.

The quoted figures incorporate the value of the forecast benefits caused by distributed generation at transmission, sub-transmission and zone substation assets. It does not include the value of the effect of distributed generation on the low voltage distribution network, as this was not possible to calculate on the basis of publicly available data.

Table A.1 should be read as follows:

- The first column of results is the value provided by existing and forecasted solar PV systems in 2017. The value is a $/kW of solar PV installed capacity.
- The second column of results is the potential value provided by an additional megawatt (MW) of solar PV system capacity installed on the network in 2017. The value is a $/kW of installed solar PV capacity. Note that it is not possible to deduce the value of a single, say 3 kW, system of solar PV from this figure. The value provided is a function of the size of the increment that was used for the calculation (i.e. +1 MW of capacity). Adding differently sized increments would produce a different average per kW value.
- The third column of results is the potential value provided by an additional megawatt of network-optimised system[152] capacity installed on the network in 2017. The value is a $/kW of installed system capacity. Note that it is not possible to deduce the value of a single 'network optimised' distributed generation system from

[152] A 'network optimised' system is one that provides firm output during periods of network congestion.

this figure. The value provided is a function of the size of the increment. Adding differently sized increments would produce a different average per kW value.

- The final column of results is the ratio of value from an additional megawatt capacity network-optimised system compared to a solar PV system.

TABLE A1 NETWORK VALUE IN 2017, BY ZONE SUBSTATION
($/kW of capacity of distributed generation system)

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Airport West	$9.48	$6.90	$37.41	5.4
Albert Park	-	-	-	-
Altona	-	-	-	-
Altona Chemicals	-	-	-	-
Ararat	$0.01	$0.00	$0.04	10.5
Armadale	$1.64	$1.23	$3.90	3.2
Bacchus Marsh	-	-	-	-
Bairnsdale	$0.91	$0.49	$2.33	4.8
Balaclava	$1.64	$1.23	$3.84	3.1
Ballarat North	$0.01	$0.00	$0.04	10.5
Ballarat South	$0.38	$0.02	$0.75	30.9
Barnawatha	$35.45	$25.82	$178.19	6.9
Bayswater	-	-	-	-
Beaumaris	-	-	-	-
Belgrave	-	-	-	-
Benalla	$0.93	$0.42	$3.13	7.4
Bendigo	$0.42	$0.11	$0.82	7.6
Bentleigh	-	-	-	-
Berwick North	$0.34	$0.17	$0.92	5.4
Boronia	-	-	-	-
Boundary Bend	$0.60	$0.30	$1.11	3.7
Bouverie Queensberry	$1.64	$1.23	$3.84	3.1
Bouverie St/ Queensberry	$1.64	$1.23	$3.84	3.1
Box Hill	-	-	-	-
Braybrook	$9.48	$6.90	$37.41	5.4
Bright	$0.00	-	$0.04	-

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Broadmeadows	-	-	-	-
Broadmeadows South	-	-	-	-
Brunswick	-	-	-	-
Brunswick	-	-	-	-
Bulleen	-	-	-	-
Burwood	-	-	-	-
Camberwell	$1.64	$1.23	$3.84	3.1
Camperdown	$1.05	$0.78	$53.50	69.0
Cann River	$0.95	$0.46	$2.08	4.6
Carrum	-	-	-	-
Castlemaine	$0.32	$0.06	$0.93	15.6
Caulfield	$0.30	$0.24	$2.43	9.9
Celestial Avenue	$0.05	$0.05	$0.11	2.3
Charam	-	-	-	-
Charlton	$0.28	$0.06	$0.63	10.8
Cheltenham	-	-	-	-
Chirnside Park	-	-	-	-
Clarinda	-	-	-	-
Clover Flat	-	-	-	-
Clyde North	$9.40	$5.10	$32.29	6.3
Cobden	$1.05	$0.78	$53.50	69.0
Cobram East	-	-	-	-
Coburg North	-	-	-	-
Coburg South	$0.03	$0.02	$0.15	6.3
Cohuna	-	-	-	-
Colac	-	-	-	-
Collingwood	$1.64	$1.23	$3.84	3.1
Collingwood	$1.64	$1.23	$3.84	3.1
Coolaroo	-	-	-	-
Corio	-	-	-	-
Cranbourne	-	-	-	-
Croydon	-	-	-	-
Dandenong	-	-	-	-
Dandenong South	-	-	-	-
Dandenong Valley	-	-	-	-
Deepdene	-	-	-	-

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Dock Area	$0.00	$0.00	$0.16	50.1
Docklands	-	-	-	-
Doncaster	$0.01	$0.01	$0.09	13.5
Doreen	$1.34	$1.24	$20.11	16.2
Dromana	$0.04	$0.04	$0.53	15.3
Drysdale	$0.66	$0.36	$1.88	5.2
Eaglehawk	$0.47	$0.09	$0.95	10.4
East Burwood	-	-	-	-
East Malvern	-	-	-	-
East Preston (66/22 kV)	-	-	-	-
East Preston Switch House A	-	-	-	-
East Preston Switch House B	-	-	-	-
Echuca	$6.61	$13.48	$43.77	3.2
Elsternwick	-	-	-	-
Eltham	-	-	-	-
Elwood	$1.64	$1.23	$3.84	3.1
Epping	$0.23	$0.13	$0.91	6.9
Essendon	$9.48	$6.90	$37.41	5.4
Fairfield	-	-	-	-
Ferntree Gully	-	-	-	-
Fishermans Bend	-	-	-	-
Fishermans Bend (2)	-	-	-	-
Fitzroy	-	-	-	-
Flemington	-	-	-	-
Flinders/Ramsden	$1.94	$1.50	$4.77	3.2
Footscray East	-	-	-	-
Footscray West	-	-	-	-
Ford North Shore	-	-	-	-
Foster	$0.86	$0.45	$1.99	4.4
Frankston	-	-	-	-
Frankston South	-	-	-	-
Gardiner	$1.64	$1.23	$3.85	3.1
Geelong	$0.11	$0.03	$0.20	7.8
Geelong B	-	-	-	-
Geelong City	$0.10	$0.05	$0.17	3.6
Geelong East	-	-	-	-

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Gisborne	$9.48	$6.90	$37.41	5.4
Glen Waverley	-	-	-	-
Hamilton	$1.05	$0.78	$53.50	69.0
Hampton Park	-	-	-	-
Hastings	-	-	-	-
Heatherton	-	-	-	-
Heidelberg	-	-	-	-
Horsham	-	-	-	-
Kalkallo	$0.23	$0.13	$109.83	839.2
Kew	$0.10	$0.09	$0.43	4.6
Keysborough	-	-	-	-
Kilmore South	$4.81	$0.29	$2.22	7.7
Kinglake	$5.19	$0.29	$2.22	7.7
Koroit	$1.05	$0.78	$53.50	69.0
Kyabram	$0.00	-	-	-
Lang Lang	$0.34	$0.17	$0.92	5.4
Langwarrin	-	-	-	-
Laurens Street	-	-	-	-
Laverton	$6.37	$14.44	$118.13	8.2
Laverton North 11	$1.69	$0.78	$4.67	6.0
Laverton North 22	$1.69	$0.78	$4.67	6.0
Leongatha	$0.86	$0.45	$1.99	4.4
Lilydale	-	-	-	-
Little Bourke Street	-	-	-	-
Little Queen	-	-	-	-
Lyndale	-	-	-	-
Lysterfield	$0.34	$0.18	$1.00	5.5
Maffra	$0.91	$0.49	$2.33	4.8
Mansfield	-	-	-	-
Maryborough	$1.30	$0.47	$6.34	13.5
McIllwraith Place	$1.64	$1.23	$3.84	3.1
Melton	$9.48	$6.90	$37.41	5.4
Mentone	-	-	-	-
Merbein	$0.60	$0.30	$1.11	3.7
Merrijig	$2.81	$1.78	$32.91	18.4
Mildura	$0.78	$0.36	$1.30	3.6

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Moe	$0.86	$0.45	$1.99	4.4
Montague	-	-	-	-
Moorabbin	-	-	-	-
Mooroopna	$1.27	$0.76	$3.78	5.0
Mordialloc	-	-	-	-
Mornington	-	-	-	-
Morwell	$0.86	$0.45	$1.99	4.4
Mt Beauty	-	-	$10.55	-
Mulgrave	-	-	-	-
Murrindindi	$4.81	$0.29	$2.22	7.7
Myrtleford	$0.00	-	$0.04	-
Narre Warren	$0.34	$0.17	$0.92	5.4
Newmerella	$0.86	$0.45	$1.99	4.4
Newport	-	-	-	-
Nhill	$0.02	$0.01	$0.19	17.6
Noble Park	-	-	-	-
North Brighton	-	-	-	-
North Essendon	-	-	-	-
North Heidelberg	-	-	-	-
Northcote	$0.07	$0.04	$2.68	61.6
Notting Hill	$0.01	$0.01	$0.04	3.6
Nth Richmond	$1.64	$1.23	$3.84	3.1
Numurkah	$0.05	$0.01	$0.31	55.4
Nunawading	-	-	-	-
Oakleigh	-	-	-	-
Oakleigh East	-	-	-	-
Officer	$0.34	$0.17	$0.92	5.4
Ormond	-	-	-	-
Ouyen	-	-	-	-
Pakenham	$0.34	$0.17	$0.92	5.4
Pascoe Vale	$9.48	$6.90	$37.41	5.4
Phillip Island	$5.54	$2.30	$47.85	20.8
Port Melbourne	-	-	-	-
Portland	$1.05	$0.78	$53.50	69.0
Prahran	$1.64	$1.23	$3.84	3.1
Preston	-	-	-	-

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Richmond	$4.61	$4.07	$13.43	3.3
Ringwood North	-	-	-	-
Riversdale	$0.06	$0.06	$0.38	6.6
Robinvale	$0.60	$0.30	$1.11	3.7
Rosebud	$0.08	$0.05	$0.57	11.2
Rubicon 'A'	$4.81	$0.29	$2.22	7.7
Russell Place	$1.64	$1.23	$3.84	3.1
Sale	$0.91	$0.49	$2.33	4.8
Sandringham	-	-	-	-
Seymour	$4.81	$0.29	$2.22	7.7
Shepparton	$0.00	$0.00	$0.01	4.1
Shepparton North	$0.76	$0.36	$1.15	3.2
Somerton	$0.23	$0.13	$0.91	6.9
Sorrento	-	-	-	-
South Melbourne	-	-	-	-
South Morang	$0.23	$0.13	$0.91	6.9
Southbank	-	-	-	-
Spencer Street	-	-	-	-
Springvale South	-	-	-	-
Springvale/Springvale West	-	-	-	-
St Albans	$12.63	$9.33	$68.95	7.4
St Kilda	$1.66	$1.24	$3.92	3.2
Stanhope	-	-	-	-
Stawell	$0.06	$0.04	$0.24	6.7
Sunbury	$9.48	$6.90	$37.41	5.4
Sunshine	$13.24	$8.45	$49.87	5.9
Sunshine East	$9.64	$6.96	$37.59	5.4
Surrey Hills	-	-	-	-
Swan Hill	$5.06	$0.18	$0.99	5.4
Sydenham	$9.49	$6.91	$37.48	5.4
Tavistock Place	-	-	-	-
Terang	$1.05	$0.78	$53.50	69.0
Thomastown	$18.11	$2.36	$8.03	3.4
Toorak	$1.64	$1.23	$3.84	3.1
Tottenham	-	-	-	-
Traralgon	$0.91	$0.49	$2.33	4.8

Zone Substation Name	Existing and forecast solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of solar PV systems ($/kW installed solar PV capacity)	+1 MW capacity of network-optimised systems ($/kW installed capacity)	Ratio of network-optimised to solar PV value (#)
Tullamarine	$9.48	$6.90	$37.41	5.4
Victoria Market	-	-	-	-
Wangaratta	$0.03	$0.03	$0.16	5.9
Warragul	$1.12	$0.56	$2.85	5.1
Warrnambool	$1.05	$0.78	$53.50	69.0
Watsonia	-	-	-	-
Waurn Ponds	$0.45	$0.16	$0.63	3.9
Wemen	$4.19	$4.11	$22.80	5.5
Werribee	$12.47	$1.65	$23.83	14.5
West Brunswick	$0.11	$0.09	$0.32	3.5
West Doncaster	-	-	-	-
Westgate	-	-	-	-
Winchelsea	-	-	-	-
Wodonga	$13.93	$8.39	$28.92	3.4
Wonthaggi	$1.77	$0.92	$10.20	11.1
Woodend	$9.48	$6.90	$37.41	5.4
Woori Yallock	-	-	-	-
Yarraville	-	-	-	-

Data source: Jacobs

APPENDIX B – TERMS OF REFERENCE

TERMS OF REFERENCE – INQUIRY INTO THE TRUE VALUE OF DISTRIBUTED GENERATION TO VICTORIAN CONSUMERS

The Andrews Labor Government recognises the importance of renewable energy for Victoria. We acknowledge sustainable sources of energy can deliver economic, environmental and social benefits to the State, including jobs for regional Victoria.

The Labor Government is acting to support the growth of renewable energy in Victoria through a suite of policy measures. These include:

- Establishing a renewable energy target of no less than 20 per cent by 2020.
- Using the government's electricity purchasing power to support the creation of hundreds of renewable energy jobs.
- Ending unfair discrimination for solar customers.
- Helping communities to transition to a clean energy future.
- Improving access to the grid for solar customers.
- Developing a Renewable Energy Action Plan.

Supporting clean energy jobs through the $20 million New Energy Jobs Fund.

An important source of renewable energy for Victoria is distributed generation, such as household solar systems. In Victoria, there are over 245,000 solar systems installed across the State, with a total generation capacity of over 700 megawatts.

The Labor Government believes Victorians with small-scale renewable energy generation should be fairly compensated for the value their generation provides. In Opposition, we committed to undertake an inquiry into the true value of distributed generation. In Government, we are getting on with it, and asking the Essential Services Commission to commence this inquiry.

The inquiry will seek to ascertain the true value of distributed generation, including determining what value distributed generation provides to the electricity market and the network. The Essential Services Commission will also be asked to consider the environmental and social value of distributed generation.

The findings of the inquiry will help inform the design of the feed-in-tariff arrangements in Victoria and assess current frameworks for the compensation of network value of distributed generation by relevant Victorian Electricity Industry Guidelines and the National Electricity Rules.

SCOPE OF THE INQUIRY

The inquiry will:

1. Examine the value of distributed generation including: the value of distributed generation for the wholesale electricity market; the value of distributed generation for the planning, investment and operation of the electricity network; and the environmental and social value of distributed generation.
2. Assess the adequacy of the current policy and regulatory frameworks governing the remuneration of distributed generation for the identified value it provides.
3. Make recommendations for any policy and or regulatory reform required to ensure effective compensation of the value of distributed generation in Victoria. These recommendations should have regard to the most appropriate policy and regulatory mechanisms for compensating different benefits of distributed generation, including considering their practicality and costs.

The inquiry will not consider the policy and regulatory frameworks governing the costs of connecting distributed generation to the network. The inquiry will also not consider whether the feed-in-tariff should be deregulated.

The inquiry should have regard to reviews and reports completed in Victoria and other jurisdictions which may be relevant to the objectives of this inquiry.

The inquiry will involve extensive consultation with industry, environmental organisations and consumer advocacy groups.

STRUCTURE OF THE INQUIRY

PART 1. THE TRUE ENERGY VALUE OF DISTRIBUTED GENERATION

This part of the inquiry will examine the social, environmental, locational and temporal value of energy produced by distributed generation. The analysis will be completed in time to inform the next FiT decision in August 2016 (for effect in calendar year 2017).

The outputs of this part of the inquiry are:

- Output 1: Approach Paper

This Paper should be presented to Government by the end of 2015.

- Output 2: Draft Part 1 Report into the true energy value of distributed generation

This Report should be presented to Government by April 2016.

- Output 3: Final Part 1 Report

This Report should be presented to Government by August 2016.

PART 2. THE TRUE NETWORK VALUE OF DISTRIBUTED GENERATION

This part of the inquiry will seek to account for the impact on the network of investment in distributed generation.

The outputs of this part of the inquiry are:

- Output 4: Discussion Paper on network value of distributed generation

This Paper should be presented to Government in the first half of 2016.

- Output 5: Draft Part 2 Report (methodology) on network value of distributed generation

This Report should be presented to Government by October 2016.

- Output 6: Final Part 2 Report (methodology) and on network value of distributed generation

This Report should be presented to Government by February 2017.

APPENDIX C – LIST OF REFERENCES

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