Solar Victoria Technology Guidelines

Guiding principles for technology within Solar Victoria's programs

Solar Victoria

VICTORIA State Government | Environment, Land, Water and Planning

Published May 2021

ISBN 978-1-76105-565-2 (pdf/online/MS word)

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Minister's foreword

With its ambitious renewable energy targets, Victoria is at the forefront of a remarkable global energy transformation. Through the Victorian Government's solar programs, households, businesses and industry are all playing a key part.

Since 2018, the $1.3 billion Solar Homes Program has been providing rebates that will enable the uptake of 778,500 solar systems, batteries and hot water systems over 10 years.

Already, rooftop solar is contributing to a significant increase in distributed generation, displacing centralised coal-fired generation and powering our state's energy transition while driving down emissions.

Solar Victoria's aims stretch beyond rebates. Alongside the Victorian Government's commitment to renewable energy generation is an outcomes-focused commitment to smarter energy use, and innovation that benefits all Victorians.

Solar technology is evolving at a remarkable pace, and by promoting grid integration and the enhanced features of modern Distributed Energy Resources (DER), there is an opportunity for distributed solar systems to collectively act as the largest single player in the electricity market.

The *Technology Guidelines* demonstrate how DER will be integrated into Victoria's electricity system of the future. They outline Solar Victoria's commitment to increase solar safety, performance and grid stability for the benefit of all energy participants. A strategic document, the *Technology Guidelines* detail how Victoria's solar programs promote innovation and send longer term market signals to encourage investment across the wider industry.

During this time of rapid change, the focus of Solar Victoria's programs is on quality and safety. Essential control measures around components, selection of equipment and installation practices are already embedded within the programs, alongside mandatory training for solar workers and eligibility requirements for approved products and systems that are beyond minimum industry standards.

But we're not stopping here. The *Technology Guidelines* create a framework to push safety, product stewardship and consumer outcomes even further over the life of our solar programs, as they incorporate new technology and innovative approaches to energy use and creation.

Victoria's energy transformation will lower emissions and energy bills. It will promote a fair and equitable energy landscape, one that is transparent and provides more participation opportunities for consumers. The Victorian Government is creating an electricity system for the future and Solar Victoria's programs are key pillars for this transition.

Hon Lily D'Ambrosio MP
Minister for Energy, Environment and Climate Change
Minister for Solar Homes

Technology Guidelines for Solar Victoria's programs

Driving the selection of technology supported by Solar Victoria to emphasise safety, quality, grid integration and innovation.

Victoria's Energy Future

The Solar Homes and Solar for Business Programs are among the most ambitious, transformative renewable energy programs in Australia. They are key initiatives in the Victorian Government's commitment to reduce energy costs, boost energy supply, create new jobs in the renewables sector and tackle climate change.

The programs provide rebates for rooftop solar, batteries and solar hot water systems, installed by accredited providers using approved products. Since launching in August 2018 with a remit to help Victorian households adopt solar energy technology, the Solar Homes Program has expanded to provide rebates for small business through a new Solar for Business Program. The Solar Homes and Solar for Business Programs will benefit 778,500 households and 15,000 small businesses.

Solar systems* provide benefits to all Victorians. Rooftop solar is contributing to Victoria's significant increase in distributed renewable electricity generation, which is rapidly displacing centralised coal-fired generation. These new systems can reduce electrical peak demand and help ensure associated grid upgrade costs are not passed on to energy consumers.

With the majority of Victoria's solar system installations now taking place within the framework of the Solar Homes Program, Solar Victoria is uniquely situated to strike the right balance between consumer access to the benefits of renewable energy, and maintaining and improving the stability and operation of the energy grid for all Victorians.

The *Technology Guidelines* outline the guiding principles that will drive the selection and evolution of technology within the Solar Homes and Solar for Business Programs. They emphasise safety, quality and innovation, and set out the priority areas for grid integration and stability.

By creating safety and quality benchmarks for retailers and installers that exceed industry standards, Solar Victoria and the *Technology Guidelines* ensure better outcomes for energy users.

The measures outlined in this document range from actions already being implemented, to important policy issues that will require further development and consultation to meet the needs of Victoria's energy transformation.

The priority areas are:

01 Ensure safety and quality of installations

02 Optimise integration with the grid

03 Maximise the benefits of generation through innovation

The *Technology Guidelines* align with Victoria's *Renewable Energy Roadmap* and other Department of Environment, Land, Water and Planning (DELWP) initiatives.

*Within this document 'solar systems' and 'solar products' are used as a collective term inclusive of solar panels, inverters, home solar batteries and solar hot water systems.

Background

The Solar Homes Program is one of several Victorian Government initiatives supporting Victorians to access more affordable, cleaner energy aimed at putting downward pressure on energy prices and decreasing Victoria's reliance on non-renewable sources of electricity.

The 10 year, $1.3 billion initiative will support 778,500 Victorian households to install solar photovoltaic (PV), solar hot water or solar battery systems at home, saving on their energy costs and reducing emissions. The program contributes to the Victorian Renewable Energy Targets of 40 per cent renewable energy by 2025 and 50 per cent renewable energy by 2030,[1] and the long-term Emissions Reduction Target (ERT) of net zero greenhouse gas emissions by 2050.[2] Over 10 years, the program will reduce Victoria's carbon emissions by almost 4 million tonnes – equivalent to taking one million of the state's 4.6 million cars off the road.

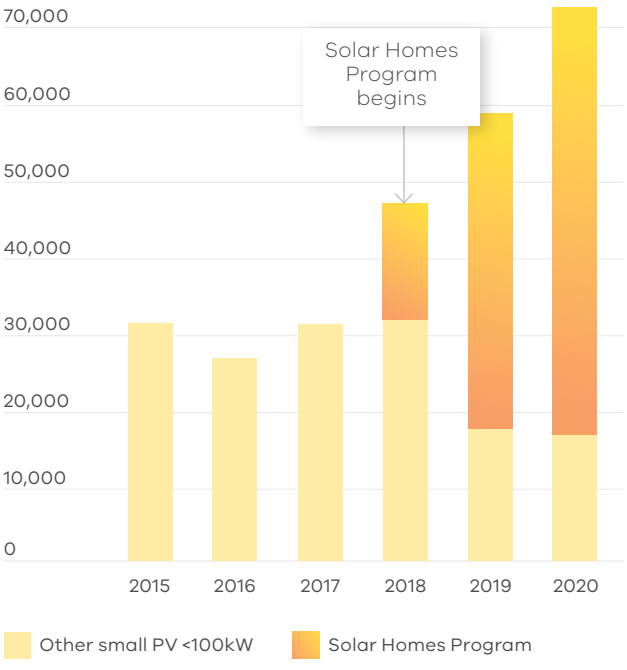
In Victoria, the program has been driving a clear increase in residential PV installations. In the second year of the Solar Homes Program, Victoria recorded an 87 per cent increase in residential PV installations compared to the year prior to launch. Despite the impacts of the COVID-19 pandemic, 2020 was a record year for solar in Victoria, with the Solar Homes Program responsible for approximately 80 per cent of all solar PV systems installed in the state. (see Figure 1).

By March 2021, more than 130,000 households had been supported with rebates to install solar PV, batteries and solar hot water systems. As well as contributing to renewable energy targets, these systems have a direct financial benefit for energy users. A typical Victorian household with a rooftop solar PV system can save up to $890 a year on average annual energy bills.[3]

The Solar for Business Program

The three-year Solar for Business Program launched in early 2021, giving eligible Victorian small businesses the opportunity to apply for a rebate to install solar PV at their business premises. This program supports up to 15,000 small businesses to reduce their energy costs as the Victorian economy recovers from the impact of COVID-19.

Figure 1 – Solar Homes contribution to all solar installations in Victoria, by year



1 Victorian Government Energy website https://www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-targets
2 Victorian Government Climate Change website https://www.climatechange.vic.gov.au/reducing-emissions/emissions-targets
3 St.Vincent de Paul Society 'An Update Report on the Victorian Tariff Tracking Project'. Available at https://www.vinnies.org.au/icms_docs/282472_Victorian_Energy_Prices_January_2018.pdf

Priority areas and guiding principles

Overview

Priority areas

01:
Ensure safety and quality of installations

02:
Optimise integration with the grid

03:
Maximise the benefits of generation through innovation

Guiding principles

01. Adopt leading safety and performance specifications
Implementing leading eligibility criteria above industry minimum standards, and leading product warranties for key products such as PV modules, inverters, solar batteries, solar hot water and auxiliary equipment (such as connectors, DC isolators, protection, smoke detectors, earthing and bonding).

02. Raise the industry benchmark for installations
Full system outcomes considering end-to-end consumer benefits, including raising the bar on installer safety training requirements, mandating compliance to industry leading codes of conduct, and leading work-quality warranty requirements and the promotion of quality assurance frameworks for businesses.

03. Promote system monitoring to increase consumer outcomes
Promotion of real time monitoring platforms and devices that inform consumers of their energy usage, energy efficiency and behaviours, help premises save on their energy bills, facilitate remote visibility, diagnostics and weather forecasting, and inform when preventative or reactive maintenance is required.

04. Encourage self-consumption of generated electricity
Shifting the time and usage of electricity at the customer level leads to direct bill savings and collectively provides wider grid benefits such as reducing network peak demand, which in turn puts downwards pressure on network expenditure and its associated passed-on costs for all energy participants.

05. Support grid performance and stability
Transitioning from passive to active distributed energy resources (DER). DER that helps maintain power system stability including through grid support response modes (Volt/Var, Volt/Watt, Freq/Watt), fault withstand (disturbance ride-through) settings, and Emergency Backstop Capability and others to address wider network challenges.

06. Promote interoperability through enhanced communications
Future proofing DER by mandating enhanced communications and internet connectivity capabilities. Promoting an industry developed 'IoT' approach that standardises interoperability in the Australian context to unlock the latent potential of aggregated/orchestrated DER.

07. Promote energy market participation
Promotion of virtual power plants (VPPs) and broader aggregation to enable DER to participate in current and future energy markets at scale. Current and future energy markets will provide immense opportunities with emphasis on unlocking new revenue streams and increased consumer outcomes.

08. Recognise the role and value of data
The secure collection and dissemination of data has benefits not only for consumers but also grid and market operators at all levels. Customer benefits include optimised energy usage and recognising 'portability' of data, access considerations, cyber security and consumer protections. Network benefits include increased visibility of the low voltage (LV) network, ability to identify constraint areas, and increased visibility of DER penetration and capacity, helping to improve planning, forecasting and operations.

09. Investigate innovative system solutions
Solar Victoria acknowledges its responsibility in looking forward towards new developments and initiatives in the dynamic transformation of Australia's electricity network, such as the impact of Electric Vehicles (EVs/V2G/G2V), de-carbonization through electrification initiatives, unconventional energy storage (eg. 'solar soaking' through hot water services and space heating/cooling), gamification of household energy usage and countless others.

Priority area 01: Ensure safety and quality of installations

Improving the safety and quality of solar products by setting exceptional industry benchmarks

Introduction

Solar Victoria's programs aim to facilitate safe, durable, high-quality systems that meet and exceed consumer expectations, for the full expected lifecycle of the technology. Safety is paramount and is the foundational building block for technology within Solar Victoria's programs.

Solar Victoria will meet this aim through the following principles:

01 Adopt leading safety and performance specifications

02 Raise the industry benchmark for installations

03 Promote system monitoring to increase consumer outcomes

Within this priority area Solar Victoria seeks to strike the right balance between consumer and network considerations by:

- Promoting products that are durable, consistently performing, and inclusive of enhanced features that will enable future customer and network needs.
- Generating demand for solar technology by reducing upfront costs, but equally, developing a mature workforce to safely and effectively meet the demand.

Solar Victoria works closely with the Australian Energy Market Commission (AEMC) and other energy market participants to improve safety standards by encouraging collaboration between governments and safety regulators to improve overall compliance levels within the industry.[4]

Solar Victoria works with regulatory bodies to promote safety and quality in the industry and to set standards above industry minimum. Solar Victoria maintains a collaborative approach regarding safety through regular engagement with industry and other stakeholders in the Solar Homes and Solar for Business programs.

4 Australian Energy Market Commission, 'Economic regulatory framework review - Integrating distributed energy resources for the grid of the future', 2019 Report, 26/09/2019. Available at https://www.aemc.gov.au/sites/default/files/2019-09/Final%20report%20-%20ENERFR%202019%20-%20EPR0068.PDF

Guiding principle 01: Adopt leading safety and performance specifications

Solar Victoria supports technology that is safe, high quality and fit for purpose.

This guiding principle relates to 'fit for purpose' product selection. Solar Victoria approved products are safe, energy efficient, and high performance. Solar Victoria's approved product lists are conveyed through the Solar Victoria Notice to Market. The Notice to Market outlines the recommended and mandatory eligibility criteria for participation in the Solar Homes and Solar for Business programs.

Initiative 1 – Leading Product Safety Specifications:

The inherent safety of solar products is a key consideration in managing overall safety outcomes for Solar Victoria's programs. The generation and storage of energy, in the form of electricity, carries risks that must be effectively managed and controlled to protect people and property from electric shock, fire and physical injury.

With the rapid uptake of rooftop solar nationwide, a variety of products have entered the market. These products vary in cost, quality and overall suitability for Australian consumers and conditions.

There is agreement in the broader industry that minimum industry safety requirements are needed to control the risks associated with new and diverse products.

To ensure program customers receive safe, quality products that are fit for purpose, Solar Victoria has mandated eligibility requirements for approved products. This includes mandated compliance with otherwise optional product safety standards. Preference has been given to safety requirements published in the public domain, including those from recognised standards bodies and trade alliances.

Solar Victoria will continue to adopt leading product safety requirements, including those that exceed minimum industry standards. These will be operationalised through regular revisions of the Solar Victoria Notice to Market. Product requirements over time will be expanded to include auxiliary equipment and componentry, cabling, connectors, DC isolators, detection equipment (for example, smoke or arc), earthing and bonding accessories and more.

DC ISOLATORS – APPLICATION CASE

Solar systems in Australia must be installed in accordance with Australian Standard AS/NZS 5033 – Installation of photovoltaic (PV) arrays. The standard includes a requirement for the installation of DC isolators, which are designed to provide additional safety protection by allowing the solar system to be de-energised to provide for periodic maintenance. DC isolators also provide a means for fire and emergency services to turn off the solar panel power supply to a house during a fire or other emergency incident.

Product and installation requirements for DC isolators are provided through national standards, particularly AS/NZS 5033:2014 (when separate to an inverter) and AS/NZS 4777.2:2020 (when built-in to an inverter). The AS/NZS 5033:2014 standard requires the installation of a DC isolator located adjacent to the solar panels on the roof and another DC isolator mounted on the wall adjacent to the inverter. The latest draft revision of AS/NZS 5033:2021 is currently 'for public comment' as of March 2021.

In recent years, research has been undertaken by the Australian Standards Committee EL-042 to evaluate the risks/benefits of DC isolators and the emergence of new technologies such as built-in/integrated isolation or microinverter technology. This has included contributions by individual Committee members including fire authorities and the AFAC (National Council for Fire and Emergency Services). The AFAC published its revised National Position Statement on PV Array Systems on 30 October 2019, encouraging further research on isolators and research-based decision making.

Solar Victoria has focused its audit program, proactive inspections by electrical regulators and industry training on addressing common issues in installations.

While arcing of DC isolators is rare, and fire risks associated with those events are also rare, Victoria's fire agencies have reported concerns about fire safety associated with some DC isolators located both on the rooftop and on walls adjacent to an inverter. The risk profiles of each type of DC isolator are different. Rooftop DC isolators have exposure to weather extremes and may be more prone to failure.

Wall mounted DC isolators (when installed correctly) are more sheltered so weather more slowly, but the risk of internal arcing leading to fire safety risk increases (especially when installed on combustible substrates or materials). Victoria's electrical safety regulator, Energy Safe Victoria, recommends that owners of solar systems engage a licensed electrician to regularly inspect their solar system and arrange replacement of DC isolators if necessary.

Solar Victoria's Solar Homes Program and the Clean Energy Regulator's Small-scale Renewable Energy Certificate (STC) require compliance with current standards. Installers accessing Solar Homes rebates must also meet additional technical requirements which are mandated by Solar Victoria from time to time and take into account emerging knowledge about risks and controls within the industry. Solar Victoria's Notice to Market responds to such changes promptly and endeavours to anticipate industry trends and technology innovation. Solar Victoria also has regard to the Clean Energy Council Installation Guidelines.

Solar Victoria acknowledges the rigorous process required to revise national standards including AS/NZS 5033 and is monitoring its progress intently. However, changes to national standards can take time (both in development and after publication) to enforce. Solar Victoria is aware that more recent amendments to installation standards have introduced improvements that have reduced the failure rate of DC isolators, however there is continuing research and discussion among electrical safety and fire agencies to explore safe alternatives to the use of the DC isolator.

Solar Victoria, in close collaboration with Energy Safe Victoria, is investigating whether to publish further industry guidance and requirements in addition to those mandated through Australian Standards and other national guidance material. Solar Victoria expects that further changes may be introduced over time that lead to improvements to the overall safety of solar systems. Such changes, where a demonstrated safety case can be made, may be expedited within Solar Victoria's programs where feasible to do so. Solar Victoria aims to continually lift the bar on technology with a paramount focus on safety and quality. This will be done in close collaboration with fire authorities and other industry stakeholders and based on the latest available research.

Guiding principle 01:
Adopt leading safety and performance specifications

Continued

Initiative 2 – Leading Product Performance Specifications:

Product performance and quality can affect how much a household with solar saves, and spends, on energy over the life of its system. A system with quality components can further reduce energy bills through better system performance, and minimise costs associated with system maintenance or the replacement of failed parts.

Solar Victoria has developed performance criteria for products eligible in its programs. These criteria specify products consisting of durable components that promote longevity and maintain expected performance over their working life, and leading product warranties and performance guarantees.

Current mandatory product compliance schemes within the solar industry focus predominantly on safety requirements, especially when referenced in electrical regulations. Less emphasis is placed on defined quality and performance requirements. The Consumer Action Law Centre (CALC) documented concerns about the quality of solar installations in its 2019 report.[5] Key issues raised by energy users related to product performance include incorrect installation of products, incomplete or missing documentation and failures to honour warranty claims.

In response, Solar Victoria is promoting the development of best practice guides and other initiatives to raise the bar on the quality and performance of solar products. This includes mandating minimum warranty requirements in its Notice to Market.

Moving forward, Solar Victoria will continue to advance product performance standards that exceed industry benchmarks to benefit Victorians, including standards around product durability and robustness. Solar Victoria will also promote technology that empowers households and small businesses to ensure the correct and optimal performance of their solar products.

5 Consumer Action Law Centre, "Sunny Side Up: Strengthening the consumer protection regime for solar panels in Victoria;, 2019 Report, April. Available at https://consumeraction.org.au/wp-content/uploads/2019/06/1904_Sunny-Side-Up-Report_FINAL_WEB_NEW-1.pdf

Solar Victoria is promoting the development of best practice guides and other initiatives to raise the bar on the quality and performance of solar products. This includes mandating minimum warranty requirements in its Notice to Market.

Guiding principle 02: Raise the industry benchmark for installations

Solar Victoria supports the installation of safe, high quality and fit for purpose systems installed by competent professionals with appropriate training.

This guiding principle goes beyond individual product requirements to steer technology at an overall system level. Ultimately it is the full system (not just its components) that directly ensures end-to-end consumer outcomes. This principle also acknowledges that performance of solar technology is intrinsically linked to the quality of work and installation practices of those who install it.

A key component of raising the industry benchmark for installations is workforce development. The solar industry is growing at rapid pace, and the systems employed by its workforce must continue to grow and mature. A mature workforce ensures quality assurance frameworks are in place to cover the overall process of design, installation, operation, maintenance and end-of-life management.

Solar Victoria is raising the industry benchmark for installations by:

- Lifting installer safety training requirements;
- Mandating compliance to industry developed 'codes of conduct';
- Evidencing installer competence including technical and occupational health & safety certification(s);
- Mandating leading work quality warranty requirements;
- Promoting quality assurance frameworks for businesses and wider small business mentoring services;
- Solar Victoria's robust inspection and audit regime; and
- Liaising with regulators and peak bodies.

Solar Victoria will continue to mandate installation requirements that go beyond minimum regulatory standards in order to deliver leading installation practices. Further collaboration with safety regulators is planned to ensure non-compliance is identified, and mechanisms are put in place to resolve and prevent future compliance issues. Collaboration can include jointly developing webinars and training material based on common non-compliances fed back through the auditing regimes, and Energy Safe Victoria (ESV)'s Licensed Electrical Inspector (LEI) regime.

Guiding principle 03: Promote system monitoring to increase consumer outcomes

Consumer outcomes are at the centre of Solar Victoria's decision making.

The third guiding principle empowers consumers through greater awareness of their energy footprint and how their assets are performing. System monitoring should be suitable for varied consumer interest, from 'set and forget' approaches through to highly granular diagnostic capabilities.

From a consumer perspective, monitoring the performance of solar systems can be challenging. This guiding principle encourages and empowers householders and business owners to take charge of their energy usage and usage behaviours to reduce their environmental impact and directly save on their energy bills.

Quality monitoring systems can enhance the benefits of PV ownership, improving the generation and financial performance of solar PV systems. The benefits outweigh the costs: over 10 years, the average cost of monitoring to households is $800, while the average benefit from increased solar generation over that same period is estimated at approximately $1,320. Load-shifting major appliances and other solar and energy management strategies can lead to even further savings of up to $3,500 over that time.[6]

Solar Victoria will promote the use of technology that empowers energy users to have a greater understanding of their solar systems, including third-party monitoring platforms that can help energy users save more on their bills.

Monitoring empowers solar system owners to optimise their energy consumption by measuring, calculating and displaying key information about a premises' energy generation and usage via user-friendly displays and interfaces. Third-party monitoring features include:

- Comparing actual and expected performance;
- Identifying weather conditions;
- Managing appliance use to enable load-shifting;
- Notifications of faults and under-performance of equipment; and
- Facilitating remote visibility, diagnostics, and identifying when preventative and reactive maintenance is required.

Substantiating performance issues with recorded data that is accessible to installers and retailers helps to efficiently detect and resolve faults and can prevent minor failures developing into more substantial risks.

Solar Victoria will continue to support the development of industry-led best practice system monitoring services and initiatives, and when appropriate, incorporate them into the eligibility criteria of its programs for the benefit of Victorian energy users.

6 Australian Renewable Energy Agency, 'Solar Analytics: Monitoring for Better Energy Outcomes,' February 2020.

Priority area 2: Optimise integration with the grid

Promote and enhance integration of solar systems into the grid

Introduction

Solar Victoria's programs promote the integration of solar products into the grid for the benefit of all energy users. In this context, grid integration refers to the response or behaviour of solar products connected to the grid. Distributed solar technology can provide opportunities to improve the electricity landscape, and Solar Victoria acknowledges that optimising integration with the grid is critical to realising the full potential of its programs.

Solar Victoria identifies the following guiding principles related to grid integration:

04 Encourage self-consumption of generated electricity;

05 Support grid performance and stability; and

06 Promote interoperability through enhanced communications.

Solar Victoria aims to strike the right balance within this priority area by introducing program criteria that:

- Balance DER owners' control with maintaining wider grid stability.
- Balance DER owners' data collection and security with the extensive benefits and opportunities unlocked by interoperability.

The grid was originally designed for one-way power flow. Electricity was created only at centralised generators, transmitted over vast distances, and finally distributed to end users, with power effectively flowing in one direction only.

With the vast uptake of distributed generation, excess electricity from rooftop solar can flow back into the grid in the reverse direction. If not integrated effectively, distributed generation can lead to adverse grid operating conditions at all levels of the power system.

Reduced demand and the effects of reverse power flows can see distribution network service providers (DNSPs) struggle to maintain line voltages within the acceptable range. Exceeding the acceptable voltage range can result in DER systems switching off or failing, and in extreme cases can result in equipment failure, potentially leading to electricity outages. The Australian Energy Market Operator (AEMO) has expressed concerns about maintaining power system reliability with large numbers of passive DER displacing centralised generation, particularly when dealing with 'minimum demand' situations.

Projections indicate that solar PV and batteries will provide a significant proportion of total energy generation in coming years, and will delay some significant grid infrastructure upgrades which would otherwise be needed to serve increasing electrical demand. Solar can reduce the need for load-shedding during high-electricity demand events such as heatwaves, where the increase in demand (predominantly caused by air-conditioning) is met by peak solar generation. During the February 2017 heatwaves, critical demand peaks that led to blackouts and load-shedding were delayed by several hours in South Australia, New South Wales and Queensland due to the input of solar electricity on the grid.[7]

As solar products have matured, standards, rules and regulations have been developed so distributed systems can work together under a range of different conditions to improve the grid. In a 2019 report, AEMO identified opportunities where all energy users can benefit from improvements to overall system stability, disturbance and withstand functionality (explained further in this section), and grid support for solar products integrated to the grid.[8]

Solar Victoria acknowledges its role in promoting the use of products with advanced features that impact positively on energy systems, afford customers greater control over their energy usage, and provide them with more benefit from their investment in DER.

7 Sydney Morning Herald, "Solar energy shines as heatwaves switch off gas and coal plants". Jan 2018 https://www.smh.com.au/opinion/solar-energy-shines-as-heatwaves-switch-off-gas-and-coal-plants-20180112-h0hfkj.html

8 Australian Energy Market Operator, "Technical Integration of Distributed Energy Resources – Improving DER capabilities to benefit consumers and the power system", April 2019 Report. Available at https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/Technical-Integration/Technical-Integration-of-DER-Report.pdf

Guiding principle 04: Encourage self-consumption of generated electricity

Self-consumption helps all grid participants. This guiding principle encourages households to consume their own electricity production, to save on their energy bills and provide wider grid benefits.

The most efficient and cost-effective way of harnessing the potential of rooftop solar systems is to use solar electricity in the premises as it is being produced. It is cheaper than using electricity from the grid, and maximises the return on investment from DER.

Increased use of solar electricity on site also benefits the grid in a number of ways, including by scheduling loads outside of peak demand times and reducing reverse power flows and their adverse flow-on effects. The Australian Competition and Consumer Commission (ACCC) noted in its 2018 report that peak demand, which is typically in the evening when consumers use the most electricity, is a significant driver of network costs, as opposed to the amount of energy used over time.[9] These network costs translate into supply charges on all household electricity bills. Optimising household loads to run at times of solar PV generation also has wider benefit, including reducing the export of excess generation into the local distribution network, alleviating over-voltage problems and in turn promoting more favourable conditions for rooftop solar systems.

Solar Victoria promotes the self-consumption of electricity to reduce energy bills and address issues such as network peak demand and operational minimum demand. This is done through communications to Solar Victoria customers via our website, social media and newsletters, and via stakeholder documents such as the *Technology Guidelines*. Advice to households includes promoting the uptake of energy storage systems such as batteries and solar hot water, scheduling energy usage during times of peak solar output, and home automation.

The increased use of third-party product suites that help shift load-demand to solar generation hours also gives solar system owners greater control over their devices, and encourages a better understanding of energy use by consumers.

Looking ahead, Solar Victoria will continue to promote self-consumption enabling technologies such as Home Energy Management Systems (HEMS), third-party devices for monitoring and load scheduling, as well as home battery systems and other enabling technologies which are key to the widespread promotion of rooftop solar self-consumption.

9 Australian Competition and Consumer Commission, "Restoring electricity affordability and Australia's competitive advantage-Retail Electricity Pricing Inquiry—Final Report', June 2018 Report. Available at https://www.accc.gov.au/system/files/Retail+Electricity+Pricing+Inquiry%E2%80%94Final+Report+June+2018_0.pdf

Guiding principle 05:
Support grid performance and stability

Technology that supports grid performance and stability marks a step change in the maturity of distributed energy resources. As vast amounts of DER enter the network the cumulative effect on the power system becomes more impactful, and needs to be carefully considered.

The national energy supply mix has undergone significant transformation,[10] with a shift to more distributed energy generation and customers taking action to reduce their energy bills. Rooftop solar systems constitute a rapidly growing portion of Australia's energy supply mix, equivalent to around 20 per cent of total capacity in the National Electricity Market (NEM).[11] Solar PV installations are increasing each year in Victoria, with a 600 per cent increase in year-on-year installations in the decade from 2009.[12]

While the change in supply mix and electricity demand introduces a variety of issues for grid operators at all levels, AEMO suggests innovative DER use can be a potential avenue to address these issues.[13] By promoting grid integration and enhanced DER features, there is an opportunity for distributed solar systems to act collectively as the largest single player in the electricity market.

Most DER interface with the grid via an inverter. Inverters are an integral part of solar power systems, converting the DC power that solar panels create (or batteries store) to AC power able to be used in the home and transmitted throughout the grid. Ensuring grid-connected inverters are systematically rolled out with features that support performance and stability is a focus of Solar Victoria.

Solar Victoria identifies three practical applications to support grid performance and stability:

Application 1 – Facilitate grid support features

Grid support modes can be thought of as automatic good behaviour of inverters based on actual grid conditions measured directly at the individual solar system level. These are "set and forget" features that will behave autonomously to assist grid operators to maintain a stable power system. These are configured locally and do not require active communications.

Over time grid support features will expand to include frequency response modes, but currently, these relate specifically to voltage. It is a complex job for DNSPs to maintain all customers within the acceptable voltage envelope (+10% and -6% of 230V), and it is crucial that inverters do what they can to help. Commonly known as Volt/Watt and Volt/Var response modes, distributed inverters regulate their output by either reducing their real power or increasing their reactive power absorption to help prevent voltages reaching the upper limit of the acceptable voltage band.

From 1 July 2019, Solar Victoria mandated the power quality response mode capability of Volt/Watt and Volt/Var for all solar connections supported by its programs. From 1 December 2019, all Victorian DNSPs followed our lead by mandating the same Volt/Watt and Volt/Var capabilities and associated settings for all solar connections across Victoria. It is now mandatory that all inverters participating in the Solar Homes and Solar for Business programs have these settings set correctly and enabled. In future, Solar Victoria anticipates more pre-set grid support modes will become mandatory, including Freq/Watt – where thresholds will be determined to increase (or decrease) the real output power, based on sustained lower (or upper) deviations from the nominal frequency range (50Hz).

10 Australian Energy Market Operator, 'AEMO observations: Operational and market challenges to reliability and security in the NEM', 2018 Report. Available at https://www.aemo.com.au/-/media/Files/Media_Centre/2018/AEMO-observations_operational-and-market-challenges-to-reliability-and-security-in-the-NEM.pdf

11 Reserve Bank of Australia, 'Renewable Energy Investment in Australia', March 2020 Bulletin. Available at https://www.rba.gov.au/publications/bulletin/2020/mar/renewable-energy-investment-in-australia.html

12 Clean Energy Regulator "Postcode Data for Small Scale Installations". Available at http://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations#Installation-numbers-for-smallscale-systems-by-stateterritory

13 Australian Energy Market Operator, 'AEMO observations: Operational and market challenges to reliability and security in the NEM', 2018 Report. Available at https://www.aemo.com.au/-/media/Files/Media_Centre/2018/AEMO-observations_operational-and-market-challenges-to-reliability-and-security-in-the-NEM.pdf

Guiding principle 05:
Support grid performance and stability

Continued

VOLT/WATT AND VOLT/VAR - APPLICATION CASE

Since 1 December 2019, Victorian DNSPs mandated Volt/Watt and Volt/Var power quality response mode capability, and associated settings for all micro-embedded generation (solar and battery) installations. These capabilities alongside other grid support modes are crucial to enable a sustainable roll-out of solar installations throughout the network. These settings help DNSPs maintain the low voltage network in the acceptable range, and in turn, help inverters remain on-line and increase the grid's PV hosting capacity to ensure a thriving solar industry.

Maintaining an acceptable voltage range on the LV network used to be relatively simple when power only flowed one way (from generators to premises). The DNSP sized the distribution transformer and set the tap-changer close to the upper acceptable limit (up to +10%) and sent the overhead (or underground) down the street for households and businesses to connect to. Setting the voltage taps toward the upper range allowed for seasonal load increases of peak demand, for instance air-conditioning, and would prevent the voltage sags from crossing the minimum threshold during such times. The type and length of the feeder and number of premises served determined the network cable impedances (losses) and the overall load profile. The voltage-drop to the first and last house on the feeder could be calculated with the conductor type, length, and load profiles. Furthermore, the final voltage-drop at the household level was ensured by sizing the consumer's mains as per the Service and Installation Rules, and the rest of the cabling in accordance with AS/NZS 3000 and the tables in AS/NZS 3008 to achieve an acceptable customer voltage envelope, 24 hours a day, 365 days a year.

When households and small businesses become generators and start feeding power back into the grid, it gets a little more complex. That voltage drop becomes a voltage rise and has a far narrower acceptable tolerance. As more and more rooftop solar systems export power into the grid simultaneously, each add to the reverse current flows and therefore need to raise their voltages. The voltage rise can include up to 2 per cent rise on the customer side to the 'point of attachment,' but also the combined impedance of the feeder up to the transformer. As a result, upper limits can be reached at customer ends resulting in inverter(s) disconnecting due to over-voltage. To prevent these disconnections in the interest of consumer outcomes, Volt/Watt and Volt/Var response modes automatically curtail real power and absorb reactive power during times of high voltages to counter-act the voltage rise.

Both Volt/Watt and Volt/Var functions reduce customer voltages. Volt/Watt linearly ramps down output power when excessively high voltages are measured. Volt/Var introduces a lag in the output current waveform through the switching of the power electronics in the inverter to effectively behave as a reactive load, while continuing to supply real power. Without DER having grid support modes likes these, DNSPs will be forced to take more drastic measures, such as increases in static and zero export limits. Volt/Watt and Volt/Var modes therefore increase network hosting capacity for solar PV and increase the business case and return on investment for solar homes and businesses, in turn contributing to a thriving solar industry.

Application 2 – Promote 'disturbance withstand' capability

It is essential that rooftop solar and other DER promote energy security for the wider grid, predominantly by behaving predictably and uniformly. The grid, inclusive of DER, should be resilient. It must ensure minor disturbances do not cascade into significant sudden losses of generation into the network, which could lead to major outages compromising overall system security.

In general terms, grid operators maintain stability by operating within a framework that ensures the total generation matches the amount of load (demand) at any given time. AEMO employs complex strategies to ensure adequate redundancies are in place to accommodate expected failures. For example, the loss of one feeder due to a fault, or the failure of one generator to meet unit commitment (UC) will not lead to a major blackout of the NEM. From time to time, brief periods of generation and load mismatch can lead to disturbances and in more severe cases, outages. Disturbances within this context could be thought of as brief deviations away from optimal grid conditions but are generally quickly recovered.

New DER functionality is being developed and implemented internationally to address the issues of transitioning to a variable renewable majority power grid.[14] A major component of this functionality is disturbance withstand (also known as ride-through) capability, or the ability to resist or combat disturbances. Inverter-based generation, such as rooftop solar, doesn't naturally respond with inertia as a synchronous generator does to resist change and combat disturbances. Instead, these features need to be designed and programmed within the control system of the inverter, to act in a way that promotes grid stability.

The implementation of strategies needs to be planned and executed with the individual constraints of the power system in mind. Such strategies have been enacted through swift reform of AS/NZS 4777.2:2020 led by AEMO and through a collaborative effort from regulators, government entities and the wider industry. AS/NZS 4777.2:2020 is the revised Australian product standard for inverter energy systems. Amongst other requirements it outlines world-leading grid support and disturbance ride-through capabilities, with clear and measurable testing criteria for industry to adopt.

Solar Victoria will consider the early adoption of standards and recommendations from AEMO, as well as other organisations and peak bodies, in the eligibility requirements of its programs. Improved disturbance withstand capability will provide more assurance to the market operator of uniform predictable DER behaviour leading to increased rooftop solar PV hosting capacity.

14 IEA, 'Getting Wind and Sun into the Grid: A manual for policy makers', 2017, available at https://www.iea.org/publications/insights/insightpublications/Getting_Wind_and_Sun.pdf.

Guiding principle 05:
Support grid performance and stability

Continued

Application 3 – Emergency Backstop Capability for distributed energy resources

Most solar customers want to maintain continuous production of energy from their solar PV system and to export excess energy to the grid and contribute more broadly to environmental benefits. The Victorian Government supports these aspirations and is exploring opportunities to integrate high levels of solar while ensuring system reliability – particularly during periods of high energy generation with low electricity demand.

AEMO has indicated that in exceptional circumstances it may need to direct actors in the energy market to shed excess production of solar in order to maintain the balance between energy supply and demand. This so-called "emergency backstop" capability is considered by the market operator as a tool of last resort to maintain power system stability, preventing major supply interruptions affecting many customers. Disconnecting and reconnecting solar and other forms of DER can also be an effective safeguard mechanism for market operators to maintain power system stability, and has the potential for unlocking new markets and revenue streams for solar system owners by driving new capabilities for inverters and aggregators.

'Minimum demand' is identified by AEMO in its 2020 Electricity Statement of Opportunity (ESOO) as one of the key challenges for the market operator to ensure power system reliability[15] and suggests that over the coming decade, intervention through emergency backstop capability may be required in extreme circumstances. It also acknowledges that the minimum demand forecasts projected are based on 'uncontrolled minimum demand'[16]. Jurisdictions have a role to incentivise market-based solutions to increase system load (preventing 'minimum operational demand' situations), including aggregated storage, coordinated electric vehicle charging, and other orchestrated demand response initiatives.

Simply put, 'Minimum Demand' is a situation leading to insufficient electrical load to meet the generation on the network. To prevent this from occurring, the market operator employs strategies, including disconnecting generators as a last resort, to ensure customers keep their lights on. This approach may not be effective if the generation that needs to be switched off is distributed PV without this capability. The only option the market operator has today, under such circumstances, is to disconnect large feeders, impacting (interrupting power supply to) tens, or even hundreds of thousands of customers at a time.

Historically, minimum demand has been an issue during night-time hours, when electrical demand is naturally lowest (when customers are using minimal electricity). With more and more electricity generation occurring during the day thanks to distributed solar PV, minimum demand situations are now more likely to occur during daylight hours. AEMO identifies by 2025 all regions are expected to experience day-time minimum operational demand, with demand reductions being most evident in Victoria and South Australia and are expecting to continue across the full 10-year forecasting horizon.[17]

15 Australian Energy Market Operator, '2020 Electricity Statement of Opportunities', August 2020 Report. Available at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo

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Solar Victoria acknowledges the challenge 'minimum demand' poses for the market operator, and the associated impacts on all energy market participants. As a prime driver in the uptake of DER in the state, the Department of Environment, Land, Water and Planning is continually monitoring the integration and collective impact of rooftop solar on the power system. Solar Victoria sees continuous improvements in the maturity of DER technical standards to contribute to a stable power system as crucial moving forward.

Solar Victoria is working closely with AEMO and distribution businesses to monitor developments and will explore outcomes-based requirements for DER to address minimum demand and other emerging power system challenges. Striking the right balance between consumer outcomes (including those that do not own DER assets) and maintaining power system stability will be crucial. Such mechanisms will prioritise customer benefits and remote control of individual systems or shedding only in exceptional circumstances as a last resort, where customers are engaged appropriately and fully informed and/or remunerated for these services.

As the supply mix incorporates more and more variable renewable energy, remote "disconnect/reconnect" features become necessary tools to manage power system stability. The Victorian Government will consider a suite of actions and responses to address minimum demand to empower customers and unlock greater potential for collective DER to solve emerging grid challenges. The benefits of DER having remote disconnect/reconnect capability include:

- Providing a last resort backstop that employs granular disconnect services to prevent larger scale supply interruptions – for increased power reliability for all (those with DER and those without);
- Providing granular reconnect services, staged to assist the network during times that require system restart ancillary services (SRAS);

Potential for orchestrated DER to provide opt-in/opt-out market-based services to reduce the likelihood of contingency events occurring (for example, increased value proposition for VPP's providing services such as over-frequency generation shedding [OFGS] and under-frequency load shedding [UFLS]).

Guiding principle 06: Promote interoperability through enhanced communications

This guiding principle relates to the interoperability of technology, which is the communications capability to activate distributed energy resources. Interoperability is the foundational requirement to enable aggregation and orchestration.

The increased connectivity of both distributed generation and smart electric devices is transforming the energy landscape by enabling greater visibility, monitoring and control of DER. Interoperability is the key to unlocking orchestration, which is the ability to coordinate many distributed energy resources in unison, leveraging their individual strengths in harmony like an orchestra of musical instruments.

> The Institute of Electrical and Electronics Engineers (IEEE) defines interoperability as "the capability of two or more networks, systems, devices applications or components to externally exchange and readily use information securely and effectively".[18]
>
> *(Explained further in Initiative 1)*

A key driver of household revenue from rooftop solar is derived by maximising household energy generation. The concept of a dynamic operating envelope, and more specifically, active control implemented through a dynamic/flexible connection agreement, is key to maximising household generation and increasing the grid's PV hosting capacity. Interoperability is fundamental to achieving this objective.

> A dynamic operating envelope essentially provides upper and lower bounds on the import or export power at a given time interval for individual DER assets. These are communicated to DER either directly by DNSPs or through aggregators or retailers, which in turn dictate the operation of these devices. This ensures the operational limits of the network are not breached and DER owners can make the most use of their resources, by generating or consuming as much electricity as feasible at a particular time and location.[19]
>
> *(Explained further in Initiative 2)*

Optimisation of the power system, unlocked through the orchestration of DER, has the potential to deliver up to $5 billion in net economic benefits across the country by 2030.[20] Advantages include effective reduction of network security risks to benefit all energy users, whilst ensuring DER customers receive maximum return on their investments.

As in the case with broader technology, the widespread interconnecting of DER will almost certainly leverage an Internet of Things (IoT) approach, by utilising communication over the internet to coordinate output and behaviour with other DER. Solar Victoria promotes initiatives that put consumer interests first, particularly with respect to privacy, security and strategic investments that create a level playing field and promote digital access for all Victorians.

Solar Victoria's programs will continue to mandate and/or recommend industry-leading requirements in their eligibility criteria. They will build on current requirements for approved solar products to have internet and communications capabilities. Beyond physical hardware, this will include aligning with industry-led initiatives that standardise data communication approaches, including protocols that define the content, format and security requirements of data flow.

18 IEEE Standard 1547-2018

19 On the calculation and use of dynamic operating envelopes, evolve Project M4 Knowledge Sharing Report, Battery Storage and Grid Integration Program, The Australian National University. Available at https://arena.gov.au/assets/2020/09/on-the-calculation-and-use-of-dynamic-operating-envelopes.pdf

20 CSIRO, Graham, P.W., Brinsmead, T., Spak, B. and Havas, L. 2019, 'Review of cost-benefit analysis frameworks and result of DER integration'. CSIRO, Australia. Available at https://www.aemo.com.au/-/media/files/electricity/nem/der/2019/oen/csiro_cbareviewreport_13-05-2019.pdf?la=en&hash=5F780EAA38108E969CD-CE8E060F01514

Initiative 1 – Standardising the Approach

A national standardised approach to interoperability is crucial for the timely development and effective implementation of 'fit for purpose' technology. Striking the right balance to ensure timely and strategic investment in public and private enterprise is key. For instance, market-based approaches to solve grid challenges require fit for purpose communications infrastructure across multiple entities, each with different requirements. This could include:

- Data requirements – information, resolution, bandwidth;
- Security requirements – cybersecurity, encryption;
- Latency requirements – action time required to provide service;
- Verification requirements – availability, watchdog, health status.

Standardising the approach on a service basis has many benefits, including clear criteria for service providers and their partners to adhere to and avoiding superfluous expenditure (i.e. investing in infrastructure that soon becomes outdated and no longer fit for purpose.)

To enable widespread interoperability, communications infrastructure must be set up between service providers at different levels ranging from market operators (AEMO and possible future distribution market operator(s)[21]), network service providers (transmission and distribution), to aggregator(s) and subsequently DER in households or businesses.

Interoperability is the foundational requirement to enable the aggregation of DER (such as through VPPs) to compete in the wholesale energy market, and provide orchestrated essential system and network services.

Solar Victoria acknowledges standardising the interoperability approach between DER and upstream aggregator(s) will lead to widespread benefits to all. We are working with leading entities in the interoperability space including AEMO, the Australian National University, Clean Energy Council, Smart Energy Council and other key stakeholders to implement, adopt and mandate well-considered interoperability requirements for inclusion in Solar Victoria's programs.

Solar Victoria supports targeted trials like AEMO, AusNet Services and Mondo's 'Project Edge: Victorian Distributed Energy Resources Marketplace Trial', funded by ARENA. This trial will coordinate the development of a replicable model for the trading of electricity and grid services from DER. The ambition of this model is that it can form a blueprint that can be expanded across the whole National Electricity Market (NEM) in the future. Solar Victoria supports this initiative and will look to the learnings of the project to inform its eligibility requirements related to interoperability in the future.

21 AEMO and Energy Networks Australia 2018, Open Energy Networks, consultation Paper. 2018 Report. Available at https://www.energynetworks.com.au/assets/uploads/open_energy_networks_consultation_paper.pdf

Guiding principle 06:
Promote interoperability through enhanced communications

Continued

Initiative 2 – Applied interoperability for Dynamic/ flexible Connection Agreements

Along with maximising household solar generation, dynamic export limits can help integrate higher levels of DER into the grid and increase the benefits to all customers.

> A Dynamic Connection Agreement (DCA) is the mechanism through which flexible export limits (maintained within the dynamic operating envelope) can be implemented for energy users. A DCA defines the basic electrical settings and other requirements for connection to the distribution network, where a customer wants to connect a DER asset.

Dynamic export limits, and efficient, strategic network upgrades provide the following benefits:

- Increases grid utilisation;
- Provides greater customer choice;
- Increases utilisation of solar PV generation;
- Promotes higher penetration of solar PV on the grid; and
- Improves flexibility for DNSPs to manage their network.

DCAs can help networks move away from 'first come, first served' approaches to new solar connections and allow solar electricity exports most of the time, with restrictions imposed only as networks approach their operational limits.

Replacing Static Connection Agreements (SCA) with DCAs can ease some of the problems associated with maximum export limits on connection agreements. DNSPs predominantly use SCAs with maximum export limits. These export limits are sometimes set at zero, and in extreme cases there is an outright rejection of a customer's application to connect. Without DCAs DNSPs will have to invest in costly network upgrades to facilitate consumer demand for DER, to control the associated adverse network impacts due to over-voltage, thermal overloads and reverse power flows.

The cost of network upgrades is shared across all energy users irrespective of whether they benefit from the investment or not, and should be kept to a minimum to ensure equitable charges to consumers. Network augmentation to provide unrestricted solar PV exports to those who are in a position to install solar PV, would lead to an unreasonable increase in costs for all energy users.

Solar Victoria sees dynamic connection agreements and wider active control benefits as a 'no regrets action' and invaluable to moving towards the 'Grid of the Future', unlocked through the widespread interoperability of DER.

Solar Victoria supports targeted trials like the ARENA-funded South Australia Power Networks (SAPN) and AusNet services' 'SA Power Networks Flexible Exports for Solar PV Trial', with strategic project partners SwitchDin, Fronius, SMA and SolarEdge, and are exploring how its programs can further support AusNet's Victorian-based trial.

Interoperability is the foundational requirement to enable aggregation and orchestration. Aggregation and orchestration allow distributed energy resources (DER) to collectively act in unison to contribute to current and emerging energy markets at scale. This will unlock the latent potential of DER and will promote competition in the market leading to favourable conditions for all energy participants.

Priority area 3: Maximise the benefits of generation through innovation

Maximise the integration of solar systems into the grid through innovative solutions

Introduction

Solar Victoria supports innovative solutions that enhance the benefits of DER for all Victorian homes and businesses.

Solar Victoria identifies the following guiding principles for technology within the innovation priority area:

07 Promote energy market participation;

08 Recognise the role and value of data; and

09 Investigate innovative system solutions.

Solar Victoria aims to strike the right balance within this priority area, by introducing program criteria that:

- Support the establishment of new markets and grid services leading to new customer revenue streams.
- Maintain existing consumer outcomes while promoting innovation.

In its 2018 'Global Energy Transformation' roadmap, the international energy peak body IRENA outlines the instrumental role public and private collaboration has in shaping the global energy transformation.[22] It highlights the role of government initiatives, beyond financial support, in developing market design reform, enabling technologies and new business models.

The Solar Homes and Solar for Business programs are more than rebate schemes. As well as increasing the quality of products and work practices in the sector, Solar Victoria also has an objective to support innovation to meet safety, training, product stewardship and improved consumer outcomes. Innovation can enable greater PV hosting capacity, lower consumer energy bills and promote a fair and equitable energy landscape, one that is transparent and provides more participation opportunities for consumers.

22 International Renewable Energy Agency (IRENA) 'Global Energy Transformation: A roadmap to 2050', 2018 Report. Available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf

Guiding principle 07: Promote energy market participation

This guiding principle relates to the orchestration of DER to participate in energy markets. Current and emerging energy markets will become more and more prominent as we transition to a net-zero carbon future.

Solar Victoria promotes the orchestration of DER to collectively participate in current and emerging energy markets.

In a high-DER future, the energy paradigm needs to change to accommodate more solar systems and maintain network stability. Solar Victoria is strategically placed to influence the technical capabilities of large amounts of DER and bridge the gap between policy developers and industry participants in Victoria. Through the Energy Security Board's Post-2025 Market Design Project and a suite of AEMC rule changes, reform is underway which will require the development of new business models and appropriate regulatory frameworks, so Victorian homes and businesses can be active energy market participants in the future.

Alongside solar PV and batteries, Solar Victoria promotes the uptake of DER (such as solar hot water and efficient space heating/cooling) that are energy efficient and can be used smartly. Solar Victoria is exploring opportunities for using solar hot water, heating/cooling and other dispatchable smart energy loads to provide network services, such as demand response, as a potential new revenue stream to help households and businesses further save on energy bills.

Initiative 1: Incorporating aggregation into the Solar Homes battery program

The Solar Homes battery rebate stream will encourage the aggregation of batteries funded under the program to share the benefits of DER technologies with more customers. Aggregation, delivered via Virtual Power Plants (VPPs), is the glue that can enable DER to benefit households both directly with new sources of revenue, and indirectly by providing more competition into a variety of current and emerging marketplaces.

Battery aggregation can unlock the potential to collectively provide grid services, not limited to:

- Network Peak Demand Management (NPDM) – reducing the overall electrical load of the network by exporting power stored in resources (commonly batteries) during particularly high demand times (peak periods);
- Participation in wholesale spot price markets – importing or exporting power from many distributed resources to collectively act in unison when wholesale energy prices are favourable (also known as 'Arbitrage');
- Participation in Frequency Control Ancillary Services (FCAS) markets – fast acting import and export of battery storage to match utilities requirements and help the power system remain stable during particularly vulnerable times; and
- Emerging markets – system strength, synthetic inertia, and other fit for purpose services needed to transition towards a secure and reliable power system with high penetration of variable renewable energy (VRE).

The Solar Homes battery rebate stream will trial battery aggregation with rebate customers with expressions of interest already underway. The trial will inform the future use of VPPs to work alongside grid operators and unlock untapped orchestrated DER capabilities. The trial will also inform future program design to maximise the benefits for energy users and the broader community.

Initiative 2: Promoting orchestration of Distributed Photovoltaics (DPV)

The evolution of essential energy services markets to include utility-scale solar farms is becoming mature[23] however for orchestrated DPV (small-scale systems, predominantly rooftop solar) participation is in its infancy.

As the name suggests, DPV are distributed and at a minimum require interoperability to act collectively to meet the needs of energy marketplace(s) at scale. DPV can generate (supply) real power but have the added challenge of being variable in nature. DPV are less versatile then their battery counterparts as they cannot absorb real power. DPV, like batteries, can both supply and absorb reactive power within the limits of the total power rating of the inverter. The output capacity of DPV is dependent on a range of external factors not limited to the weather, cloud coverage, shading, maintenance regimes, local grid constraints (like voltage) and others.

As a result, orchestration of DPV to provide essential grid services is more complex when compared to other DER, such as solar batteries. A battery is less dependent on environmental factors. Most battery monitoring systems (BMS) can determine the charging and discharging capacity of a system in near real time, considering a range of inputs such as State of Charge (SoC), cell temperatures, and cell voltages amongst others. The DC power output capabilities are easily transferred to the AC side limits considering the inverter efficiency to then operate in energy markets.

A range of measures could be used to overcome the variability challenges of DPV, for instance they could be paired with batteries in hybrid solutions, or aggregated (diversified) over larger geographic distances, or operated with sufficient headroom in their output supply to accommodate predicted weather variability. Overcoming the challenges of DPV orchestration will untap latent DER capability and provide immense opportunities over time.

23 National Renewable Energy Laboratory (NREL) ' GRID-FRIENDLY RENEWABLE ENERGY Solar and Wind Participation in Automatic Generation Control Systems', 2019 Report. Available at http://www.nrel.gov/publications

Guiding principle 08: Recognise the role and value of data

This guiding principle recognises the role and value of data in the transformation of the electricity system, and the far-reaching impacts of data for consumers, grid operators, businesses and wider innovation.

The integration of large amounts of variable renewable generation, coupled with consumer demand for DER, is creating a transformation of the power grid as we know it. The collection and management of large volumes of data is a necessary enabler for the transition to a smart grid, one in which the lines between DNSPs, retailers, generators and energy users are not always clearly delineated.

The Energy Security Board identifies the role of data and digitalisation in transforming the energy sector, by making energy more accessible, efficient, transparent and affordable, as the market transitions to more sustainable energy technologies.[24] It outlines four pillars within its 2020 Data strategy including identifying the data needs of today, establishing a new data governance framework, driving leadership capability within the industry, and supporting an on-going proactive and adaptable forward-looking approach.[25]

The collection of data at distributed locations around the network can benefit all energy users. It can provide greater transparency of grid conditions, improve DER access to wholesale markets, open new energy markets at distributor or potentially neighbourhood levels, and provide energy users with greater control over their data.

Solar Victoria recognises its responsibility in promoting technology that has advanced features which can be used in coordinated trials for smart grid projects. Solar Victoria promotes, and in some cases mandates, products that can effectively measure, record, store, analyse and securely transmit data as part of its programs and associated trial projects. Privacy is an essential consideration in the responsible sharing and use of this data. Solar Victoria takes three broad considerations on the role and value of data for the future energy landscape.

Consideration 1 – DER data visibility

System visibility, or the ability to view key information about DER in near real-time, is crucial to ensure correct operation of solar products in Solar Victoria's programs, and benefits the customer, retailer, DNSPs and others.

Visibility can allow customers to actively view energy production yield, record self-consumption and subsequently help them to optimise their energy usage. The data can be used by participants to evaluate system performance based on projected outputs from retailers.

Solar Victoria supports greater visibility tools that can further enable retailers and installers to diagnose system faults remotely, and potentially streamline warranty or performance claims.

Solar Victoria recognises that visibility of data is also beneficial to DNSPs. Without data it is difficult to know where constraints are, and where they are likely to develop in the future. In 2019, the AEMC found that DNSPs have good visibility of their high voltage assets through comprehensive Supervisory Control and Data Acquisition (SCADA) networks, but have very limited details about their low voltage distribution network.[26]

24 Energy Security Board, "ESB Data Strategy Media Release.pdf", 20 October 2020, Available at: http://www.coagenergycouncil.gov.au/publications/energy-security-board-data-strategy-submissions-consultation-paper-published

25 Energy Security Board, "ENERGY SECURITY BOARD, Data Strategy, Consultation Paper", October 2020, Available at: http://www.coagenergycouncil.gov.au/publications/energy-security-board-data-strategy-submissions-consultation-paper-published

26 Australian Energy Market Commission, "Economic regulatory framework review", 2019 Report, Available at https://www.aemc.gov.au/markets-reviews-advice/electricity-network-economic-regulatory-framew-1

Extensive smart meter coverage means Victoria is ahead of other states with these capabilities. Victorian DNSPs have greater detail about power quality measurements relating to voltage, current, harmonic distortion and power factor in low visibility locations of the distribution system, that traditionally had not been recorded.

Additionally, data recorded at the DER device level can provide even more granular information. For instance, it may decouple home electricity usage and generated solar PV, which may otherwise be combined at the smart meter. High resolution data can be used to verify inverter behaviour during and after grid disturbances. By observing output behaviour, it is possible to make inferences on whether inverter grid support features respond correctly during such events. This data is also integral to support the development of dynamic connection agreements and for aggregated participation in new markets.

Consideration 2 – Consumer data rights and portability

The secure generation and portability of data to inform stakeholders about energy usage and DER performance, in a readable and translatable manner, promotes customer engagement and consumer choice.

Effective data management can empower customers to understand their energy usage, generation, potential revenue streams, return on investment, and ultimately, improve consumer choice with greater granularity.

However, consumer data is valuable, and access and usage should be governed to protect consumer rights which ultimately will increasingly will involve questions of ownership of data and the ability to retrieve and transfer it (data portability).

In its Consumer Data Rights Workstream, AEMO explains that the use of such datasets can offer Australians greater control over their energy data and empower energy users to choose from a range of tailored products and services.

Solar Victoria acknowledges the value of data and the evolution of data rights including portability and promotes its use for the empowerment of householders and business owners and improved consumer outcomes. We will continue to monitor developments in this important area to ensure we are striking the right balance.

Consideration 3 – Digital inclusion

We strive to make our programs inclusive and accessible to as many Victorians as possible, to make sure all Victorians can share in the benefits of renewable energy.

We understand that some of our customers and potential customers may face challenges in accessing our programs, particularly those with limited access to digital services or digital literacy, or who may be living in vulnerable circumstances that limit access to affordable, renewable and reliable energy services.

Solar Victoria supports inclusive access through our focus on lower income households, provision of interest free loans, financial hardship assistance, and programs to support renters and tenants of community housing to enjoy the benefits of solar.

We also support customers with limited digital access through provision of postal application options and through making resources available in diverse languages. We are committed to continuing to purposefully action initiatives and implement additional supports that boost access to Solar Victoria's programs, particularly for those who may experience vulnerability and limited digital access.

Guiding principle 09: Investigate innovative system solutions

The final guiding principle recognises that innovation within the industry moves at a rapid pace. A forward outlook is integral to future-proofing our programs and their participants.

Innovative system solutions are required to navigate the profound changes seen in the generation and consumption of electricity. Energy participants, including DNSPs, retailers, government agencies and energy users, need to innovate to remain current in this transformative landscape.

Australia's power system is undergoing a remarkable transformation, particularly in the areas of distributed generation and the digitalisation of electricity.[27] In some areas of the NEM, the uptake of distributed generation is world leading.[28] The management and incorporation of increasing levels of distributed generation brings challenges for network and system operation. It also brings opportunities for innovative system solutions.

Solar Victoria acknowledges that otherwise-passive energy users are now being transformed into active energy market participants (knowingly or unknowingly) through their DER. Household and small business DER has a promising outlook for the future, including but not limited to:

- Electric vehicle impacts – peak demand smoothing and 'solar soaking' by incentivising charging times and vehicle to grid (V2G) export to collectively provide grid services in a VPP arrangement;
- Unconventional energy storage – new battery chemistries, supercapacitors, hydrogen, and thermal storage utilising hot water as well as space heating/cooling;
- Peer to peer trading – virtual energy trading using blockchain and other enabling technologies and/or energy markets;
- Gamification of energy management – the incorporation of interactive elements to motivate and engage energy users to be actively aware of their usage and generation of electricity. Motivation can be derived from economics, environmental considerations and even competitive or aligned social action.

The future is bright for innovative system solutions, enabled by a world-leading uptake of DER[29] in Victoria, as an integral part of Australia's largest electricity grid.

Solar Victoria will actively engage with emerging technologies and innovation to ensure our customers are able to benefit.

27 Clean Energy Council, "THE DISTRIBUTED ENERGY RESOURCES REVOLUTION", August 2019 Report, Available at https://www.cleanenergycouncil.org.au/resources/resources-hub/the-distributed-energy-resources-revolution-a-roadmap-for-australias-enormous-rooftop-solar-and-battery-potential

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Consultation

Solar Victoria formally consulted with key internal and external stakeholders in the development of the Technology Guidelines, including:

- Australian Energy Market Operator (AEMO);
- Australian Renewable Energy Agency (ARENA);
- Energy Safe Victoria (ESV);
- The Clean Energy Council (CEC);
- The Smart Energy Council (SEC);
- Energy Networks Australia (ENA);
- As well as presentation of the key concepts of the Technology Guidelines within the following forums:
  - Solar Victoria's Industry and Consumer Reference Group (including the Electrical Trades Union, industry peak bodies, consumer advocates, safety regulators and solar retailers);
  - All Victorian Distribution Network Service Providers (AusNet Services, Jemena, CitiPower, Powercor and United Energy);
  - DELWP-led Energy Consumer's Insights Forum (comprising: Consumer Action Law Centre, Brotherhood St Laurence, Victorian Council of Social Service, Energy and Water Ombudsman, Consumer Policy Research Centre, St Vincent De Paul Society Victoria, Council of Small Business Organisation, Victorian Chamber of Commerce and Industry, Jesuit Social Services, Council on the Ageing, Renew, Uniting Church in Australia and Community Information and Support Victoria);
  - DELWP-led Network Services Advisory Committee (comprising: AEMO, AusNet Services, Tesla, ReNew, and Monash University).

The guiding principles of the *Technology Guidelines* will inform Solar Victoria's *Notice to Market*. The Notice to Market details the rules and expectations for participation in the Solar Homes and Solar for Business programs, including notice of forthcoming changes.

Solar Victoria welcomes feedback to further improve its programs and the shift to cleaner, more affordable energy for Victorians. Feedback can be provided to enquiries@team.solar.vic.gov.au referencing "Solar Victoria's Technology Guidelines."

Acronyms and glossary

ACCC – Australian Competition and Consumer Commission

AEMC – Australian Energy Market Commission

AEMO – Australian Energy Market Operator

ARENA – Australian Renewable Energy Agency

CALC – Consumer Action Law Centre

CEC – Clean Energy Council

CSIRO – Commonwealth Scientific and Industrial Research Organisation

Distributed generation – Electrical generation (or storage) performed by a variety of small, grid-connected devices

DCA – Dynamic Connection Agreement

DEIP – Distributed Energy Integration Program

DER – Distributed Energy Resources

DNSP – Distribution Network Service Provider

DOE – Dynamic Operating Envelope

DPV – Distributed Photovoltaics

ERT – Emissions Reduction Target (ERT)

ESB – Energy Security Board

ESV – Energy Safe Victoria

EV – Electric Vehicle

EWOV – the Energy and Water Ombudsman Victoria

FCAS – Frequency Control and Ancillary Services

HEMS – Home Energy Management System

IoT – Internet of Things

IRENA – International Renewable Energy Agency

NEM – National Electricity Market

Network augmentation – Upgrade of the existing distribution network capacity in order to meet customer demand

NPDM – Network Peak Demand Management

OFGS – Over frequency generation shedding

PV – Photovoltaic

SCA – Static Connection Agreement

SCADA – Supervisory Control and Data Acquisition

SEC – Smart Energy Council

SEM – Smart Energy Management

SRAS – System Restart Ancillary Services

UFLS – Under frequency load shedding

VPP – Virtual Power Plants

VRE – Variable Renewable Energy

VRET – Victorian Renewable Energy Target

*Within this document 'solar systems' and 'solar products' are used as a collective term inclusive of solar panels, inverters, home solar batteries and solar hot water systems.

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