Enabling rooftop solar exports

Options paper for consultation

Regulatory proposal 2021–2025

April 2019

1 Overview

1.1 Introduction

Our customers have more choice in meeting their energy needs than ever before. They can choose between fuel sources, retail plans, whether to purchase green electricity, or whether they generate electricity themselves—particularly through rooftop solar.

Our engagement activities over the past two years have demonstrated across all networks that our customers want to export their excess solar back into the network. They are choosing exports to lower their bills, have greater energy independence and to help the environment.

In the future, exports will also enable customers to participate in new markets such as wholesale price arbitrage and network support that will improve the efficiency of the electricity market and lower costs. Without access to these markets, the usefulness of solar and value of the substantial solar investments will not be fully realised. We want our solar customers to get the most out of their investment and the Victorian Government's new Solar Homes Package subsidy.

We are supportive of the energy transition and customer's right to choose how they use or generate electricity—we believe part of our social obligation is accommodating broad trends in the way customers use electricity. This is particularly important given customers do not have a choice between distributors.

In this context, we recognise it is increasingly untenable for us to prevent reasonable exports and the choices they enable. Without some form of intervention, we all risk ending up with a 'dumb' solar systems—systems that continuously trip off and high voltages that may damage equipment. The challenge this options paper seeks to discuss, therefore, is how we can enable our customers' solar preferences equitably and with least cost.

We are greatly assisted in meeting this challenge by drawing on the data from our Advanced Metering Infrastructure (**AMI**) investment. Unlike other jurisdictions, we are able to see where export constraints are developing and find the least cost solution. However, while our networks are among the most highly utilised in the National Electricity Market (**NEM**) to extract the maximum benefits from our assets and ensure affordability, it also means we have less headroom to accommodate exports.

We recognise that when enabling exports we need to keep an eye on the future, such as accommodating electric vehicles, to ensure any activities undertaken now are complementary. Any investment, or non-network solutions, must be on a 'least regrets' basis such that we have confidence the investment will be used now and well into the future.

1.2 Summary of options considered

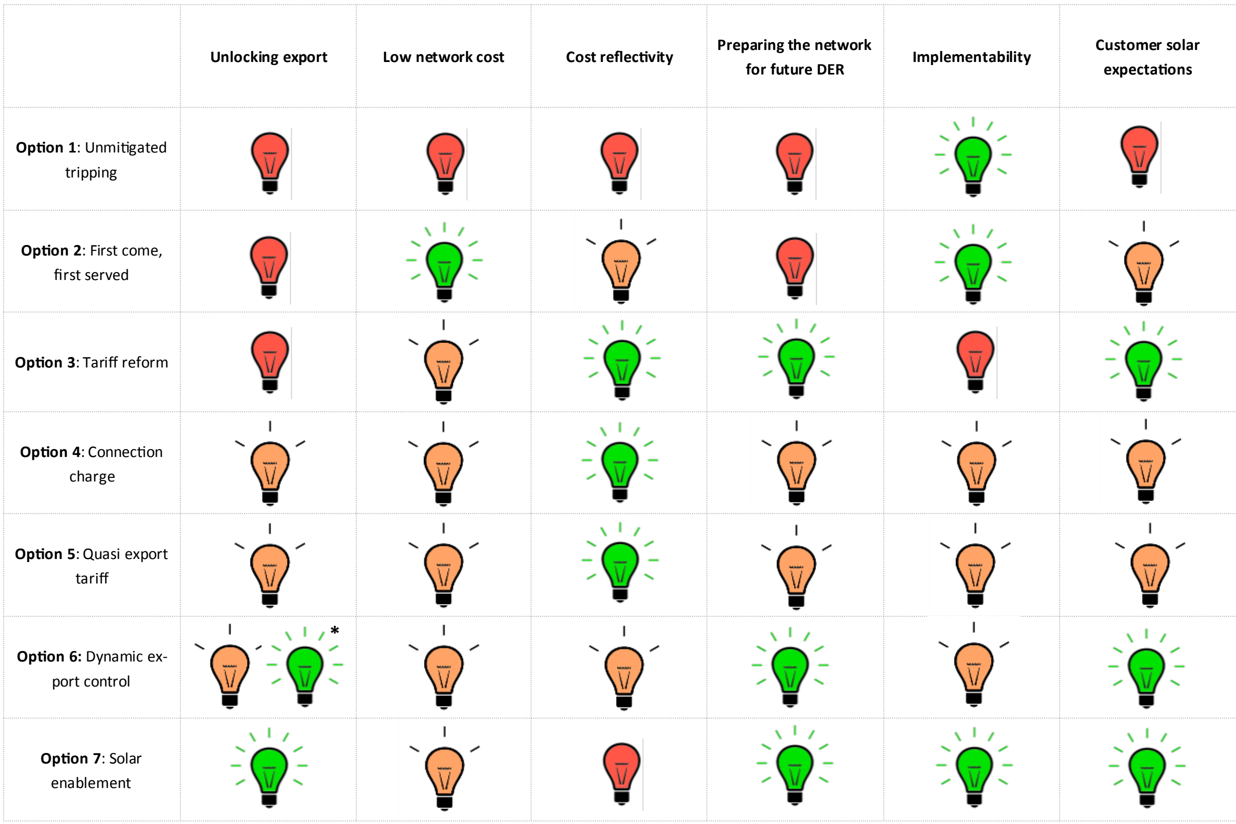
The options we consider in this paper to unlock solar exports differ across three dimensions:

- the number of customers that can export and the magnitude of the export
- how often customers can export
- who pays the costs of enabling exports.

The options are not necessarily stand alone and we can potentially adopt different options in each network area.

Our views of the options considered in this paper are summarised below.

Figure 1 Summary of approaches—initial views



Source: CitiPower, Powercor, United Energy Analysis
* Modelling required to demine amount of solar unlocked relative to option 7

2 Background

We held a Future Networks Forum on solar enablement on 1 April 2019 as part of our Energised 2021–2025 engagement program. Feedback suggested we needed to do more when it comes to solar, particularly around our options assessment. Specifically, our stakeholders indicated we did not provide them with sufficient information to determine whether the options put forward were the right ones in the wider context; and which option they preferred.

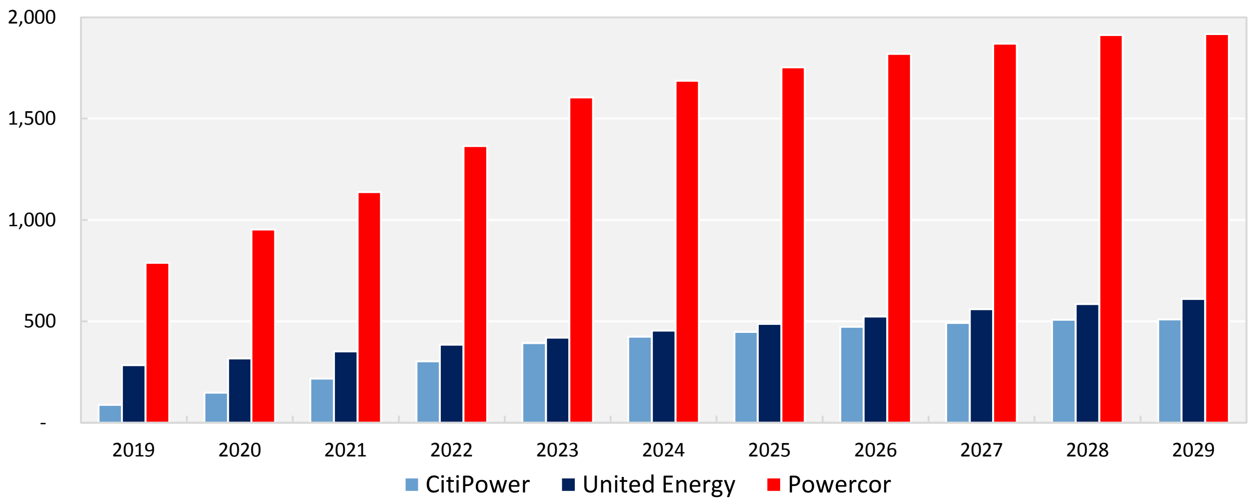
We will use feedback on this paper to refine and undertake more detailed analysis on the preferred options.

2.1 The number of solar installations is set to increase

In August 2018, the Victorian Government announced a 50% rebate for up to 650,000 homes and 50,000 rental properties to install solar panels over 10 years.[1] The Victorian Government expects this program to save Victorians $890 on their electricity bills each year and generate 12.5% of Victoria's target for 40% renewable energy by 2025.[2]

We engaged independent forecasters Oakley Greenwood and the National Institute of Economic and Industry Research (**NIEIR**) to forecast the solar uptake on our networks as shown below.

Figure 2 Solar uptake (MW)



Source: CitiPower, Powercor and United Energy analysis

Solar on Powercor's network is forecast to more than double by 2025. By 2025, solar penetration will be 27% for Powercor, 11% for CitiPower and 17% for United Energy.[3] These are substantial increases over current solar levels.

1 Based on a 4kW sized system

2 Victorian Government, Cutting Power Bills With Solar Panels For 650,000 Homes <https://www.premier.vic.gov.au/cutting-power-bills-with-solar-panels-for-650000-homes/>

3 Measured as a percentage of total customer numbers.

2.2 It is important to facilitate existing and future exports

Exporting solar is increasingly becoming an important part of the way customers consume and generate electricity and so we must consider ways to enable it.

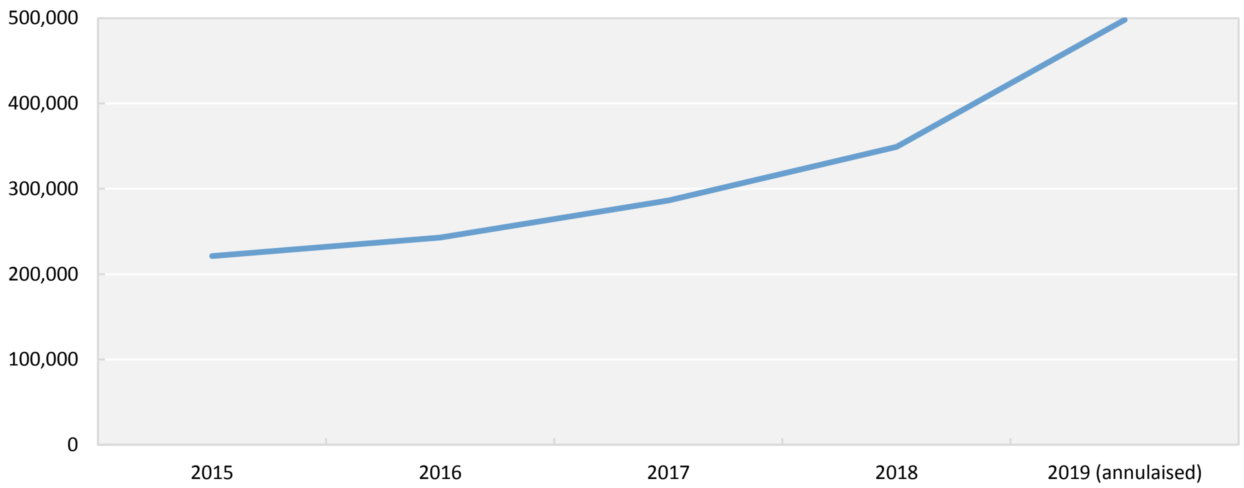
2.2.1 Customers are choosing to export

Our engagement activities over the past two years have demonstrated across all networks that our customers want to export solar electricity to:

- lower bills
- have greater energy independence
- build a sustainable future.

Customers' preferences to export solar are also evident by looking at the increasing trend in total exports on our network.

Figure 3 yearly exports (MWh)



Source: CitiPower and Powercor

As the only provider of distribution services to customers in our area, we must be a facilitator and not a barrier to customer trends. We need to accommodate customers' choices in the same way businesses operating in competitive markets must adapt.

Additionally, as far as practicable we should seek to facilitate the Victorian Government's policy decision that more customers should benefit from solar.

We consider this form a part of meeting our social obligation for operating a distribution network. This social obligation, however, also requires we balance these considerations with affordability and equity in terms of who pays to enable solar.

2.2.2 Unlocking the value customers solar investments

Customers benefit from exporting solar. Today, customers receive a financial benefit through the Feed-in-Tariff (**FiT**) for each kilowatt hour (**KWh**) of solar exported.[4] Exports also result in wholesale generation fuel cost savings. For example, some generators burn coal or natural gas to produce electricity; solar displaces the amount of these resources burned, which provides an economic benefit. The fuel cost saving can also place downward pressure on wholesale electricity prices.

Perhaps even more importantly, the Australian Energy Market Commission (**AEMC**) has highlighted that exports will allow customers to participate in a raft of new markets in the future, including:[5]

- engaging in local energy (peer-to-peer) trading—buying and selling electricity from other customers rather than from central generators
- retail and wholesale electricity price arbitrage activities—selling exported electricity to a third parties (such as retailers) to avoid that party having to purchase wholesale electricity
- wholesale market support—selling electricity at times of wholesale generation shortfalls
- transmission congestion management and distribution network investment deferral—selling electricity at times of peak load on the networks to avoid the need for capacity driven network investments.

These new markets improve the efficiency of the electricity market operations and reduce overall costs. These markets also create value for solar customers who will be paid for participating in them. Without exports, these markets will not properly develop and the value of the substantial solar investments made by customers and the Victorian Government will be stifled.

2.2.3 Voltage management

We have obligations under the Electricity Distribution Code (**Code**) to keep voltages below 253 volts (**V**) (or up to 262V for less than 1 minute) to ensure customers receive a reasonable quality of electricity supply.

We are aware that solar is already pushing these voltage limits. The implications of this are discussed more in section 2.3 below.

2.3 Network voltages are rising

To enable exports, customers’ solar inverters operate at a higher voltage than the network to 'push' the solar electricity back into the network. This causes the localised network voltage to rise, which creates the following impacts:

- when voltages reach either 255V for 10 minutes or 260V for 2 seconds, customers' solar inverters trip off as a safety measure to protect the network from damage.[6] When solar inverters trip, they are incapable of exporting, but importantly are also incapable of producing solar for in-home use. Inverters may only reconnect 1 minute after voltages return to normal levels.

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[4] The minimum FiT is set by the Essential Services Commission (Victoria) (**ESC**). The FiT represents the avoided costs of wholesale generation, market fees, reduced transmission and distribution losses, and reduced carbon emissions from solar exports. FiT are recovered by retailers from their customer bases.

[5] AEMC, Distribution Market Model, August 2017.

[6] Prior to the update to the AS4777 standard in 2015, the disconnection operate within 2 seconds where max voltages exceeds 270V.

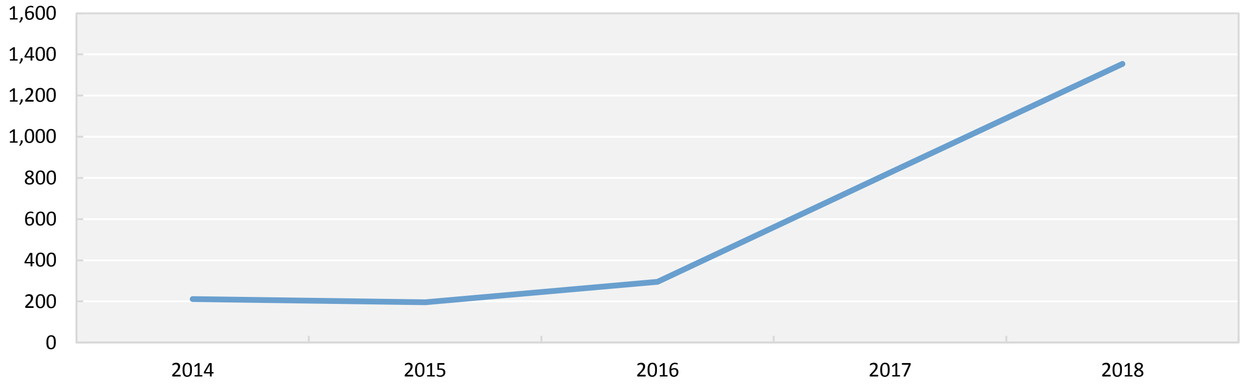
- over time, high voltages can reduce the life of network assets leading to higher network costs and reduce household appliance lives (even for non-solar customers).
- poor quality supply resulting in, for example, flickering lights.

Therefore, it is important for us to manage voltages.

2.3.1 Customers' solar experience

We have seen a steady rise in customer enquiries from solar tripping as shown below.[7]

Figure 4 Number of solar voltage enquiries



Source: CitiPower and Powercor

This is only a subset of our solar enquiries; as our solar penetration thresholds are reached, more customers are becoming dissatisfied with receiving notification that their exports need to be restricted (CitiPower and Powercor only, as discussed more below).

2.3.2 Our AMI data has provided unique insight into the impact of solar

We are in a unique position to understand the voltage impact of solar—and address it in a targeted and least cost way—given the investment made into Advanced Metering Infrastructure (**AMI**). Below we outline insight from our AMI data.

High voltages across the networks during solar exports

In 2018 the following number of transformers reached 255V on a single high (but not unusual) export day:

- CitiPower—7.4% or 269 transformers
- Powercor—16.8% or 12,581 transformers
- United Energy—15% of 1,980 transformers

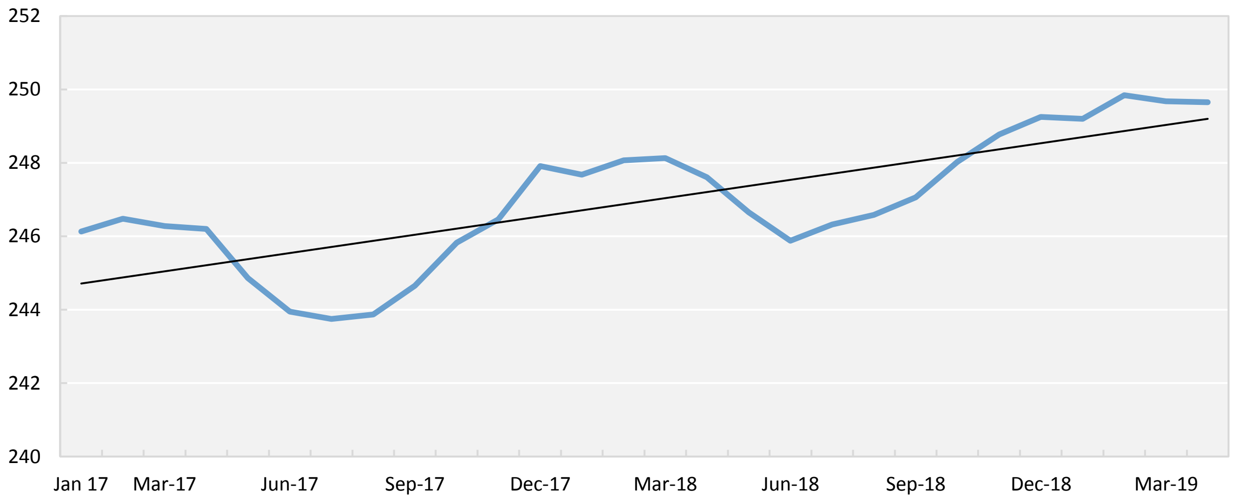
It is likely a number of solar customers connected to these transformers would have experienced tripping.

7 This is occurring notwithstanding CitiPower's and Powercor's current policy of restricting exports in areas of high penetration (Option 2—'first come first served' discussed below).

Increasing voltages as solar penetration increases

We have also examined the impact of rising solar penetration on voltages. The following figure shows the maximum voltages of a transformer that experienced a 40% increase in solar penetration from January 2017 to March 2019.

Figure 5 Maximum voltage on transformer as solar penetration increases



Source: Powercor

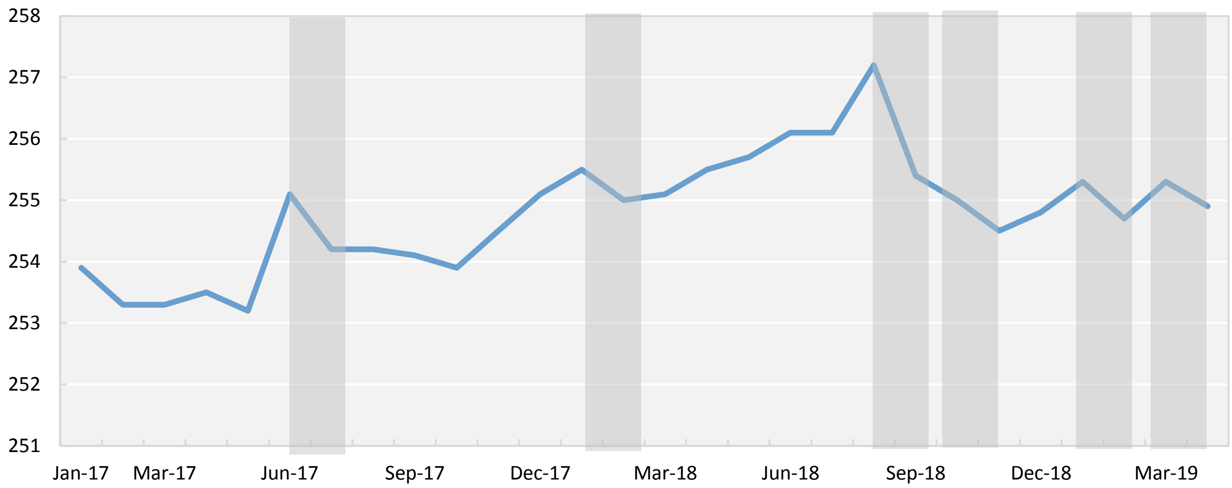
This figure demonstrates the:

- seasonal impact of solar exports on voltages—in the months with higher solar irradiance and exports, voltages increase
- voltages rise as solar penetration increases.

Overall high voltages from solar

Similarly, the following figure shows the maximum monthly voltage from the 25 transformers with the highest solar growth from January 2017. The grey bars indicate when we have tapped down voltages on some of these transformers (this forms part of our solution in option 7 as discussed below, however, there are limits to the number of times a transformer can be tapped).

Figure 6 Maximum voltage per month on transformers as solar penetration increases



Source: Powercor

This illustrates:

- maximum voltages rise as solar penetration increases.
- the overall high voltages that are experienced on high solar penetration transformers.

2.3.3 Our networks are highly utilised

Our networks are different to those in other jurisdictions. They are among the most highly utilised in the National Electricity Market. While this ensures we extract the maximum benefits from our assets and ensure affordability, it means we have less headroom to accommodate higher voltages generated by rooftop solar.

We have determined the utilisation of distribution transformers (where solar issues are mostly being experienced) using the Australian Energy Regulator's (**AER**) Regulatory Information Notice (**RIN**) data. This data shows our assets are more utilised that other jurisdictions with high solar penetration.[8]

[8] Calculated as the 10% probability of exceedance maximum demand divided by the total capacity of distribution transformers.

Table 1 Distribution transformer utilisation (%)

Distributor	Utilisation
United Energy	42.8
CitiPower	37.9
Powercor	36.3
Energex	34.9
SAPN	31.7
Ergon	29.0

Source: AER benchmarking RIN and category analysis RIN

2.4 Identified need

From the above analysis, we have identified the following need for change:

- meet our customers' expectations to export excess solar
- facilitate the Victorian Government's policy of allowing more customers to benefit from solar
- enable markets that improve the efficient operation of the electricity market to develop
- ensure a reasonable quality of electricity supply and meet our voltage obligations under the Code to protect network assets and customers' appliances.

3 Options analysis

There are many options available to us when it comes to solar. This is no more evident than when we look to other distributors across the NEM and the options they're presenting as part of their regulatory proposals. One thing is for certain, no two networks are the same and so our analysis of options must consider the constraints we work within for each network.

After feedback from our solar forum we broadened our thinking and have presented seven options to support solar enablement. Given the number of options, we have not been able to quantify the impact of them all but rather we have qualitatively discussed the advantages and disadvantages of each option.

We will use feedback from this options paper to narrow down the most preferred options and then undertake more detailed analysis. The options we have presented are not necessarily standalone and the outcome could be a combination of options.

3.1 Option 1—'unmitigated tripping'

We could not constrain solar customers from connecting and exporting and allow inverters to trip when voltages reach 255V. This is a 'do nothing' scenario.

As solar penetration increases, customers will experience more periods of tripping. Indeed, inverters may trip in a continuous cycle—as inverters compete with each other to export the network voltages will rise, inverters will trip, reset, and then push up voltages again. Even customers seeking to use solar for in-home use at those times will experience tripping.

Customers will miss out on current, and perhaps more importantly, future benefits of solar from accessing new markets. If solar exports are not enabled, the development of these new markets will be stifled; perhaps to the extent they do not develop.

Voltages will also rise above limits set out in the Code, which are designed to protect the quality of customers' electricity supply. Over time the high voltages will potentially reduce the life of network assets and household appliances.

We don’t support this option—trip settings are a last resort measure to protect the network, not a tool for managing exports.

Advantages	Disadvantages
• No immediate network investment required	• Detrimental to network assets and customers' appliances leading to longer term costs • Customers experience significant solar tripping • Voltages regularly rise above maximum levels set in the Code

3.2 Option 2—'first come first served'

We would establish solar penetration thresholds on distribution transformers and if solar connects to transformers with headroom, exports will be allowed. Once thresholds are met, we would require inverters to be set to 'no export'.

This reflects CitiPower's and Powercor's current approach where we automatically approve exports when solar penetration is below 30% on rural transformers and 50% on urban transforms.[9] Once reached, customers must set their inverters to 'no export' or, for a fee, request a technical study on whether the local network can accommodate more exports. There is no guarantee exports will be allowed once this study is completed.

Our policy is currently resulting in the following outcomes:

- 88% of customers are approved for the requested export capability
- 12% receive reduced exports.

The number of export restrictions will increase exponentially as thresholds are reached. Customers that are not granted export capability will not be able to access current benefits such as FiT or future markets.

This option leads to the inequity of customers connecting later having less chance of being able to export.

Advantages	Disadvantages
• No network investment required	• Exporting is allowed on a 'first come first served' basis • Exports will be restricted for increasingly more customers as thresholds are reached • Study fees

3.3 Option 3—tariff reform

Tariffs can be used to change customer behaviour and potentially result in fewer voltage issues.

Tariff structures could encourage solar to be used in-home resulting in fewer network voltage issues. Some structures are:

- SAPN's 'solar sponge'—very low prices at peak export periods (10am-3pm) to encourage people to use electricity that has been exported onto the network before it creates voltage issues
- demand tariffs based on total maximum demand, which could include export load
- higher tariffs for solar exporting customers reflecting the cost of managing voltage issues
- 'social tariffs' that would not include the cost of managing solar for customers vulnerable to electricity prices

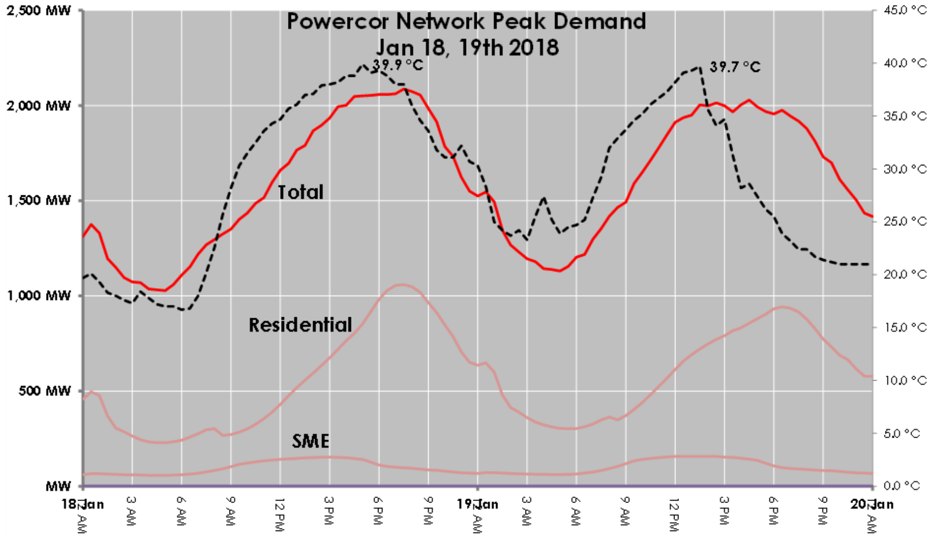
The effectiveness of tariffs and whether they are supported by our stakeholders rests on factors including:

- SAPN's 'solar sponge'—is not fit for purpose for our networks because they can experience peak load at this time—CitiPower experiences peak load during the day due to its commercial load and Powercor and United Energy can peak as early as midday as shown below.[10]

9 In light of the recent solar uptake driven by the Solar Homes Package subsidy and the resultant high voltages and complaints, it is also evident this policy will not be sustainable in its current form and that the thresholds will need to be further reduced.

10 We are proposing a time of use tariff with higher prices during the evenings. While this is likely to reduce load at this times, it is unlikely to materially increase load during the day given the more modest price differential and that it is likely to apply to new and modified connections.

Table 2 Powercor peak load curve



- retailers may not pass on the tariff structure to customers/may not pass on the full strength of the tariff
- customers' response to tariffs will be impacted by their understanding of it
- with a larger price signal customers are more likely to respond, however, this also increases the likelihood of bill shocks
- tariffs may encourage efficient use of the network from a load perspective and/or an export perspective but this behaviour change is unlikely to be sufficient to remove the voltage issues caused by solar
- a 'social tariff' is not supported by the National Electricity Rules and the AER has previously rejected such a tariff.

Given this, it is more likely tariff reform could be used as a complement rather than as a stand-alone option enabling more solar exports. Further, tariff reform such as a 'social tariff' or an 'export tariff' needs support from the Victorian Government and/or the AER.

Our stakeholders overwhelming supported time of use tariffs. This tariff aims to reduce peak load by encouraging customers to use the network outside of peak load times.

We recognise the tariff reform discussions to date with our stakeholders have not focused on the uptake of solar and we welcome your views on potential tariff options that could enable more solar. Potentially, depending on our stakeholders response we can advocate more effectively with the Victorian Government and regulators.

Advantages	Disadvantages
• More cost reflective • Can encourage more efficient use of solar • Will support future DER	• Has been difficult to implement • Requires significant and sustained behavioural response • Unlikely to do away with the need for other solutions

3.4 Option 4—connection charge

We would charge customers at the time they connect their solar for the ability to export.

A connection charge could operate as follows:

- only customers seeking to export would pay the charge i.e. no charge for non-exporting solar
- the charge is based on the solar inverter size i.e. customers capable of exporting more would pay more
- the charge would cover the cost of removing voltage issues (on average) for those customers seeking to export.

Not all customers would be eligible to pay the charge and export. There are a number of small transformers on the network with limited export capacity. In these areas, it would not be cost effective to enable more exports because the average charge would fall well short of the upgrade cost and the difference would end up being paid for by all customers through electricity bills.

Our previous analysis found it would typically be economically viable to enable exports where 6 or more solar customers were expected to connect. With 6 customers, the total revenue the solar customers receive from exporting would exceed the average cost of facilitating the exports.[11]

There is some disagreement as to whether a connection charge is allowed under the National Electricity Rules (**Rules**). The final decision on this would rest with the AER.

Advantages	Disadvantages
• Enables more solar exports • Customers who pay are able to export • Works also assist to prepare the network for future DER.	• Customers face a connection charge. This may not be consistent with customers' expectations or the Victorian Government's policy • May not be allowed by the Rules • Solar is not enabled for everyone

3.5 Option 5—'quasi export tariffs'

Solar customers would pay to enable exports through an ongoing charge levied on exports.

Enabling this would require a change to the market framework—at present customers rather than generators pay for using the network. The principle of an export tariff, however, can be achieved by reducing the FiT to recognise the cost imposed on the network.

This option could be implemented by the Victorian Government and Essential Services Commission (Victoria), and could be implemented to different extents as outlined below.

3.5.1 Partially reducing the FiT

We could determine the investment needed to enable exports and translate this into a KWh charge. The FiT paid to customers could be reduced by this amount and instead directed to distributors to enable exports.

We could enable exports to different extents. For example, we could calculate the cost to enable exports for all customers all of the time or have a lesser reduction to FiT by only enabling partial exports.

11 We undertook a private cost benefit analysis that considered the benefit accruing to exporting customers, as these customers pay the cost to export.

Advantages	Disadvantages
• Unlock more, but not all exports • No additional cost to all customers (rather, it is redirecting existing FiT payments) • Solar customers encouraged to use more solar in-home	• Requires network investment • Lower financial incentives to export

3.5.2 Reducing FiT to zero

FiT could be reduced to zero/abolished. Solar customers would not have a financial reason to export and would instead seek to use as much solar themselves, for example by orientating their panels to ensure maximum production when they are at home (typically in the evenings) and purchase batteries to store solar for when its needed.

This would reduce voltage issues while still enable customers to use their solar for in home use. However, by not enabling more exports, customers will miss out on benefits in terms of lower wholesale prices and future new markets.

It is likely some export related voltage issues will remain as exports will still occur. The costs of this could be recovered through network charges to all customers.

Advantages	Disadvantages
• Limited network investment • Solar customers use more solar in-home • Customers without solar stop paying for FiT	• No financial incentives to export • Not enabling more exports leading to fewer benefits and stifling future markets • May not be supported by/aligned with Victorian Government policy

3.6 Option 6—dynamic export control

We would dynamically reduce customers' exports at times of network constraints.

We would remotely 'talk' to solar inverters and ratchet down exports to avoid tripping. While all customers would be able to connect export capable solar and participate in future energy trading markets, as solar penetration increases, exports will be ratcheted down more often. However, this option could potentially be paired with some works outlined in option 7 to increase the network's hosting capacity in areas where ratcheting down exports would be substantial.

To implement this option, all new customers would need to install inverters and potentially additional equipment capable of communication and detailed control, which may require new inverter standards to be put in place. Additionally, we would need to develop a communication platform—potentially the existing AMI network could be leveraged.

The cost of developing the communications platform would be spread across all customers (i.e. including those without solar). However, solar exports would only be enabled at times of spare capacity meaning non-solar customers would not pay for works to the network to enable exports.

We would only be capable of talking with new inverters. This would lead to an inequity where new solar customers would be subject to export ratcheting whereas existing customers would not.

This communication platform could potentially be used to control future Distributed Energy Resources (**DER**) such as electric vehicle charging times.

The first step of this option is being proposed by SAPN in its 2020–2025 regulatory period, however, it is not expecting to communicate with inverters until after this time.

Advantages	Disadvantages
• Enables all customers to have export capabilities • Communication platform potentially could be used to control other DER such as electric vehicle charging times	• Exports will be ratcheted down • Requires network investment in communications and customer investment in communication capable inverters • All customers pay for network investments, even those who do not export • Inequity whereby only new solar customers would experience export ratchetting.

3.7 Option 7—'solar enablement'

We would undertake works to prepare the network for more exports.

This is the option we presented at our forum. This option is currently adopted (in part) by United Energy for residential solar and is having immediate impacts on reducing the number of customer inverter trips.

The works involved to enable solar in this option are:

- applying customer inverter 'volt-var' settings to reduce the voltage impact of solar exports
- dynamic and static voltage management at zone substations using voltage data from smart meters
- distribution transformer tap changing
- phase re-balancing
- low voltage network augmentations to improve conductor impedances
- replace legacy distribution transformers with a narrow tapping range (or nearing) capacity with standard transformers
- low voltage network storage (we are about to trial this)

Using AMI data we can target the correct and lowest cost solution for each part of the network.

This option is capable of unlocking the most solar leading to wholesale fuel cost saving, lower network peak demand and hence lower (load driven) network investment, participation in future markets and stabilise electricity supply quality.

The works undertaken in this option are also important for enabling future DER such as electric vehicles. Balancing the network and having more levers to manage voltage and load flows allows us to better utilise network capacity while maintaining supply quality.

3.7.1 Cost allocation and forecast costs

Forecast costs

This option can be implemented to various degrees, and we could select the option that provides the highest net benefits. The options presented at the forum were:

1. **all customers** can export up to 5kW **at all times** (we prevent voltages rising to 255 where inverters trip)

2. **all customers** export **most of the time**—we allow voltages to rise to 255V on the occasions when net exports are highest. In our forum, we presented the costs of allowing tripping around 10% of the time.
3. **most customers** export **most of the time**—we do not undertake works in all parts of the network.

After feedback from the forum, we have forecast reducing the maximum exports enabled to recognise customers with 5kW systems export less than 5kW.[12] This, along with other model improvements and corrections has lowered the expectant costs as shown below.

Table 3Cost of solar enablement ($, million)

Network	Cost presented at forum for most customers to export up to 5kW most of the time	Updated cost for most customers to export up to 3.1kW most of the time
Powercor	73	50
CitiPower	37	24
United Energy*	24	24
Total	**134**	**98**

Source: CitiPower, Powercor and United Energy analysis
*United Energy's costs have not declined as more conservative estimates were already adopted in its model

Cost allocation

Under this option the costs are spread over our customer base through network charges like the majority of our investments. This is approach has been applied in other jurisdictions that have high solar penetration. For example:

- the AER approved $25.3 million for Energex in 2015–2020 to address power quality issues. Energex outlined this was needed to because 'power flows can now occur in directions, leading to greater voltage regulation to be managed and operational issues to be addressed.'
- the AER approved in 2015–2020 $28 million for Ergon sought $44 million to install voltage regulators, and upgrade distribution transformers and low voltage feeders to address voltage issues from solar.
- in 2020–2025 Ergon and Energex are seeking a further $15.1 million $44.1 million respectively for power quality monitor and solar driven augmentation works.
- the AER approved $52.7 million for SA Power Networks (**SAPN**) proposed due to the rapid growth of solar that drove an increasing number of 'two way' power flows across the low voltage network, leading to high-voltage fluctuations.

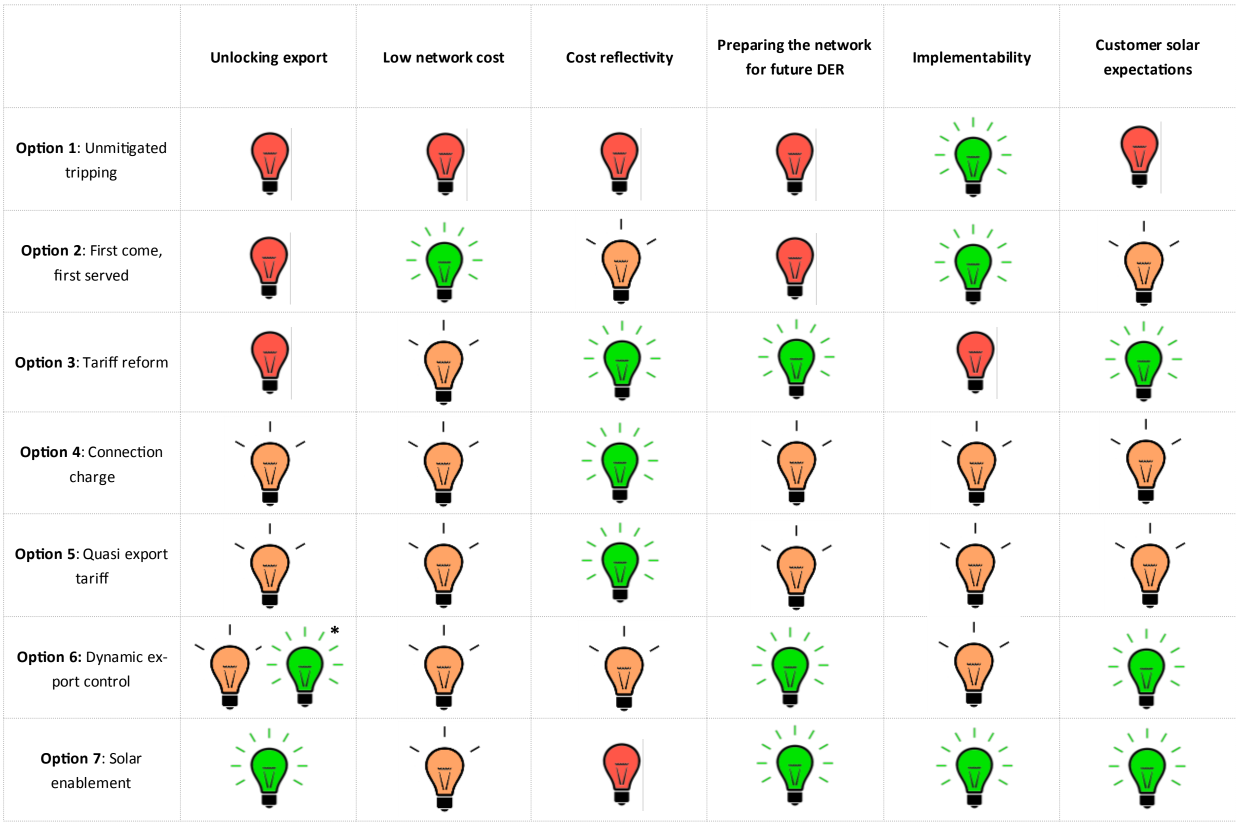
12 For CitiPower and Powercor we found that 3.1 kW is the average export of customers with a 5kW system on one of the higher experienced export days. We note our forecast model further reduces the estimated impact of exports by considering the 95 percentile voltages experienced on transformers rather than the maximum voltage meaning using 3.1kW would result in more tripping than previously assumed.

Advantages	Disadvantages
• Enables more solar exports • Provides benefits to all customers, but may not all be passed through—may have a positive net present value depending on extent to which the option is implemented • Works also assist to prepare the network for DER.	• Requires network investment • All customers pay to enable exports, even those who do not export

4 Key impacts

We have summarised our views on the impact of the options discussed as shown below.

Figure 7 Summary of approaches—initial views



Source: CitiPower, Powercor, United Energy Analysis
* Modelling required to demine amount of solar unlocked relative to option 7

We want to hear our stakeholders' views on the options considered in this paper and those options worth further investigations.