SRES and Small-scale PV Projections

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Contents

Executive Summary

The Clean Energy Regulator (CER) is responsible for the regulation of the Australian Government's climate change laws and programmes, including the Renewable Energy Target (RET). One of its functions is to administer the Small-scale Renewable Energy Scheme (SRES). The SRES is designed to achieve generation of electricity from small-scale renewable sources, reduce emissions of greenhouse gases in the electricity sector, and ensure that renewable energy sources are ecologically sustainable.

The SRES offers small-scale technology certificates (STCs) at a price of $40 per certificate through the STC clearing house to purchasers of eligible solar water heaters (SWH), air source heat pump water heaters (HPWH) and small-scale photovoltaic (PV), wind and hydro systems. STCs are also traded on the open market.

There is no cap for the number of STCs that can be created. Up until 2017, each installed system could create certificates equivalent to 15 years of expected generation from the system for a small-scale renewable generator and equivalent to 10 years for a renewable water heater. From 2016, the number of STCs generated per unit is one year less than previous, with the view that the scheme tapered off in a gradual linear manner.

The purpose of this report is to forecast the number of STCs, and small-scale capacity installed that will be generated in the calendar years of 2020 up to and including 2023. This will assist in determining the number of STCs each electricity retailer is obliged to surrender.

In the past, the majority of uptake has been through solar hot water units and residential solar PV generation. Uptake in solar PV generation has now largely supplanted uptake from solar hot water and has been influenced by reductions in the installed cost of new solar PV systems, growing market acceptance of these technologies, higher electricity retail prices and government incentives.

High retail electricity tariffs have increased growth in the rate of PV installations. Continuing strong uptake for commercial installations are also projected over the forecast period driven by perceived economic benefits. Over the projection period, we see uptake also boosted by state-based incentives particularly in Victoria.

Table 1 shows our projections of STC creation. These projections are based on our time-series modelling approach.

The approach involved the development of hybrid ARIMA time-series models and an agent-based model for the residential solar PV uptake. The ARIMA time series model provides robust forecasts over a short-medium timeframe, while the agent-based model enables the longer-term market saturation effects to be explored. We have used several relevant independent regressors to estimate the impact of electricity prices, interest rates, feed-in tariffs, capital costs and capital rebates, as well as instrumental variables to mimic shocks (such as the COVID-19 pandemic) and policy changes.

For estimating the commercial models, we have used national ARIMA based timeseries approach utilising the same independent variables as discussed above.

The solar PV uptake projections have been used to calculate the STC projections as included in **Table 1**. The outputs indicate that STC creation is expected to peak in 2020 before a downward trend is observed as the STC scheme tapers to completion by 2030.

The projected installed capacity of small-scale rooftop solar is shown in Table 2. Modest growth in installed capacity is expected over the projection horizon, although the projection sees the continuation of the high level of uptake observed in recent years.

Table 1: Small scale technology certificate creation projections (‘000s)

	2020	2021	2022	2023
Australian Capital Territory	610	570	621	650
New South Wales	11,282	10,668	10,983	10,611
Northern Territory	333	240	173	123
Queensland	9,418	9,644	9,236	8,696
South Australia	3,673	3,202	3,311	3,139
Tasmania	273	277	269	289
Victoria	5,379	4,983	4,485	3,987
Western Australia	4,326	4,868	4,392	3,864
Commercial <15 kW	1,198	1,306	1,424	1,486
Commercial 15 kW-90 kW	3,572	3,580	3,112	2,706
Commercial 90 kW-100 kW	2,104	2,125	1,894	1,711
Residential Solar Hot Water	1,820	2,323	2,528	2,674
Commercial Solar Hot Water	47	35	24	16
All STCs	44,035	43,821	42,452	39,952

Table 2: Projected installed capacity of small-scale systems (MW)

	2020	2021	2022	2023
Australian Capital Territory	39	42	50	59
New South Wales	730	774	885	962
Northern Territory	19	16	12	10
Queensland	621	701	746	790
South Australia	238	234	269	286
Tasmania	21	24	25	31
Victoria	411	419	419	419
Western Australia	289	355	356	352
Commercial <15 kW	81	98	118	139
Commercial 15 kW-90 kW	242	268	259	253
Commercial 90 kW-100 kW	143	159	158	160
All small-scale PV Installations	2,834	3,090	3,297	3,461

1. Introduction

The Clean Energy Regulator (CER) is responsible for the regulation of the Australian Government's climate change laws and programmes. One of its functions is to administer the Small-scale Renewable Energy Scheme (SRES). The SRES is designed to achieve the following objectives:

- Generation of electricity from renewable energy sources;
- Reduced emissions of greenhouse gases in the electricity sector; and
- Ensuring that renewable energy sources are ecologically sustainable.

The SRES offers small-scale technology certificates (STCs) at a fixed price of $40 per certificate through the STC clearing house to purchasers of eligible solar water heaters (SWH), air source heat pump water heaters (HPWH) and small-scale photovoltaic (PV), wind and hydro-electric systems. STCs are also traded on the open market, historically usually at a discount to the clearing house price. There is no cap for the number of STCs that can be created.

The number of STCs created is based on an estimate of electricity generated or displaced by the renewable energy sources over their economic lifetime. The number of STCs created is also influenced by geographical location.

The purpose of this report is to forecast the number of STCs that will be generated in the calendar years of 2020, 2021, 2022 and 2023. This will assist liable entities to anticipate the extent of their liability over the coming years.

The STC forecast is developed through the completion of several tasks including:

- Modelling of expected small-scale technology installations (⩽100 kW) and provision of updated SRES forecasts for 2020-2023, including projections of the number of STCs and installed capacity for 2020 in addition to the three compliance years from 2021 to 2023.
- Identification of key factors affecting the type, number and size of small-scale systems installed and the trends in STC creation by various categories including residential and commercial uptake across states and territories in Australia.
- Review and update previously developed models and methodologies to improve accuracy of projections. This has been done by analysing and identifying changes to circumstances, trend breaks and/or inclusion of alternative estimators.

Historical data has been supplied by the CER containing detailed information on the number of STCs created and registered including the type and location of unit installed. Data was provided from April 2001 until December 2020 to assist with the forecasts. All analysis and forecasts in this study are based upon STCs created in the month of installation and STCs are only considered if they have passed validation.

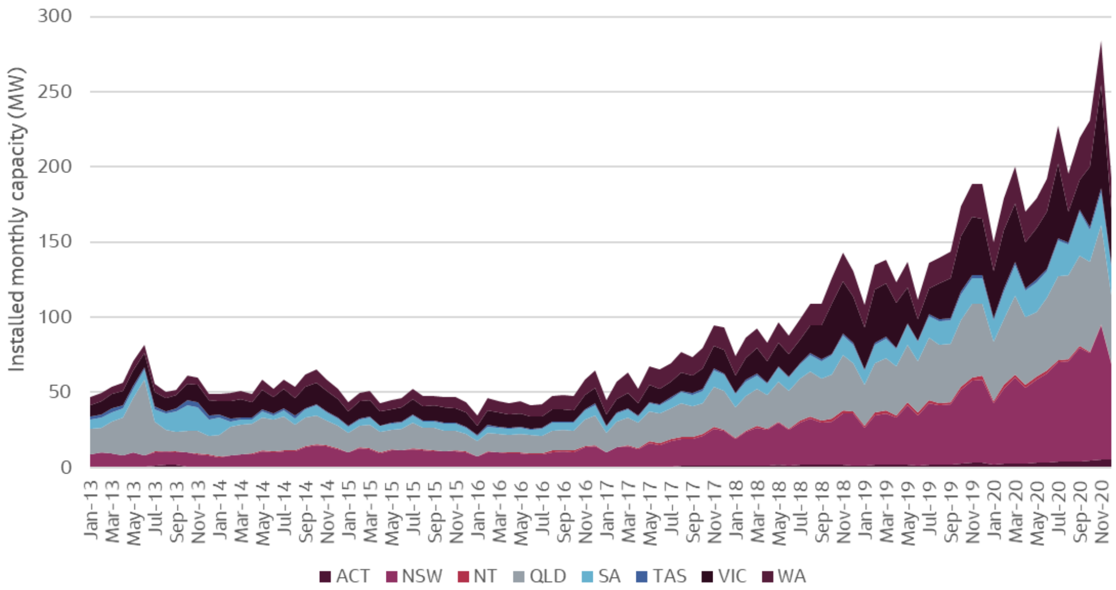
This report continues with an analysis of the trends in uptake in section 2, followed by a description of the current Government incentives and solar PV policies in section 3. Section 4 describes the method, and the assumptions are discussed in section 5. Section 6 presents the results, which are summarised in section 7. The appendices include detailed modelling outputs, statistics, data tables and references.

2. Trends in Uptake

2.1 Small-scale PV Systems

Figure 1 illustrates the monthly residential rooftop PV capacity installed from the beginning of 2013. The first half of 2020 indicates no slowdown in the rate of growth of residential installations observed since 2017, despite the social and economic impacts of the response to the COVID-19 pandemic.

Figure 1: Monthly installed residential capacity across states



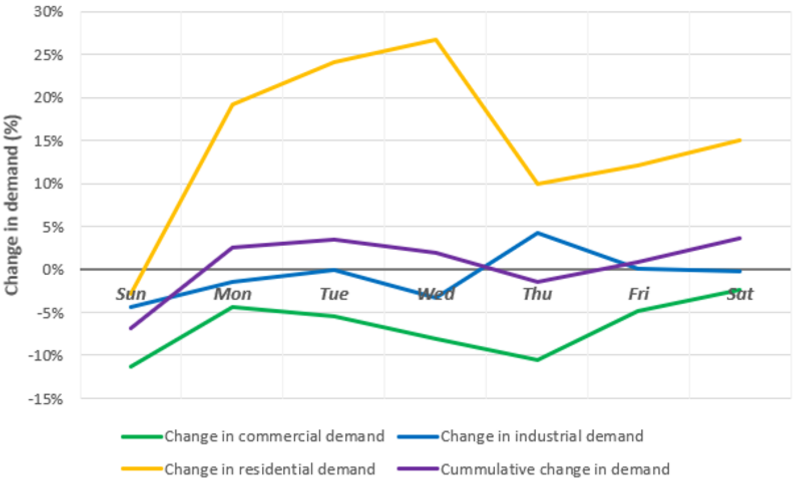
Source: Jacobs' analysis of CER data

The impact of COVID-19 and the subsequent nation-wide lockdowns, government stimulus packages and consumer behaviour has had a two-speed effect on the economy. While the net impact of the extensive lock downs and strict social distancing rules imposed has reduced gross domestic product, some sectors have prospered. Small-scale solar PV installations appear to be one of these sectors. With consumers in various stages of lockdown and unable to spend much on outdoor entertainment, dining out and travel, the result has been a shift to an increase in spending on household items. Additionally, the extra consumption of power during daylight hours from the shift to working from home and record low interest rates makes the installation of PV systems attractive.

However, the long-term effects of the COVID-19 crisis are still unclear and they could impact consumers' ability to invest in solar PV in the medium to long-term.

Examining recent changes to Australian electricity consumption by consumer class illustrates the impact of COVID-19 on residential electricity demand (see Figure 2). The analysis indicates that industrial demand has seen relatively little impact, with commercial demand reductions being offset by higher residential demand.

Figure 2: Change in daily demand for March 2020 for the Jemena distribution network (Victoria)



Source: Figure 1 from Energy Networks 2020 'Commercial down v residential up: COVID-19's electricity impact'. https://www.energynetworks.com.au/news/energy-insider/2020-energy-insider/commercial-down-v-residential-up-covid-19s-electricity-impact/

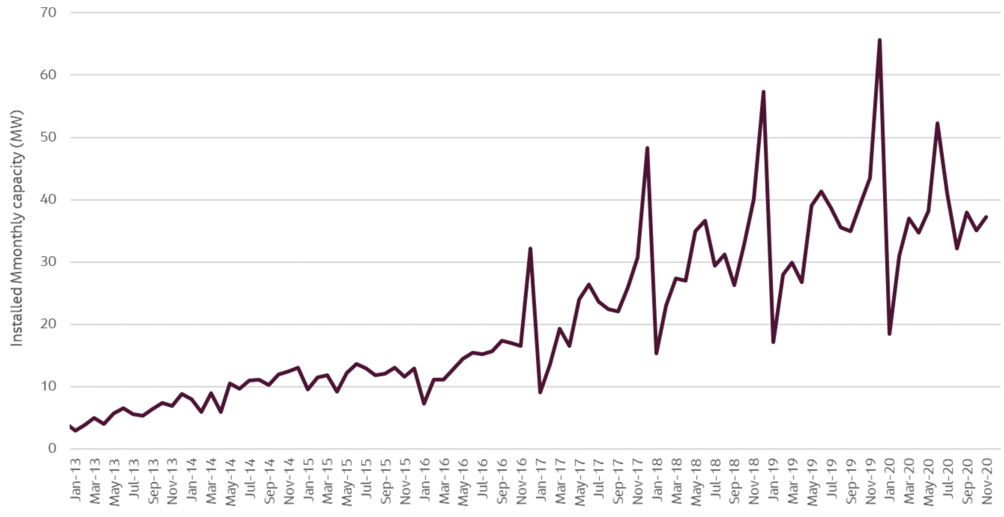
The rise in uptake of rooftop PV installation since 2017 is also attributed to the elevated electricity prices in addition to higher feed-in tariffs. The retail price of electricity increased in NEM states in 2017, driven by rising wholesale costs resulting from higher wholesale gas prices and the retirement of the Hazelwood power station. Higher wholesale prices also flow through indirectly to the feed-in tariffs offered as the value of solar exports to an energy retailer is proportional to the wholesale price of electricity. Feed-in-tariffs jumped in 2016 and 2017 to levels double those in prior years.

There are several other factors contributing to the rise in rooftop PV installations:

- Reductions in capital cost of installations;
- Reducing cash and mortgage rate;
- Increasing environmental awareness;
- Increase in awareness via advertising, word of mouth, neighbourhood uptake.

Figure 3 illustrates the recent trends in installed capacity by schools and businesses. A strong growth in uptake has occurred since 2017. A distinct seasonal trend has emerged as businesses hasten to commit to installations prior to annual step down in rebates applied to small scale technology. The COVID-19 situation also appears to have had a positive influence on commercial PV installations, despite the temporary closure of many small-medium enterprises. This may be attributed to government incentives (such as the instant tax write-off) and the SME's that have benefitted from the lock downs such as data centres and online retailers.

Figure 3: Monthly trend in STC creation from commercial solar PV installations

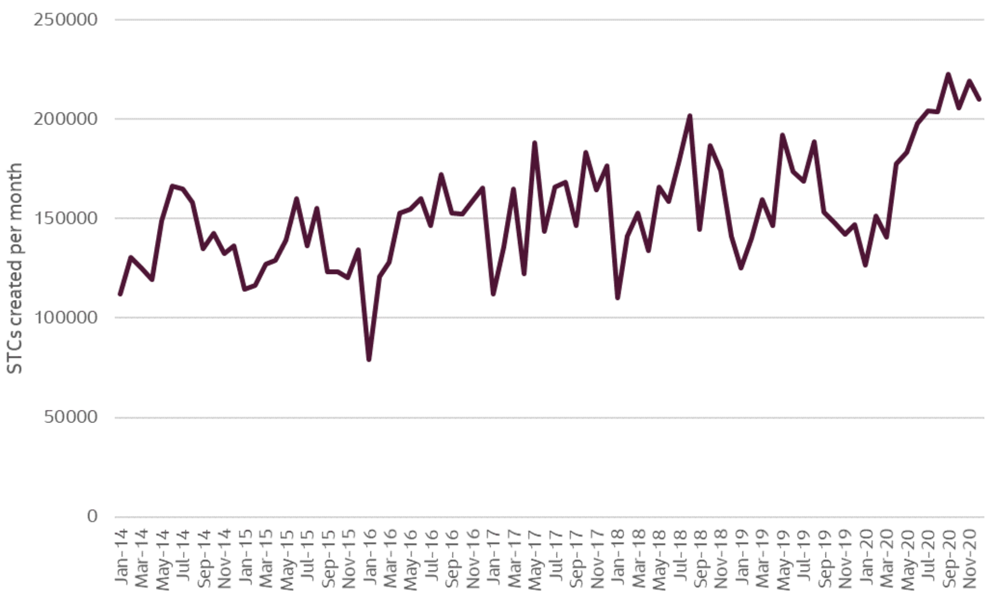


Source: Jacobs' analysis of CER data, with data for months of July-December 2020 including estimates due to registration lag

2.2 Solar water heaters

Figure 4 shows the trend in creation of STCs by the installation of residential solar hot water systems. The market had steadied in the last few years, with the year 2019 having an overall decrease of 0.2% in STCs created compared to 2018.

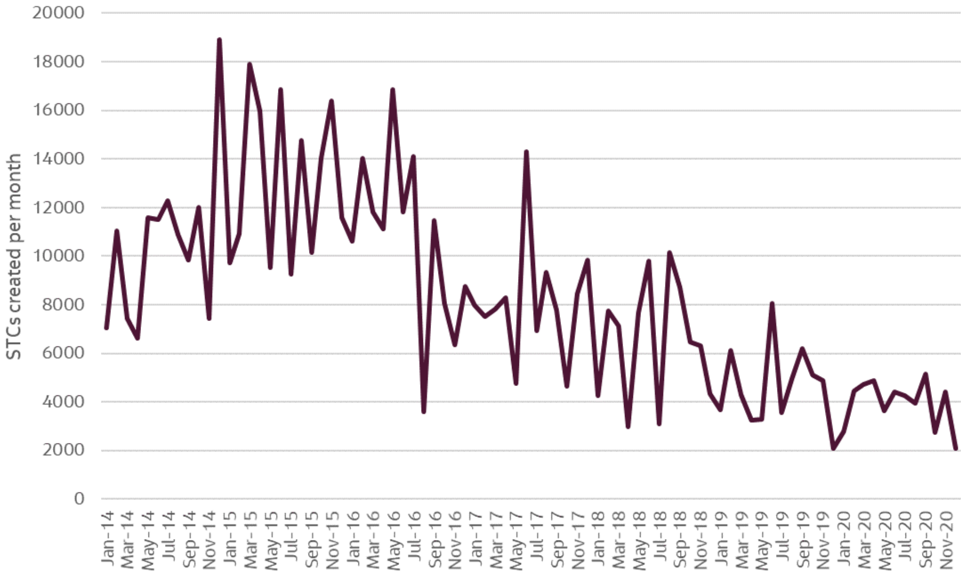
Figure 4: Monthly trend in STC creation from residential SHW



Source: Jacobs' analysis of CER data

STC creation from commercially sized units continues to decline with a decrease of 24% in 2017, a 19% reduction in 2018 and a further 29% decrease in 2019 as shown in **Figure 5**.

Figure 5: Monthly trend in STC creation from commercial SHW



Source: Jacobs' analysis of CER data

3. Government Incentives and Policies

The number of STCs generated is dependent on uptake of eligible technologies by households and businesses which is in turn influenced by financial incentives and regulations such as federal and state rebates, the state-based FiT schemes, and building standards. The energy efficiency building standards in place still impact the choice of water heaters installed in new houses.

The blackout in South Australia during September 2016 has shifted the state government from incentives based purely on energy saving and renewable generation to focus more on energy security in the form of energy storage. This has made the government realign incentives towards residential battery storage systems.

More recently, South Australia has given AEMO authority to control rooftop solar exports when necessary. The plan aims to better integrate distributed energy resources (DER). There are also plans to enforce improved inverter standards for new rooftop solar. Additionally, all smart meters installed must have internet capacity and residents are required to appoint a 'Relevant Agent' responsible for turning their system off and on during an emergency. It is expected that curtailment of exports from rooftop solar would only occur under extreme circumstances, and therefore it is unlikely that these new rules would have an impact on the uptake of rooftop solar in South Australia.

Western Australia and the Northern Territory have also significantly reduced their standard feed-in-tariffs in a move to reduce incentives for export of solar generated power from rooftop systems due to concerns of the impact on grid stability. This is discussed further in section 5.6.

All jurisdictions in Australia except Tasmania and the Northern Territory have in place at least one scheme to encourage uptake of distributed renewable resources including rooftop solar PV and household batteries. This section outlines state-based schemes and regulations that could influence the uptake of solar PV and hot water systems.

3.1 Solar Homes Program - Victoria

In August 2018, the Victorian Labor government announced a new solar rebate scheme for the installation of eligible rooftop solar PV. The plan is means tested to households of income less than $180,000 and is expected to fund the installation of PV systems on 720,000 homes over a 10-year period. According to the latest ABS Census data, approximately 11% of Victorian households would be ineligible for the program due to an annual household income exceeding $180,000.

The offer is currently open to Victorian households who installed solar panels on or after 19 August 2018 and can apply for a rebate to cover half the cost of a solar PV system up to a maximum of $2,225. From July 2019, eligible Victorian residents will also be able to receive an interest free loan for a period of 4 years to finance the remainder of the capital cost of installation. Rebates of up to $1,000 are also being offered for the installation of solar hot water units in dwellings that are unsuited for solar PV installations.

In addition, the Victorian Labor Party has pledged to support uptake of solar on rental properties. This component involves an additional $82 million package of 50,000 rebates to be delivered over a 10-year period to eligible tenants and landlords that agree to share the remaining costs of the system.

3.2 Home Battery Scheme – South Australia

The South Australian Home Battery Scheme comprises $100 million in government subsidies available for 40,000 homes for the installation of a battery component. Participating households are eligible to apply for finance via the Commonwealth Clean Energy Finance Corporation.

The battery subsidy is based upon the size of the battery and is currently set at $600 per kWh storage for energy concession holders and $500 per kWh for all other households. Strict specifications need to be met to ensure that batteries can also be aggregated to the Virtual Power Plant, although the participating household can choose whether to operate their battery as part of this system. The subsidy is open to household applications from October 2018.

While the batteries themselves will not contribute to STC creation, it is expected that the increase in benefit to households via load shifting may encourage the installation of rooftop PV and battery packages.

3.3 Virtual Power Plant – South Australia

In early 2018, the South Australian government announced plans to engage with Tesla to develop a Virtual Power Plant in that State in a scheme that aims to aggregate 50,000 residential batteries to work together. The expected $800 million scheme is expected to add 250 MW of dispatchable power to the grid over a 4-year period.

The Virtual Power Plant is set to roll out in 3 stages.

1. A trial of 1,100 housing trust properties, each provided a 5 kW solar panel system and 13.5 kWh Tesla Powerwall battery, installed at no charge and financed via the sale of electricity throughout 2018.

2. Systems set to be installed to a further 24,000 housing trust properties in South Australia.

3. Similar deal offered to all low-income households available upon assessment of original trial.

3.4 Residential solar and battery incentive schemes – New South Wales

In September 2018, the NSW government announced an initiative to install free rooftop PV systems in place of a cost of living rebate targeted to low income households. The $15 million scheme offers eligible households the option to forego the $285 energy bill deduction “living rebate” payment in exchange for the installation of a 2.5 kW rooftop solar system. The scheme is available for up to 3,400 eligible households, with an expectation that they will be up to $300 better off per year by accepting this offer.

The NSW Government announced early in 2019 a program to provide interest-free loans for solar batteries and solar and battery storage systems through a 10-year Empowering Homes program. This will target approximately 300,000 households. This program provides interest free loans of up to $9,000 for a battery system and up to $14,000 for a solar plus storage system. Eligible households must be owner-occupiers and have an annual household income of up to $180,000. The first battery or solar-battery system was available for installation under this program in the 2019/2020 summer.

3.5 Solar for low income households – Australian Capital Territory

From December 2017, pensioners in the ACT are eligible to apply for a rebate of up to 60% on costs for the supply and installation of a rooftop solar PV system capped at $3,000. A 3-year interest free loan to ActewAGL is also available to pay back the remaining cost over a 3-year period. The scheme is available to pensioners only and is expected to assist approximately 500 households.

3.6 Next Generation Energy Storage – Australian Capital Territory

As witnessed in several other jurisdictions, the Australian Capital Territory is promoting distributed energy storage solutions as a means towards a low emissions future. Under the Next Generation Energy Storage program, the ACT Government is supporting up to 5,000 battery storage systems in ACT homes and businesses.

The current rebate is $825 per kilowatt (kW) up to a maximum of 30 kW. A standard household with a 5 kW system would typically be eligible for around $4,000 in support.

For residents without a current rooftop system, the combined PV and energy storage system would cost between $13,000 and $18,000 including the rebate. This is still a significant upfront capital cost, and for this study we assume that only residents already considering PV uptake would consider an application for this scheme.

3.7 Affordable Energy Plan – Queensland

As part of "The Affordable Energy Plan", the Queensland government has 3 initiatives to encourage the uptake of distributed renewable generation and storage:

1) A $4,500 interest free loan for up to 7 years is available for homeowners that receive the family Tax Benefit Part B. Eligible households not only must receive this benefit, but also must have had electricity costs greater than $1,000 for the past 6 months or $2,000 for the past year.

2) From 19 November 2019, Queensland householders can apply for interest free loans for up to $10,000 and grants of $3,000 to purchase combined solar-battery systems. Small businesses are also eligible to apply.

3) Grants of $3,000 and interest free loans of up to $6,000 are available for households that already have solar to install batteries.

The government allocated $21 million over three years to fund the no-interest loans and rebates. The funding was restricted to 3,500 solar assistance packages and 1,000 solar and battery systems and 500 battery only systems and was available for Queensland residents until the funding was exhausted or until 30 June 2019.

3.8 Western Australia – DER roadmap

In December 2019, the West Australian government outlined a roadmap that enables the transition of the South West Interconnected System (SWIS) network from a synchronous, centrally controlled network to one with more intermittent generation and increasingly decentralised supply.

It is recognised that if DER are to displace traditional generators they need to be integrated into the operation of the power system, and subject to remote management and operating standards to stabilise the power system.

The continued uptake of rooftop solar PV will see daytime demand fall to levels at which there is significant risk that the stability of the SWIS will be compromised – this is forecast to occur around 2022. In response, the Australian Energy Market Operator (AEMO) will be expected to intervene more frequently and to a greater extent to maintain system security, increasing costs for customers.

The government acknowledges that the high levels of rooftop PV in the SWIS are beginning to contribute to technical issues at the distribution network level. Generation output from rooftop solar PV is now flowing two ways and causing problems for network operation as physical limits are reached. Without improving the rooftop PV integration in the network, resolution of these issues in the SWIS would require costly infrastructure investment, or imposition of limits on the size and number of rooftop solar PV systems customers can install.

The Roadmap outlines proposed steps to fully integrate distributed energy resources into the operation of the power system. The aim is that customers are rewarded for providing services that support the system.

The steps outlined in the roadmap largely address the following areas:

1. Upgrades to DER functions to see them automatically help mitigate network and system disturbances;

2. Distribution battery storage deployment;

3. Pilot tariff structures that support uptake and optimal utilisation;

4. Ensuring all customers can continue to install DER.

4. Method

4.1 Overview

The forecast of STC creation for calendar years 2020 to 2023 has been undertaken using a specifically developed time-series model. Using this approach, the uptake of renewable technologies is determined based on trends in historical data, including testing for inclusion of the use of net consumer benefit - or a mix of upfront costs and system benefits - as regression variables. In addition, we have included several control variables testing for the impact of current interest rate levels, state gross product, population levels and the impact of the COVID-19 pandemic.

A time series is a sequence of data points measured at different points in time, and its analysis comprises methods for extracting meaningful characteristics of the data (e.g. trend, seasonality, autocorrelation). Forecasting using time series techniques involves predicting future events based on a model of the data built upon known past events. Unlike other types of statistical regression analysis, a time series model accounts for the natural order of the observations and will reflect the fact that observations close together in time will generally be more closely related than observations further apart.

This uptake then flows into our agent-based model, which has primarily been developed to capture the effects of saturation.

4.2 Small generation unit modelling

The model utilised for the forecasting of residential STC creation is an ARIMA time series model combining autoregressive components with exogeneous economic control variables.

Python software was utilised for the majority of time series forecasting, using time series models with additional economic control variables as external regressors.

4.2.1 Residential and commercial system categorisation

Small generation unit installations in the data supplied by CER are classified as either Unknown, Residential, Commercial, or School. All data is flagged as 'Unknown' prior to September 2013, though by October 2014 all data is classified as type of installation.

For use in the time-series modelling, unknown property types were classified as commercial or residential based on their capacity - those less than 15 kW were considered residential, and those 15 kW or above were considered commercial. Schools were combined with the commercial data due to their similarity in size and function.

The residential data was then processed and aggregated into monthly steps to create time series by technology for each state.

Due to the limited number of commercial installations, commercial data remained at a nationally aggregated level.

Small-scale commercial uptake samples were split into three categories:

- Rooftop solar PV systems under 15 kW;
- Rooftop solar PV systems between 15 kW and 90 kW; and
- Rooftop solar PV systems of 90 kW up to 100 kW.

The split into these three categories is based on several considerations.

The bulk of all commercial developments is in the 15 kW to 90 kW category and has seen the highest historical growth rates, while the category of systems below 15 kW shows the lowest growth rates.

Commercial systems of 90 kW to 100 kW are separated as we understand most of these systems are deliberately scaled back to this size or are likely part of larger developments split into multiple phases or as separately metered connections to take advantage of the STC benefits.

Analysis performed by Jacobs suggests that systems of 100 kW show better returns than systems from 100 kW up to 120 kW, because of their entitlement to STCs. In addition, planned systems up to approximately 260 kW are likely to have better returns if they are connected in multiple stages or as separately metered connections of 100 kW maximum. Systems above 260 kW are generally more likely to generate higher returns taking advantage of LGCs than similar large systems that are split to receive STCs.

4.2.2 Sample size

The sample size has been restricted for residential uptake to only include data from 2012 onwards for large states and from 2013 onwards for small states and territories[1]. This approach was taken because during the growth phase of the PV technology, the uptake was strongly affected by policy changes, subsequent economic benefits and other behavioural factors such as early adopters or environmental decisions. These changes are difficult to model, utilising our economic cost and benefit-based approach.

The sample size was determined after visually examining the uptake data. For example, historical data suggests that commercial rooftop PV systems under 15 kW did not show significant take-up before late 2014 and therefore we have included uptake from January 2015 onwards in our modelling sample. For systems between 15 kW and 90 kW uptake significantly ramped up in 2010, but with volatility. However, from 2012 onwards this category showed stable growth rates and therefore the sample was set to include uptake from 2012. The systems in the largest commercial small-scale uptake category (90-100 kW) only had significant uptake from 2013 onwards and therefore the sample was set to include data starting January 2013.

4.2.3 Dependent variables

The number of installations was utilised as the dependent variable for the residential PV projections. This was to allow the incorporation of these results into our agent-based model, where the agents represent household decision makers.

For the commercial PV projections, the installed capacity was utilised as the dependent variable. This enables modelling of the greater variance in installed capacity that exists across the commercial segment.

Utilising STC as the dependent variable was not considered the best choice due to the scaling down of deeming period of the STC scheme.

4.2.4 Independent variables in residential SGU modelling

There exists a relationship between the uptake of PV technology, consumer costs and benefits. As the capital cost, STC rebates, electricity price and the feed-in tariff are the main indicators residential energy users take into consideration when deciding to invest in rooftop PV, these drivers are the building blocks of our models. Dummy variables are included as an indicator of policy changes or specific impacts of policy or other unknown shocks (e.g. the step-down in deeming period as the forecasts enter a new calendar year).

The onset of the global COVID-19 pandemic and resulting lockdowns appears to have had a positive impact on the residential rooftop PV sector. With a significant and sudden shift to work from home mindset, consumers are now able to utilise their rooftop systems to a greater extent. The shift of certain sectors to a working from home environment is also likely to be permanent.

[1] The sample size selection was based upon the best statistical fit for each state for the different ARMIA models utilised.

Furthermore, with consumers in lockdown and unable to spend on outdoor entertainment, dining out and travel, the result has been a shift of spending on household items. With record low interest rates and an increase in household energy consumption, it makes the installation of PV systems a beneficial choice.

This has implications on the independent variables utilised in the model. For example, Gross State Product (GSP) per capita is historically a good predictor to capture general growth, however the COVID-19-related economic downturn sharply contradicts the recent increases in residential rooftop PV uptake.

For these reasons, we have incorporated a dummy COVID-19 variable into the regressions to reflect a structural change. This is incorporated from March 2020 onwards for the residential models. We have also decided not to include a GSP-related variable in the model.

Additional variables that we have tested include: consumer confidence, cash rate, home-loan rate, all ordinaries stock price index. Modelling showed that the interest rate variables showed significant correlation with the installed PV capacity. During the modelling process we dropped the consumer confidence and stock price variables as they were not significant and did not improve the models.

In several cases, lagged independent variables have been used to improve significance of the variable and overall model-fit. For example, it is likely that consumers use electricity bills that are a few months old or have an existing agreement with a retailer based on temporary fixed (older) price levels. Therefore, it is likely that there will be a lag of the impact of electricity prices and feed-in-tariffs on the uptake of rooftop PV.

Further details of the independent variables utilised in the models can be found in Appendix B.

4.2.5 Variables used in commercial SGU modelling

Small scale commercial systems were modelled using an ARIMA time-series model, utilising historical PV uptake data from January 2012 onwards for 15 kW to 90 kW systems, from January 2013 onwards for systems from 90 kW up to and including 100 kW systems and for systems below 15 kW from January 2015.

The upfront net capital cost (total capital cost minus rebates) and the electricity price as a proxy for future benefits, were tested as independent variables in the model as well as the interest rate. Due to a general reduction in electricity prices over the last few years this variable did not prove to be a good fit for the recent growth trends and was subsequently discarded.

Gross Domestic Product (GDP) is a variable that provides a proxy for the economic health of the nation and is used in most econometric time-series models as a control variable. The GDP indicates whether the economy is contracting or expanding. Unlike in the residential sector where the lockdowns and home working environment shifts have insulated the rooftop PV segment from economic downturns, this is not the case for small to medium enterprises and this variable has been left in the models.

Despite the economic downturn in the June 2020 quarter, small-scale commercial rooftop installations still showed modest growth. This is potentially the result of government stimulus packages supporting consumer spending and the instant asset write-off awarded to eligible businesses. For this reason, we have incorporated a dummy variable that runs from March 2020 until March 2021 when the job seeker and job keeper packages are expected to expire.

Further details of the independent variables utilised in the models can be found in Appendix B.

4.2.6 Model fitting

The time series at the state level were stationary when modelled using the extended benefit, economic and dummy variables, showing no evidence of changing mean or variance over time. The models were examined for stationarity and autocorrelation.

Once the sample size was determined (discussed in section 4.2.2), we examined different formulations of the model, including time-series only analysis, single regression variable models, and combinations of variables, rejecting any models that were statistically inadequate.

Inadequate models included:

- Models with a statistically poor fit as measured through the Akaike's AIC criterion (where available) goodness of fit tests.
- Non-stationary models as assessed with the augmented Dickey–Fuller test and/or Durbin-Watson test.

The developed ARIMA model includes independent variables such as net upfront cost, system benefit (e.g. electricity price, feed-in-tariffs), economic control variables and (policy) shock dummy variables as regressors as well as auto regression modelling to the residuals. This approach allows the modelling to consider external cost functions but also allows for appropriate consideration of recent time trends which is useful in time series approaches because of inherent autocorrelation in the dataset.

The residential models were estimated by the different states and territories, while the commercial sector is modelled nationwide.

4.2.7 Agent based modelling

Jacobs has recently developed an agent-based model to assist with the projection of uptake of small-scale PV systems. The key benefits of this model are that it can encompass the probability of monthly uptake as derived from our time series models whilst accounting for effects of market saturation and behavioural characteristics in key market segments. Additional advantages of our agent-based model are the ability to model uptake in specific geographic regions and to incorporate additional factors such as the uptake of household batteries and electric vehicles in a holistic approach.

Agent-based modelling is a bottom-up method which models unique agents at the micro-level to simulate customer level decision making. Agents are autonomous, have internal behaviours and characteristics, and make the appropriate decisions in response to both exogenous and endogenous factors.

In the context of Australia's energy market and DER uptake, agents are defined as households with similar household characteristics (e.g. home-owner, renter) and dwelling type within a similar proximity to each other.

Residential agents are first assigned a dwelling type (House, Terrace/Townhouse, Flat/Apartment) by cumulative probability distribution. A similar method is utilised to allocate a tenure type (Owner, renter, other). These probabilities are based upon data from the Australian Bureau of Statistics.

Our time-series modelling assists with the growth rate to determine the initial probability of uptake based on their location. The probability of uptake is then adjusted based on the agent properties. For example, agents that are assigned with a flat dwelling type are given a zero probability of uptake, however the probability of uptake is increased for houses.

Initially, these probability factors are calibrated to reasonably fit the historical data. Every year, the residential agents who are eligible but have not yet adopted iterate into a probability based decision-making process. These agents include the non-adopted original agents, and the newly introduced growth agents.

4.3 Time-series model for water heaters

The water heater data were modelled by number of STCs registered, since unlike PV, these time-series were not distorted by a multiplier and they were also directly reflective of water heater uptake volumes.

The original water heater time-series were non-stationary, showing both a changing mean and changing variance over time. However, the logarithm of the original time-series was found to be stationary after the trend was removed.

In summary, the time-series analysis of the data for the water heaters was carried out by fitting univariate ARIMA models to the logarithm of the monthly number of registered STCs by water heaters, split into domestic and commercial categories for all of Australia. The projection also considers deeming reductions in future years.

5. Assumptions

This section outlines the key modelling assumptions utilised for the forecasting models.

5.1 Financial benefits

The financial benefits of installing a PV system have historically been the key measurable drivers to the uptake of residential and commercial systems. There are various contributing factors that determine the overall financial benefit of the installation of a PV system, including:

- Capital cost of installation;
- State and federal government rebates;
- Retail cost of electricity;
- Cost of capital (e.g. Home-loan rate);
- Feed-in-tariffs;
- Expected solar generation usage versus export to the grid.

Critical assumptions in the calculation of the upfront cost are the historical and forecast capital cost of installation of a PV or SHW system, capacity of the system, potential STC benefits from installation and any other state or federal based rebates.

Key factors to assess the lifetime benefit of a system include assumptions surrounding the retail electricity cost and capacity of the system. For small generation units, the feed-in tariffs and expected net export of electricity to the grid are also important considerations.

Both export and self-use of solar PV generation are important factors in the investment decision. It is difficult to determine what the exact preference is for consumers regarding usage versus export, therefore we have used both variables directly in our regression rather than calculated a fixed benefit based on predetermined shares of usage and export. In addition, with the introduction of small-scale battery storage and EVs, the reliance on export and thus feed-in-tariffs may reduce as a result of the ability for consumers to shift load using their storage device or charge their electric vehicle.

The time-series model utilises historical and forecast calculations of these indicators as potential regressors. However, since 2018 the retail electricity price rises observed across most of the states have levelled off, and in several states have reduced through 2019 and 2020. Meanwhile growth in PV installations have been observed in the same states.

For these reasons, these variables are no longer incorporated as regressors in all states. It is acknowledged that the financial benefits are still key drivers, however as rooftop solar provides such a reasonable payback, there are potentially other drivers of the current growth rate such as advertising, word-of-mouth and neighbourhood presence. These factors are difficult to measure and are captured in the time-series trends of our models.

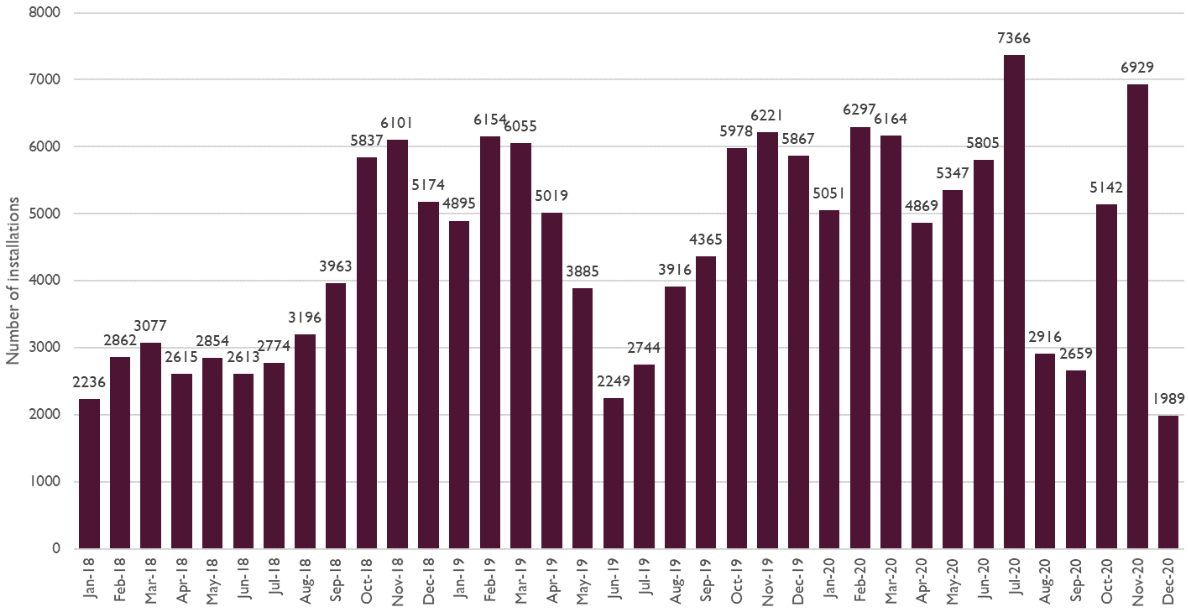
5.2 Rebate assumptions

For the purposes of this study, the South Australian government’s battery scheme, Virtual Power Plant scheme, ACT Solar for low incomes, Queensland’s Affordable Energy Plan, NSW solar rebates and Victorian rebates will be treated separately.

5.2.1 Victorian Solar Rebate Scheme

The introduction of the Victorian solar homes rebate, commencing from 19 August 2018, resulted in a flood of installations of rooftop PV on Victorian homes. **Figure 6** shows the number of monthly residential instalments since January 2018 and the large increase in installations highlights the popularity of the subsidy.

Figure 6: Number of monthly residential PV installations in Victoria since January 2018



Source: Jacobs' analysis of CER data (estimates for 2020 will be affected by lag in registrations)

Due to the popularity of the scheme, the initial allocation of 24,000 households to the end of June 2019 was increased to 32,000 before the government temporarily stopped the program on 12th of April 2019, with the view of reopening it again in July. The program was reopened again in May and offered to customers who had installed panels but had been locked out of the program.

The policy from July 2019 originally offered 3,333 rebates per month. In late August, the Government increased the number of rebates on offer each month and are currently at 5,000 per month.

As with other states in Australia, the impact of COVID-19 initially had a positive impact on the number of rooftop installations. However, during August, Stage 4 restrictions were imposed on the metropolitan Melbourne and Mitchell shires, which prohibited the PV installers conducting installations on occupied homes within these regions. On the 19th of October, the Victorian Premier announced an easing of restrictions that enabled rooftop solar installation work to continue across homes in Melbourne in a COVID-safe manner.

Due to the popularity of the state government rebates and the expected impact of stage 4 COVID-19 restriction in Victoria, it is not suitable to project installations in Victoria utilising our time series models. Projections are instead based on the following assumptions:

- The Victorian Solar Homes scheme will go ahead in its entirety and 650,000 owner occupied homes will have rooftop solar installed by the end of FY 2030 under the scheme.
- The rebate will continue for the next 9 years with the remaining Government funds to be distributed over this period with an increasing number of installations and decreasing value per installation into the future.
- About 11% of households are ineligible for the scheme will continue to install PV systems at a rate of 290 installations per month. This assumes that 11% of 31,733 residential installations that occurred in the year to June 2018 were from households earning over $180,000 per year, and that these will continue at a constant rate.

- For the months of August to late October 2020, it is assumed that installations only occurred in regional Victoria, which accounts for approximately 25% of dwellings. We expect additional installations to occur in the final week of October.
- A rebound effect is assumed for the months of November to December 2020, where we project 6,500 installations to occur during each of these months.
- The average size of systems installed is 6 kW.

Table 2 outlines our assumptions for the year 2020.

Table 2: Victorian assumptions during 2020

Month	Installations	Capacity
January - August	44,137	282
September	2,836	20
October	5,851	40
November	10,120	69
December	6,500	39

Based on these assumptions, **Table 3** outlines the number of installations, capacity installed and STCs produced in Victoria until the end of 2023.

Table 3: Assumptions on Victorian residential PV installations, capacity and STC generation for forecasting period[2]

Time period	Owner Occupied installations	Rental installations	Ineligible owner installations	Total Installations	Capacity (MW)	STCs '000s
2020	N/A	N/A	N/A	69,444	411	5,379
2021	62,158	4,167	3,480	69,805	419	4,981
2022	62,158	4,167	3,480	69,805	419	4,483
2023	62,158	4,167	3,480	69,805	419	3,987

5.2.2 South Australian Virtual Power Plant Scheme

With the scheme primarily aimed at residents living in public housing and other low-income earners, we have assumed that the 250 MW of capacity installed under this scheme will be additional capacity to what would otherwise be installed. Therefore, this capacity will be added to the time series modelled results.

Tesla has completed the installation of the first two stages of installing 1,100 units committed to the scheme. Results from the first two phases of the scheme are being considered prior to the commencement of the third phase of the scheme.

[2] STCs are calculated by multiplying the deeming period ratio by capacity by the expected STCs per kW per region

Subject to the success of phases 1 and 2, program financing, and the satisfaction of both Tesla and the government in the final program design, the full program could be rolled out to a further 49,000 households including private properties as part of phase 3.

Phase 1 and Phase 2 results, estimated to have completed in October 2019, would already have been tallied in the actuals. As Phase 3 is primarily targeted at private home owners and not lower income households, it is assumed for this study that only households already in a position to consider installation of PV will apply for the program, and therefore these are assumed to be incorporated in our standard regression modelling.

5.2.3 Queensland Affordable Energy Plan

The first component of the Queensland Affordable Energy Plan, available to 3,500 households, began in June 2018 and has now closed with all payments finalised by June 2020.

The second component of the scheme offers 1,000 households a $3,000 grant plus $10,000, 10-year interest free loan to install a solar battery package. With household batteries still commanding a considerable upfront cost, it is not expected that households not already considering solar PV will take on additional debt. Our assumption is that only households already considering installing PV will collect this grant. We have decided not to incorporate this scheme into the model.

5.2.4 NSW Solar Rebate

The NSW Solar rebate has been open to low-income households since December 2018. Due to the maturity of the scheme, we have assumed that the time series component of the model has factored this scheme into the growth rate.

As the recently introduced Empowering Homes scheme is primarily targeted at the installation of household battery systems, the assumption is that only households who were already planning on installing a solar PV system will apply for the interest free loan. It is therefore not expected to have a significant influence on the uptake of residential rooftop solar systems in NSW.

5.2.5 Solar for Low Income Households

The ACT solar for low income household scheme is expected to affect approximately 500 pensioner households. With the assumption that these 500 installations of 4 kW will occur evenly over a 3-year period, the assumption is that half of the capacity expected to be installed under this scheme would have occurred by mid-2019. Furthermore, as these installations are included as part of the dependent variable in the time series model, it is assumed that the time-series component has factored in the growth rate under this scheme, and for these reasons the STC's assumed as part of this scheme will not be added to our time-series projections.

5.2.6 Western Australia Distributed Energy Roadmap plan

The West Australian Distributed Energy Roadmap's aim is that all customers continue to install distributed energy resources in a manner that supports the network. However due to the issues that high rooftop PV penetration is beginning to cause in the SWIS, it is not expected that any steps will be placed in the near future to accelerate the uptake of rooftop PV systems.

Reducing the feed-in-tariff from 7.135c/kWh to 3.0c/kWh before 3pm during the day is expected to negatively impact the uptake of residential PV systems in Western Australia and is incorporated into our time-series modelling.

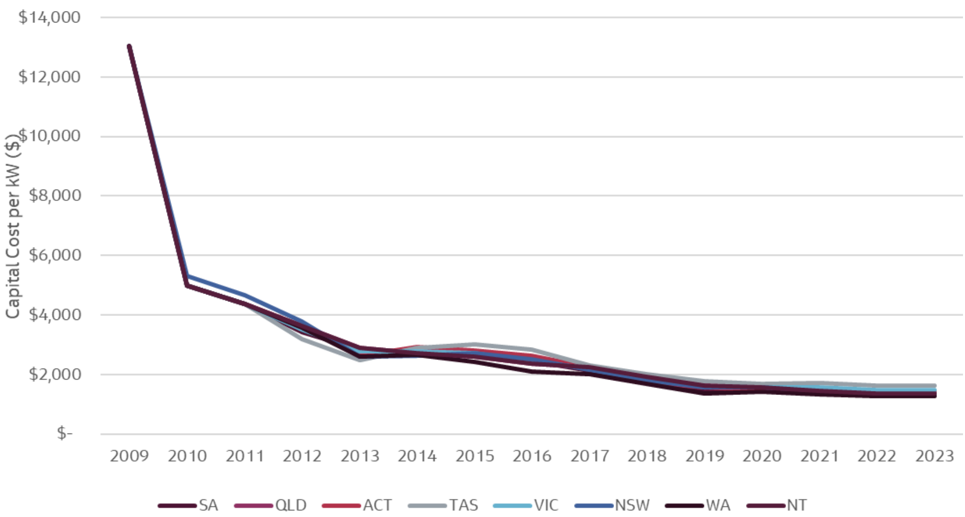
5.3 Capital cost

The global oversupply on PV module manufacturing capacity has diminished. Although this would tend to put upward pressure on system prices, there is also a restructuring of the industry which is seeing large capacity manufacturing plant replacing the older and smaller manufacturing facilities. The larger plants allow for the capture of economies of scale in production, minimising any increase in system costs and perhaps even leading to further decreases in costs. Recently there has been a shortage in manufacturing capacity (due to greater than anticipated global demand for solar PV systems) and this started to be reflected in upward pressure on panel prices. The solar industry had the potential to take a further hit from the COVID-19 outbreak due to the reliance on manufacturing of panels from China. However, Bloomberg New Energy Finance has reported PV component production has resumed in China, and while short-term shortages are anticipated, China is expected to prioritise meeting export demands ahead of those of its domestic market.

Capital cost assumptions for PVs in 2020 are based on the Solar Choice website's[3] monthly unit pricing overview, which is based on price data from 125 solar installation companies across Australia. These were converted into real dollars using historical CPI data.

For residential systems, the price per system per kW for capacity sizes of 5 to 10 kW was trended over time, and forecasts for each State were performed by utilising the expected learning curve extrapolated from CSIRO's 2019 GenCost forecasts for rooftop PV. These forecasts are illustrated in **Figure 7**.

Figure 7: Capital cost assumed for residential solar PV systems ($/kW 2020)



Source: Jacobs' market analysis, Solar Choice monthly system cost estimates 2012 – 2020, CSIRO

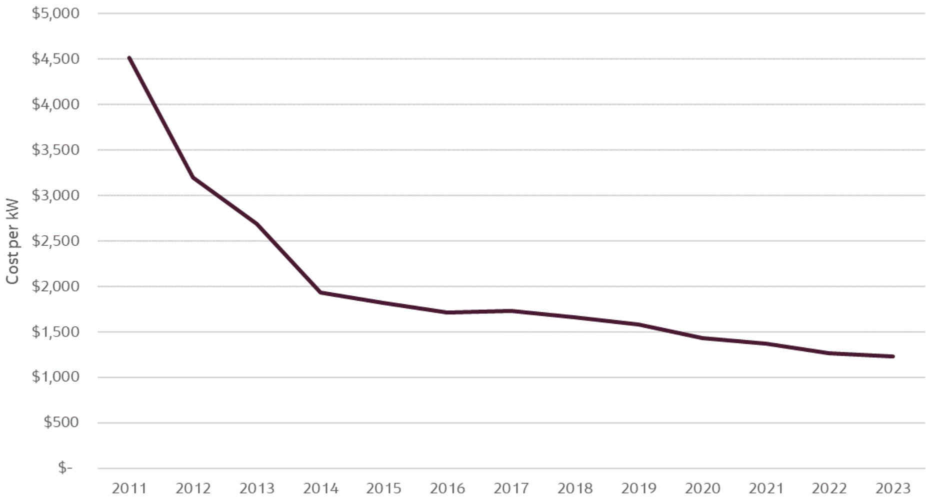
A similar method was applied to costs of commercial systems, by utilising the data for systems between 10 kW and 100 kW. Due to the limited number of commercial systems installed, and therefore subject to outliers when filtered to state level, it was decided to aggregate the commercial systems at a national level. The average cost was plotted for all states, and the CSIRO's rate of decline was applied from 2020 to 2023.

The economies of scale were also less apparent in commercial systems, with little difference between cost per kW for a 10 kW system versus a 100 kW system. Therefore, a ratio for economies of scale was not applied, and rather the cost per unit was assumed to be constant.

Figure 8 shows the historical and forecast costs assumed for commercial systems.

[3] http://www.solarchoice.net.au/blog/

Figure 8: Capital costs assumed for commercial solar PV systems ($/kW 2020)



Source: Jacobs' market analysis, Solar Choice monthly system cost estimates 2012 – 2020, CSIRO

5.4 Residential system size

Figure 9 shows the trends in average PV system sizes being installed since January 2015. The graph shows that average system size has continued to grow at a consistent rate over the last six months, consistent with growth patterns since mid-2016.

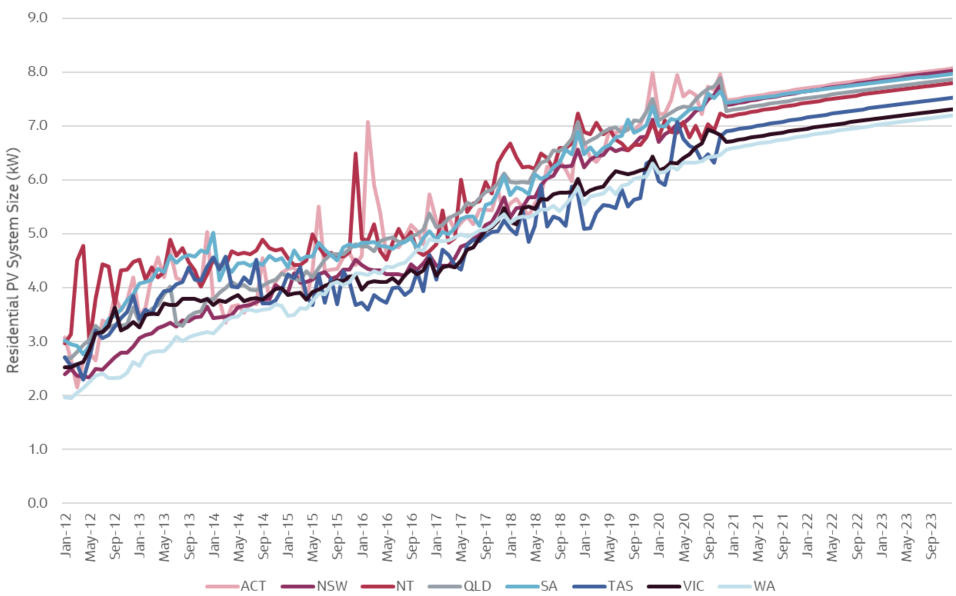
Another observation is that consumers have continued to install large PV systems, now averaging above the 6.6kW limit imposed by many distribution network service providers. This would also result in the average household consuming approximately 15kWh/day to export roughly 70% of energy produced via their solar system to the grid. The tendency to oversize could be driven by several reasons including:

- Generous Feed-in-tariffs offered by many retailers;
- Residents hedging against future electricity price increases;
- Residents hedging for future demand increases such as electrification of appliances and electric vehicles;
- Increasing environmental awareness and consumers wishing to contribute to the grid;
- Economies of scale offered by installers for larger systems;
- Continued increase in efficiency of PV panels.

We expect that average system sizes will not grow at the observed linear rate indefinitely. Residential system sizes will become constrained by available roof space, and most states have a restricted inverter capacity of 5 kW_{ac} for residential phase 1 systems, which limits many residential PV systems to a capacity of 6.6 kW. We expect this restriction in combination with the availability of roof space to eventually curtail the average system size for residential properties.

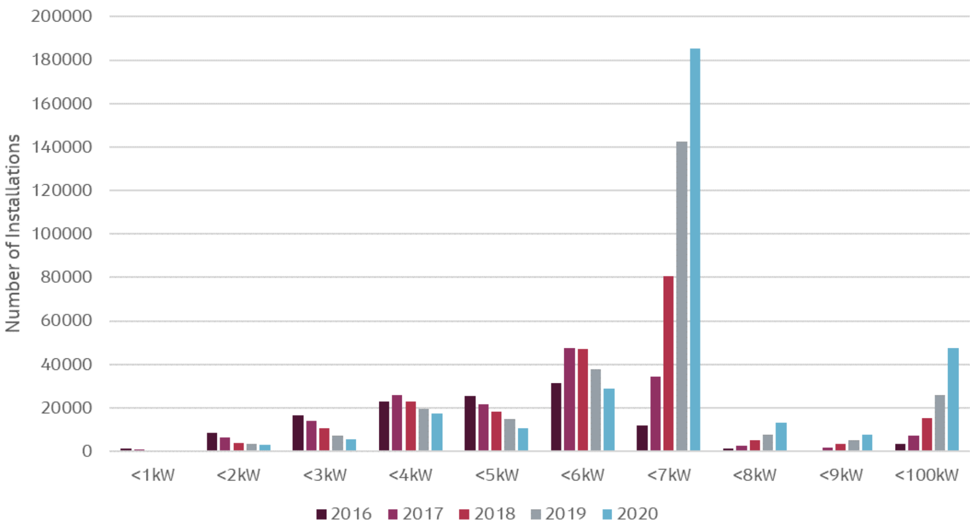
Power curves have been fitted in each state to reflect this assumed reduction in growth rate.

Figure 9: Monthly trend and forecast for average residential PV solar system size, selected states



Source: Jacobs' analysis of CER data

Figure 10: Residential system size brackets since 2016



Source: Jacobs' analysis of CER data, 2020 incomplete dataset

5.5 Electricity price projections

Jacobs' wholesale electricity price predictions were used as the basis for estimating retail electricity prices, which in turn were used in calculating future electricity savings and/or revenues for SGUs.

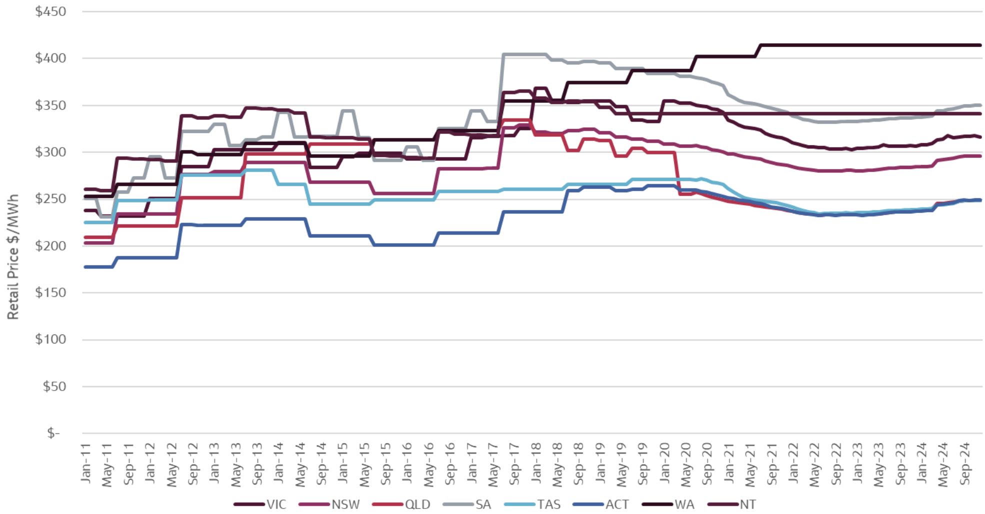
The wholesale prices were based upon market modelling studies employing a set of assumptions, including median economic demand growth, median gas price and median technology cost projections. A separate model was then used to convert wholesale prices to retail prices by applying average network tariffs and retail marketing expenses. These wholesale prices were also utilised to project commercial retail prices for SMEs for forecasting the economic benefits of commercial based solar installations.

Figure 11 shows the residential electricity prices used in the modelling for NEM states. Electricity prices are expected to peak in 2019/20, before a downward trend is projected over the period of 2019 to 2022. This is primarily due to the influx of large-scale renewable plant expected during this period. Electricity prices are expected to rise again in 2023 as a result of Liddell Power Station's retirement.

In Western Australia, retail prices were historically heavily subsidised. In 2009, the state government introduced a policy to increase retail prices to eventually reflect the cost of production and distribution. It is expected that parity will be reached in 2022 and our projections are that price rises will continue until then.

The Northern Territory prices are regulated and it is assumed that these prices will remain constant for the projection period.

Figure 11: Residential retail price - historical trend and forecast for selected states



Source: ABS, Jacobs analysis

5.6 Feed-in tariffs

Feed-in tariffs in Australia for small-scale renewable energy generation are offered by the retailers and in some instances, they have an obligation imposed by the relevant state government to offer a minimum tariff. Where the required data of retailers' tariffs and customers per retailer were available, a price based on the weighted average retail offer of the three largest retailers and combination of remaining retailers was assumed in the modelling. In the ACT, where ActewAGL supplies the bulk of the market, the ActewAGL tariff was selected.

Due to the projected decreases in retail electricity prices over the forecasting period for NEM states, the feed-in-tariffs for each state was then calculated as a percentage of the most recent retail price. Moving forward, the feed-in-tariffs were then assumed to move relative to the retail price based on this initial proportion.

Both the Northern Territory and Western Australian governments have sharply reduced the standard feed-in-tariffs in a move to reduce incentives to export rooftop solar power due to concerns relating to the stability of the grid. In April 2020, the Northern Territory standard feed-in-tariff was reduced from 26.05 c/kWh to 8.3c/kWh which is applied to all new installations.

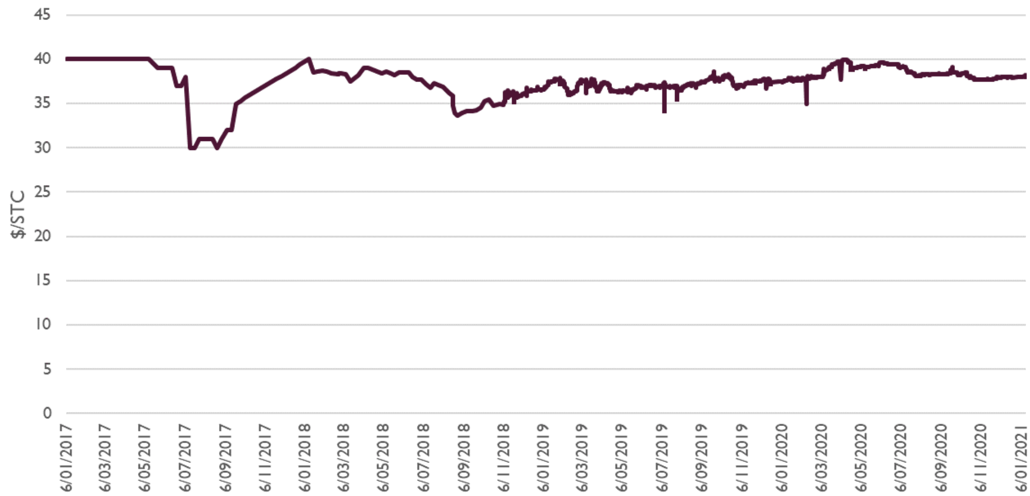
In Western Australia, the standard feed-in-tariff rate of 7.135 c/kWh was changed to 3 c/kWh prior to 3pm and 10 c/kWh after 3pm. This is a move to encourage the installation of west facing panels and energy storage systems to encourage export during the evening peak period. This change is to occur in all systems installed from September 2020.

These reductions in feed-in-tariffs in Western Australia and the Northern Territory are expected to impact the market and will be incorporated into our ARIMA models.

5.7 STC prices

Figure 12 shows the weekly historical STC prices for the period January 2017 to January 2021. During this period the STC prices have continued to hover below the target of $40, indicating that a surplus of STCs is being generated in the market. We assumed that STC prices traded at $40 per certificate for the projection period.

Figure 12: Weekly historical STC price (nominal)



Source: Demand Manager and Jacobs' analysis

5.7.1 STC zoning

CER divides Australia into four regional zones based on the estimate of renewable energy that can be generated by a solar panel in a given area, so installations in areas with high insolation will create more certificates per kW than rooftop installations based in areas in the south of the country. Zones are defined by postcodes. To convert the capacity of solar panels installed to the number of STCs produced, the average STC per kW of installed capacity was calculated for the years 2013 to 2016 for each state and territory, the effective period when STC generation was not affected by multipliers or reduced deeming periods. The average commercial STC per kW of solar PV installed was calculated for this period too at a national level. **Table 4** shows the effective multiplier for each state and commercial installations utilised for conversion of the forecast capacity into STCs.

Table 4: Average STC generated per kW PV installed

Region	STCs per kW
Residential	
ACT	20.7
NSW	20.8
NT	23.3
QLD	20.8
SA	20.6
TAS	17.8
VIC	17.8
WA	20.7
Commercial	
National	20.2

5.8 Time lag to registration

As there is a 12-month window from the date of installation in which to register systems, the most recent registrations database will be missing records of systems that have already been installed, but which have not yet been registered. If not corrected for, this will lead to an underestimate in the number of systems installed in the most recent few months. This is particularly relevant for the time-series forecasting, which is sensitive to the most recent data points.

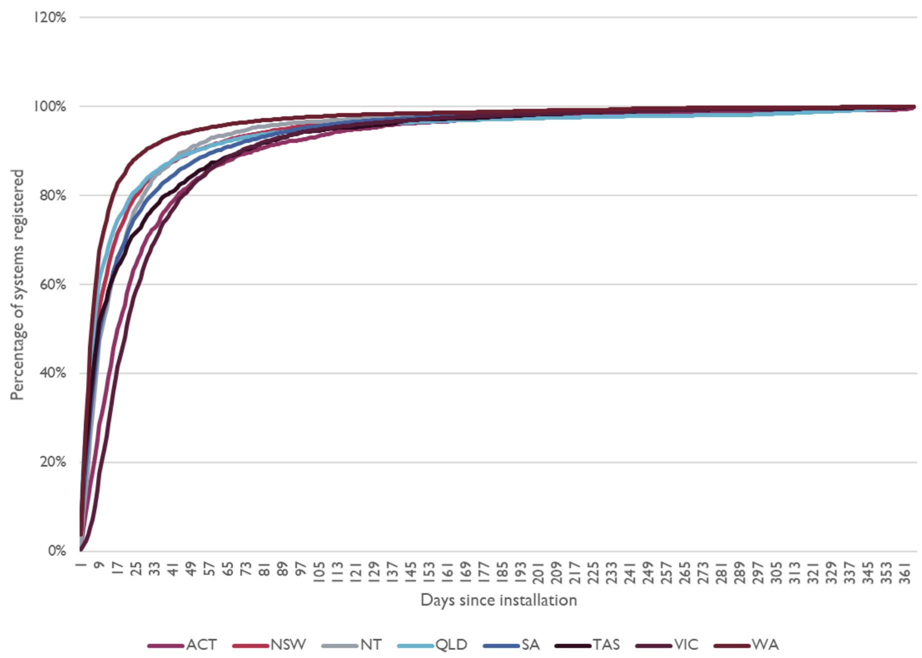
We have examined how long it takes before eligible systems are registered for STCs. The data provided by the CER includes both the date of system installation and of STC creation, so we can calculate an estimate on the proportion of systems that registered one, two, three, or more months after the system itself was installed.

Data was analysed for the period of calendar year 2019, with the assumption that all PV systems installed in 2019 were registered by 31st of December 2019. This period was selected as it would reflect current trends whilst still maintaining an adequate sample. Months for the year of 2020 were not incorporated in this analysis due to the bias that would occur favouring the population who install early rather than later, resulting in an underestimate of time taken to register PV systems. The cumulative ratio of the time lag between the number of systems installed each month and the time lag to their certificate registration was then calculated for the latest five months of the dataset. The majority of systems installed tend to be registered within a five-month period.

The ratio is then applied to the latest dataset from July to November 2020 (**Table 5**). We have elected not to use registrations for the month of December 2020 in our analysis due to the high percentage of unregistered systems that have not been included in the available dataset.

Figure 13 shows the typical delay in registration for residential system installations by state.

Figure 13: Delay in STC creation from installation, 2019 residential SGUs



Source: CER data

Table 5: Percentage of installed capacity used in modelling for residential and commercial systems

Month	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Commercial
Jul 2020	97%	98%	98%	97%	98%	97%	97%	99%	95%
Aug 2020	95%	97%	97%	96%	97%	96%	96%	98%	93%
Sep 2020	92%	95%	96%	95%	95%	94%	94%	97%	90%
Oct 2020	87%	92%	93%	92%	91%	88%	88%	96%	83%
Nov 2020	72%	84%	83%	85%	80%	77%	68%	91%	69%

6. Projections

This section presents the combined outcome of the modelling for the time series and agent-based modelling. In all cases results are presented in calendar years.

6.1 Residential system uptake

The state-based residential forecasts were derived by first projecting the number of installations, then converting this to expected capacity for PV systems followed by inferring the STCs per unit of installed capacity from historical data.

Figure 14 shows the historical actual and projected total installed capacity for residential systems in New South Wales. New South Wales shows the greatest growth of all states. The recent lockdown trends such as increase in energy consumption and spending on household items are key drivers to the continued growth in combination with relatively low saturation levels.

Figure 14: Historical and projected installed capacity for NSW residences

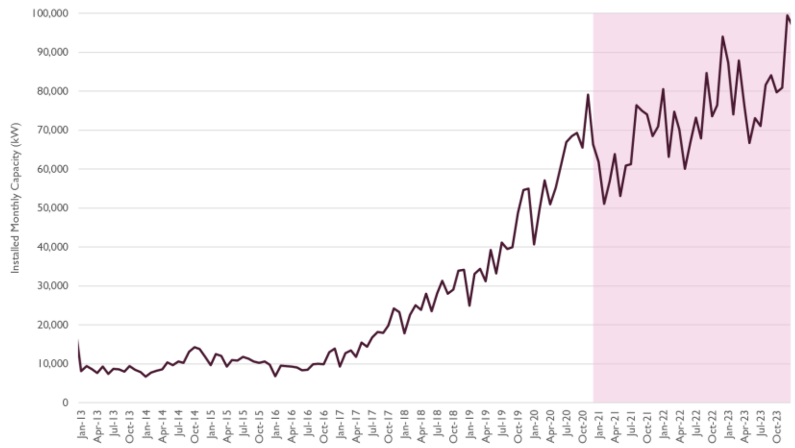
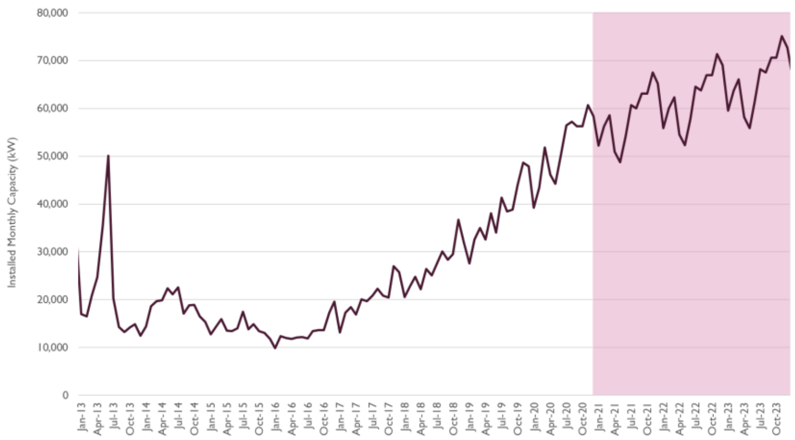


Figure 15 shows the fitted data of installed monthly capacity for residential systems in Queensland. Uptake in Queensland is also expected to increase over the second half of 2020 and early 2021, driven by stay at home orders and government stimulus packages. Slower economic growth then causes brief reduction in the growth rate before the expected economic recovery, and a pickup in growth rate again.

Figure 15: Historical and projected installed capacity for Queensland residences



Historical actual and fitted data for the uptake of residential PV in South Australia are shown in **Figure 16**. South Australia exhibits a continued strong growth rate. Of all the states, South Australia's rapid uptake drives the state closest to saturation. These effects begin to curb the rate of growth of installations towards the end of the projection period.

Figure 16: Historical and projected installed capacity for SA residences

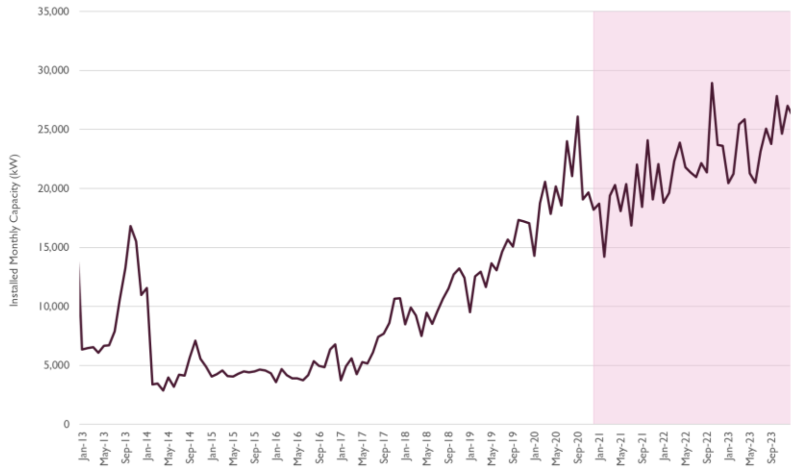


Figure 17 shows the historical actual and projected solar PV uptake for residential systems in Western Australia. A reduction in feed-in-tariffs causes a stabilisation in the rate of growth from the year 2021 onwards.

Figure 17: Historical and projected installed capacity for WA residences

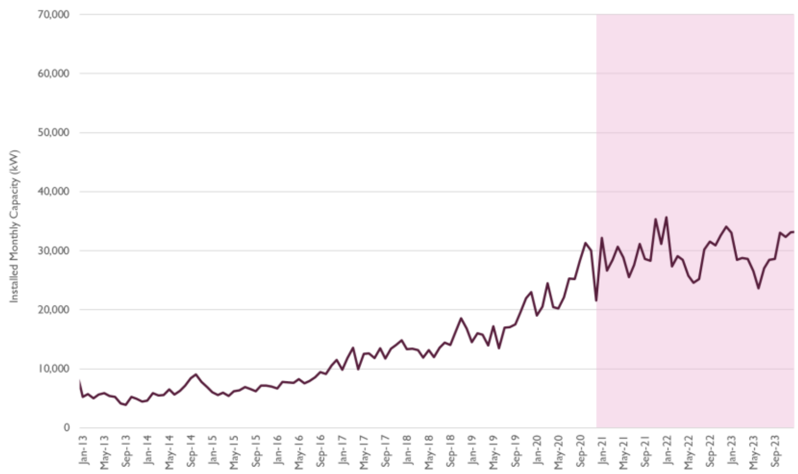


Figure 18 shows solar PV forecast used for STC creation in Tasmania. The low insolation levels in combination with low GDP growth in 2017 only saw modest growth of STC creation in the years 2017 and 2018. The continual reduction in capital cost and reductions in the cash rate created favourable conditions for uptake of solar PV during 2019 and an increase in uptake was observed. However, a decline in electricity prices in the short term has resulted in a relatively steady uptake of PV systems over the projection period, with a small uptick in 2022.

Figure 18: Historical and projected installed capacity for Tasmania residences

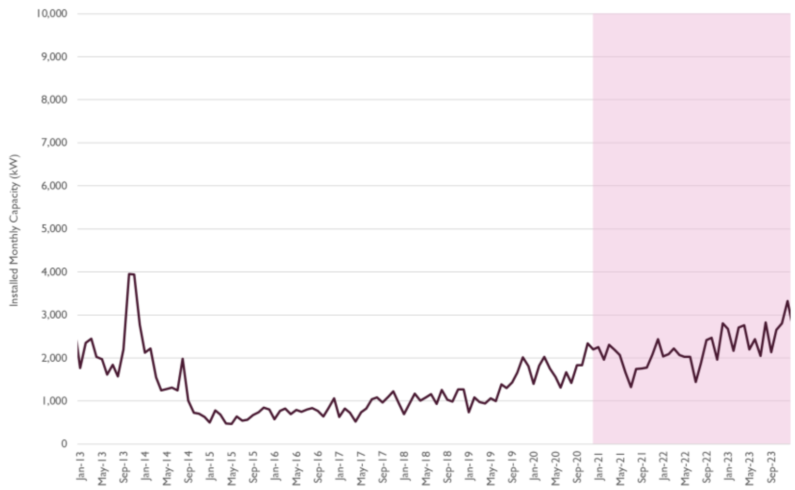


Figure 19 shows the solar PV forecast used for STC creation in the Australian Capital Territory. As with New South Wales, a relatively strong growth rate is expected for the projection period. Boosted by the work at home trends, the strong growth is also driven by a high level of house ownership and low levels of saturation.

Figure 19: Historical and projected installed capacity for ACT residential properties

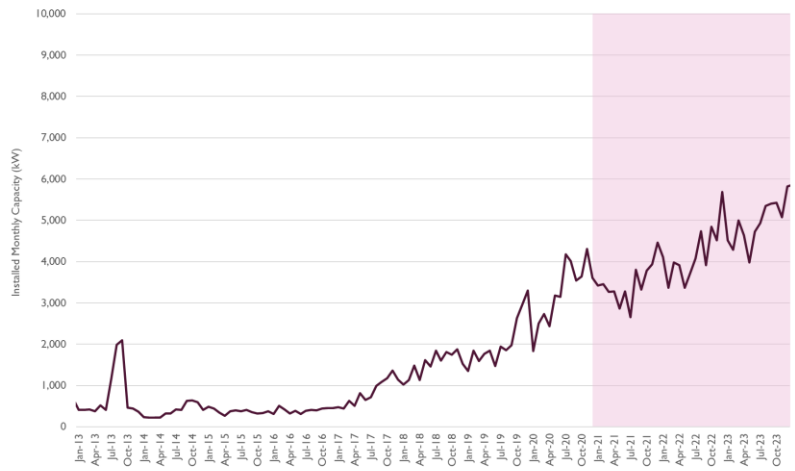
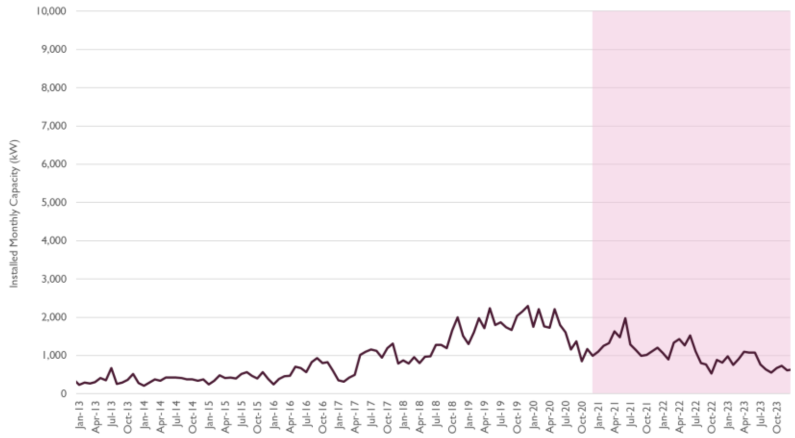


Figure 20 shows the solar PV forecast used for residential STC creation for the Northern Territory. Good insolation levels, high feed in tariffs and reductions in capital costs of PV installation has resulted in very good economic benefits of PV installations during 2019 and a resulting increase in uptake. However, the sharp reduction in feed-in-tariffs from 23c/kWh to 8.3c/kWh has resulted in a slowdown in the projected growth rate.

Figure 20: Historical and projected installed capacity for NT residential properties



6.2 Commercial systems uptake

Uptake of commercial solar PV systems has been modelled for three different sizes.

Figure 21 shows the historical and projected installed rooftop PV capacity for commercial systems smaller than 15 kW. As with residential systems, the impact of COVID-19 also appears to have had a positive impact on the rate of installation of these systems.

Figure 21: Historical and projected installed capacity for <15kW commercial properties

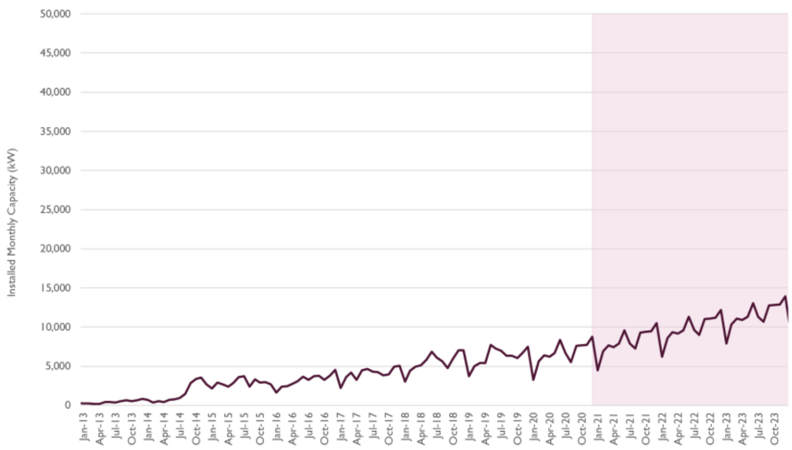
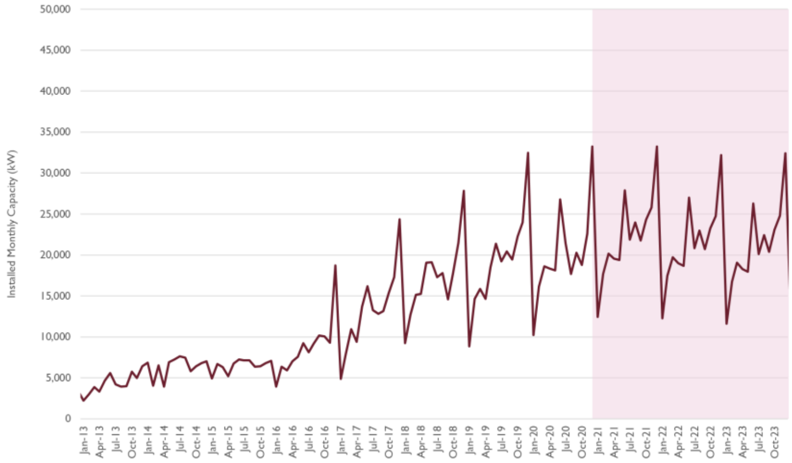


Figure 22 includes the uptake of solar PV projections for systems between 15 kW and 90 kW, which is the largest category of systems. There is a more pronounced seasonal uptake (December - January) than observed in the residential system uptake projections. The latter is expected, as it is likely that businesses are more aware of and sensitive to the scaling down than residential consumers.

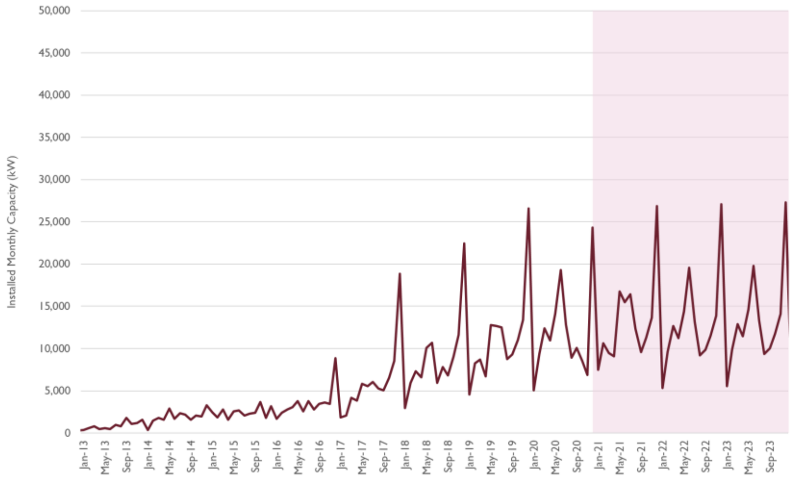
A large growth in uptake is expected in 2020, as expected by the government stimulus packages, such as the instant tax write offs. After 2021, the growth in uptake remains relatively steady reflecting the weaker expected economic conditions.

Figure 22: Historical and projected installed capacity by month,15 kW to 90 kW



The final commercial category includes 90 kW up to and including 100 kW commercial solar PV systems and is displayed in **Figure 23**. There is a similar seasonal pattern observable as in the previous category. However, the December peak is even higher. As indicated earlier, we believe that most systems installed in this category are part of a larger system likely to be installed in multiple phases or as separately metered sections, to take full advantage of the STCs and therefore the scaling down of the STCs is likely to have a very significant impact on the push to invest before the end of each year.

Figure 23: Historical and projected installed capacity by month, >90kW systems



6.3 Solar water heaters

Figure 24 shows the historical and forecast data for the creation of STCs via solar hot water residential installations. Our modelling suggests that net economic benefit is not a strong driver of the installation of such systems, and the increasing trend is more likely attributed to the growth in the housing market.

Figure 24: Historical and projected residential STC projections (<40 STCs per installation)

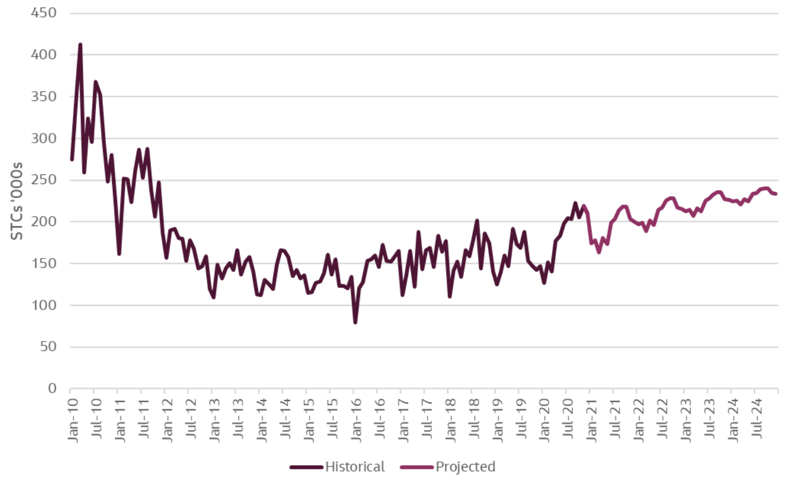
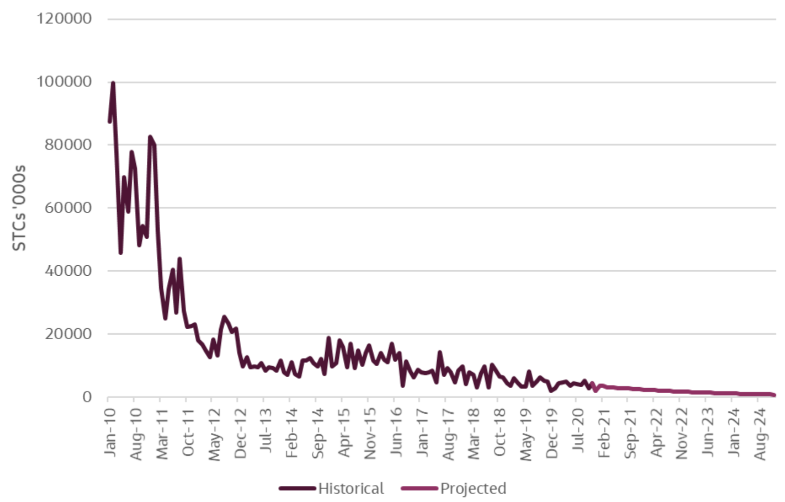


Figure 25 shows the historical and forecast data for the creation of STCs via solar hot water systems classified as commercial sized units. This declining trend is in contrast with the commercial installation of solar PV systems, which have been experiencing a growth rate over the same period. It is likely that this is no coincidence as the elevated cost of electricity and the net benefit of solar PV systems out-weigh the economic benefit that solar hot water heaters would bring on competing roof space.

Figure 25: Historical and projected commercial STC projections (>40 STCs per installation)



7. Summary

The projections for STC creation are shown in **Table 6**. These estimates include STCs created through both solar PV and hot water systems (wind and hydro STCs make up a negligible portion). In 2021, we project a total of 43.8 million STCs generated despite the scheme entering another year of scaling down by a ratio of 1/15 or 6.7% when compared with 2020.

Table 6: Small scale technology certificate creation projections, ('000s)

	2020	2021	2022	2023
Australian Capital Territory	610	570	621	650
New South Wales	11,282	10,668	10,983	10,611
Northern Territory	333	240	173	123
Queensland	9,418	9,644	9,236	8,696
South Australia	3,673	3,202	3,311	3,139
Tasmania	273	277	269	289
Victoria	5,379	4,983	4,485	3,987
Western Australia	4,326	4,868	4,392	3,864
Commercial <15kW	1,198	1,306	1,424	1,486
Commercial 15kW-90kW	3,572	3,580	3,112	2,706
Commercial 90kW-100kW	2,104	2,125	1,894	1,711
Residential Solar Hot Water	1,820	2,323	2,528	2,674
Commercial Solar Hot Water	47	35	24	16
All STCs	44,035	43,821	42,452	39,952

Figure 26 illustrates the small-scale technology certificate creation projections by sector. Results for the projected number of installations and capacity can be found in Appendix A.

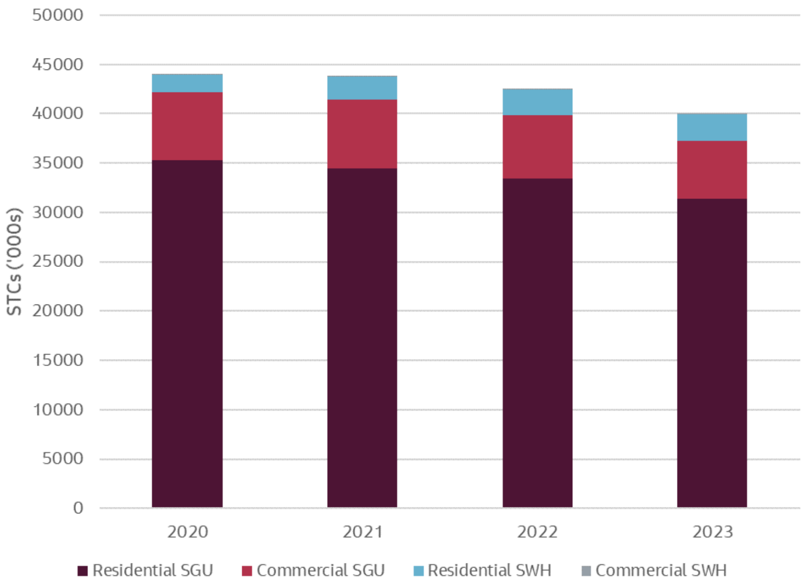
Residential rooftop installations in 2020 have occurred at a rapid growth rate, fuelled at least in part by forced lockdowns and an increase in spend on household items. The change to a work from home mentality, while not to the same extent of 2020, is expected to continue into the foreseeable future with a lasting increase of the benefits of household PV.

However, the rapid growth in rooftop PV is beginning to have a negative impact on the network in fringe locations. The Western Australian, South Australian and Northern Territory governments have all made moves to mitigate the rise in rooftop PV systems until grids and processes can be effectively augmented and managed. More recently, the Australian Renewable Energy Agency (ARENA) has announced funding for a new trial for dynamic or flexible solar systems in Victoria and South Australia. This study aims to investigate how smart controls can allow network companies to manage the export of rooftop solar back to the grid subject to local and centralised grid conditions. The aim is to assist in managing the rapid growth of rooftop solar systems across Australia.

With the incorporation of our agent-based modelling, we also see that market saturation has a greater impact on growth from 2022 onwards in the high growth states of South Australia, Queensland and Western Australia.

While initial data suggests that the commercial sector has not being unduly affected by the COVID pandemic, we do not expect this sector to be as robust as the residential sector against the broader economic implications. Modest growth of the three commercial bands is expected during 2020 buoyed by various government stimulus packages. A slight downturn is observed in 2021 due to the sluggish economy and stifled growth expectations. Modest gains are observed in the last few years of projections as the economy recovers.

Figure 26: Small scale technology certificate creation projections by sector



Commercially sized solar hot water units are expected to continue their declining trend and are not expected to have considerable influence on small-scale technology certificate creation for the duration of the forecasting period.

Domestic size solar hot water systems are expecting modest growth, largely attributed to the growth in housing and the increasing need to replace existing solar hot water heaters.

Appendix A. Projected Capacity and Installations of PV Systems

These tables summarize the projected number of installed small-scale systems and total capacity installed over the forecasting period.

Table 7: Projected installed capacity of small-scale systems (MW)

	2020	2021	2022	2023
Australian Capital Territory	39	42	50	59
New South Wales	730	774	885	962
Northern Territory	19	16	12	10
Queensland	621	701	746	790
South Australia	238	234	269	286
Tasmania	21	24	25	31
Victoria	411	419	419	419
Western Australia	289	355	356	352
Commercial <15kW	81	98	118	139
Commercial 15kW-90kW	242	268	259	253
Commercial 90kW-100kW	143	159	158	160
All small-scale PV Installations	2,834	3,090	3,297	3,461

Table 8: Projected number of installations of small-scale systems and solar water heaters

	2020	2021	2022	2023
Australian Capital Territory	5,421	6,231	7,428	8,638
New South Wales	103,998	110,481	123,697	132,016
Northern Territory	2,846	2,146	1,688	1,325
Queensland	84,054	94,851	99,127	103,404
South Australia	33,561	33,969	38,408	40,396
Tasmania	3,249	3,489	3,706	4,426
Victoria	69,444	69,805	69,805	69,805
Western Australia	45,141	53,414	53,096	52,172
Commercial <15kW	11,852	14,482	17,536	20,591
Commercial 15kW-90kW	7,436	8,716	8,418	8,237
Commercial 90kW-100kW	1,445	1,609	1,594	1,619
All small-scale installations	368,447	399,193	424,503	442,629
SHW installations	54,500	68,800	74,500	78,500

Appendix B. ARIMA Model Exogenous Variables

The following table outlines a description of the exogenous variables utilised in the ARIMA time series models.

Independent Variable	Source	Explanation - impact
Electricity Price ($/MWh)	ABS Historical price-index for electricity for each capital city. Jacobs' retail and wholesale price forecasting models for projections.	The electricity price is the first of the two major benefits from a small-scale rooftop solar PV system. As the small-scale PV system is built behind the meter it is able to displace electricity usage from the grid and therefore generate equivalent benefits for the residential customer. We expect there will be a positive significant correlation between the electricity price and the PV uptake in the models we specify, as higher electricity prices will increase potential benefits of rooftop solar PV.
Net capital cost ($)	Data obtained via Solar Choice website. Projections based on CSIRO GenCost cost reduction rate.	The variable includes the capital cost per kW of a small-scale rooftop PV systems over time, reduced by the benefits from the STC rebate. The expectation is that with decreasing capital costs the uptake of small-scale rooftop solar PV will increase and visa-versa. Therefore, we are expecting a negative correlation with the dependent variable.
Cash rate	The Reserve Bank of Australia (RBA). We assumed the cash-rate plus a 2.5% mark-up.	The cash rate is an indicator for the home loan rates and subsequent cost of capital for a residential customer or an opportunity cost for cash savings. The residential customer is likely to finance the PV system through their mortgage or if they have savings, forgo the return on a savings account in favour of an investment in a rooftop PV system. We expect that the cash-rate correlates negatively with the uptake of small-scale solar PV as higher rates will make the direct cost and/or opportunity cost of taking up small-scale PV higher and therefore should reduce the uptake and vice-versa.
Gross State Product (GSP), Gross Domestic Product (GDP)	ABS time series 5220 – Australian National Accounts: State Accounts	Gross State Product is a variable that provides a proxy for the economic health of the respective State and is used in most econometric time-series models as a control variable. The GSP indicates whether the economy of the state as a whole is contracting or expanding. The expectation is that expanding economies will see higher general levels of investment and therefore we expect a positive correlation with small-scale PV uptake. For commercial projections we have used the aggregated state products of all states and territories as these projections are nationwide.
State Population, Aggregated State Population	ABS time series 3101 – Australian Demographic Statistics	State population as a stand-alone variable has not been considered in the modelling but rather used as a component of an interaction variable as described below. For commercial projections we have used the aggregated state population as these projections are nationwide.

Appendix C. ARIMA Time Series Models

A range of variables were tested. The final model was selected based on a number of parameters including goodness of fit tests (e.g. AIC), residual analysis (e.g. Durbin-Watson statistic), significance of included independent variables and Ljung-Box test.

The final variables selected for each model are:

New South Wales:

- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19.

Queensland:

- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19.
- One dummy to represent high outliers in the input sample.

Northern Territory:

- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- The natural log of the Electricity Price multiplied by the Feed-in Tariff with a lag of 4 – log(ElecPrice*FIT)(-4)
- A dummy to represent the impact of COVID-19

Western Australia:

- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- The natural log of the Electricity Price multiplied by the Feed-in Tariff with a lag of 4 – log(ElecPrice*FIT)(-4)
- A dummy to represent the impact of COVID-19
- One dummy to represent outliers in the input sample.

Tasmania:

- The natural log of the Electricity Price multiplied by the Feed-in Tariff with a lag of 4 – log(ElecPrice*FIT)(-4)
- One dummy to represent outliers in the input sample.

South Australia:

- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19
- One dummy to represent outliers in the input sample.

Australian Capital Territory:

- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19.
- One dummy to represent high outliers in the input sample.
- One autoregressive term, one order of differencing and one seasonal order of differencing.

Commercial Systems < 15kW:

- The natural log of the Gross Domestic Product divided by the Population – *log(GDP(-5)/POP(-5))*.
- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19.

Commercial Systems 15-90 kW:

- The natural log of the Gross Domestic Product divided by the Population – *log(GDP(-5)/POP(-5))*.
- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19.

Commercial Systems >90 kW:

- The natural log of the Gross Domestic Product divided by the Population – *log(GDP(-5)/POP(-5))*.
- The Cash Rate multiplied by Net Capital Cost of residential systems squared – *(CSH_RATE*NET_CAPITAL)^2*.
- A dummy to represent the impact of COVID-19.