Small-scale Technology Certificate Projections

Clean Energy Regulator

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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. The SRES scheme 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 scheme offers small-scale technology certificates (STCs) at a current price of $38.20[1] 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 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 that will be generated in the calendar years of 2019 up to and including 2023. This will assist in determining the number of STCs each electricity retailer is obliged to surrender.

Historically, 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, increasing electricity retail prices and government incentives.

High retail electricity tariffs has seen substantial growth in the rate of PV installations. Continuing strong growth for commercial installations are projected over the forecast period driven by perceived economic benefits. In 2019, we see uptake also boosted by state-based incentives in Victoria and South Australia.

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 time-series panel regression models for the residential solar PV uptake. Utilising panel regression models has allowed us to obtain more data points with smaller samples and increase the robustness of our models. We have also used a number of 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 and policy changes.

For estimating the commercial models, we have used national (non-cross-sectional) timeseries regression models utilising the same independent variables as discussed above.

The solar PV uptake projections have been used to calculate the STC projections as included in the table below. The outputs show increasing STC uptake until 2023, but the increases are greatest from 2019 to 2020.

As a result of scaling down the STC creation per kW, the projected growth of solar PV uptake is curbed so that the growth of STCs is likely to level out sometime in the future.

[1] Latest spot price from demandmanager.com.au (24/09/2019).

Table 1: Projected STCs

	2019	2020	2021	2022	2023
Commercial STCs	**6,793,285**	**8,730,344**	**8,524,083**	**7,904,982**	**7,253,789**
Residential STCs	**26,436,800**	**30,180,932**	**30,963,690**	**31,156,029**	**31,244,673**
ACT	336,646	421,341	452,541	486,924	530,314
NSW	6,844,830	7,983,218	8,135,409	8,152,306	8,166,029
NT	341,968	394,447	439,649	459,939	473,866
QLD	7,004,635	7,776,730	7,871,008	7,832,344	7,797,732
SA	2,428,420	2,784,033	2,853,090	2,851,897	2,844,406
TAS	189,799	283,312	301,404	319,529	341,903
VIC	4,018,131	3,914,719	4,164,719	4,366,937	4,503,599
WA	3,154,029	3,746,438	3,928,644	3,935,023	3,906,625
VPP STCs	-	925,000	841,000	757,000	673,000
Residential Solar Hot Water	2,118,342	1,951,694	1,976,225	1,994,129	2,007,198
Commercial <15 kW	1,253,926	1,507,357	1,451,165	1,326,374	1,199,116
Commercial 15 kW-90 kW	3,532,560	4,456,176	4,328,187	4,012,126	3,678,056
Commercial 90 kW – 100 kW	1,953,589	2,736,350	2,724,898	2,553,559	2,368,196
Commercial Solar Hot Water	53,210	30,460	19,833	12,923	8,420
All STCs	**33,230,085**	**38,911,276**	**39,487,773**	**39,061,011**	**38,498,461**

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to project STC volumes for calendar years 2019, 2020, 2021, 2022 and 2023 in accordance with the scope of services set out in the contract between Jacobs and the Clean Energy Regulator (CER).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the CER and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the CER and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, the CER, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the CER. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

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. The SRES scheme 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 scheme offers small-scale technology certificates (STCs) at a fixed price of $38.20 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, typically 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 2019, 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 2019-2023, including projections of the number of Small-scale Technology Certificates (STCs) and installed capacity for the five compliance years from 2019 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 2004 until 1 January 2019 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.

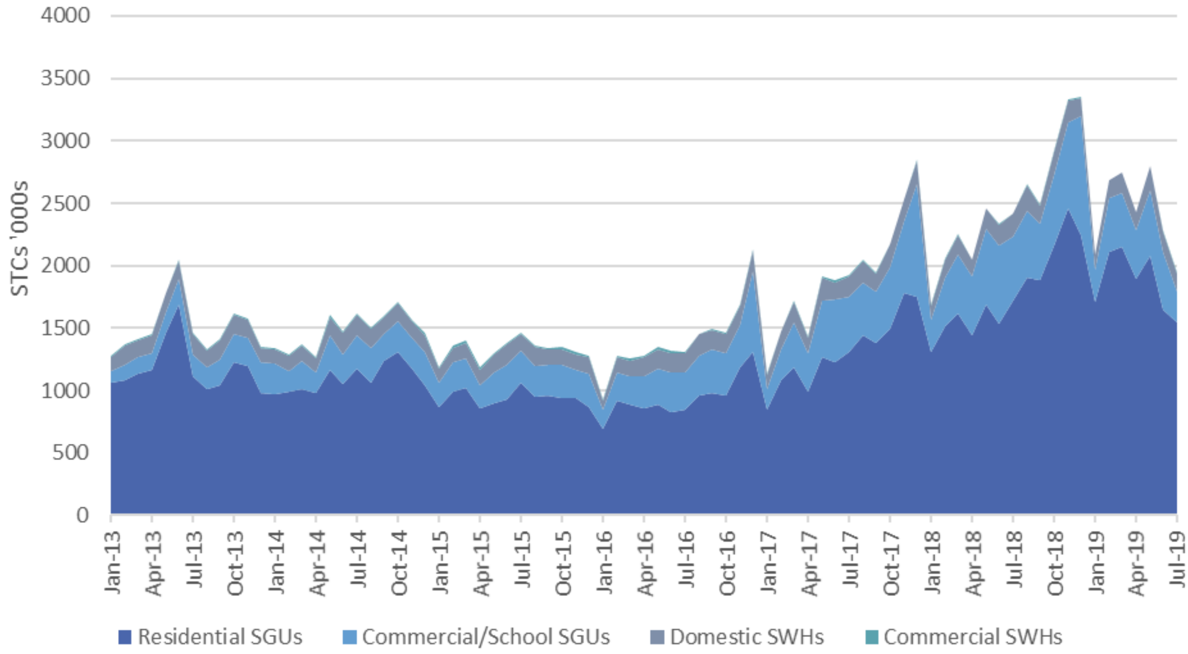
This report continues with an analysis of the trends in uptake in section 2, followed by a description of the current Government incentives and solar PV policies in section 3. Section 4 describes the method, and the assumptions are discussed in section 5. Section 6 presents the results, which are summarised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

2. Trends in Uptake

2.1 Small Scale Certificate creation

Figure 1 illustrates the trends in STC creation by the various categories. Dominance of residential PV installations remains, with the STCs created via installation of commercial systems having a growing influence within the mix. No small-scale wind or hydro SGU have had validated STCs produced since 2017. Domestic solar hot water systems are defined as systems that create less than 40 STCs upon installation, these systems have continued to make a relatively consistent contribution to the market since January 2013. Commercial sized hot water systems make a small contribution to the market.

Figure 1: Monthly trend in STC creation by category since January 2013

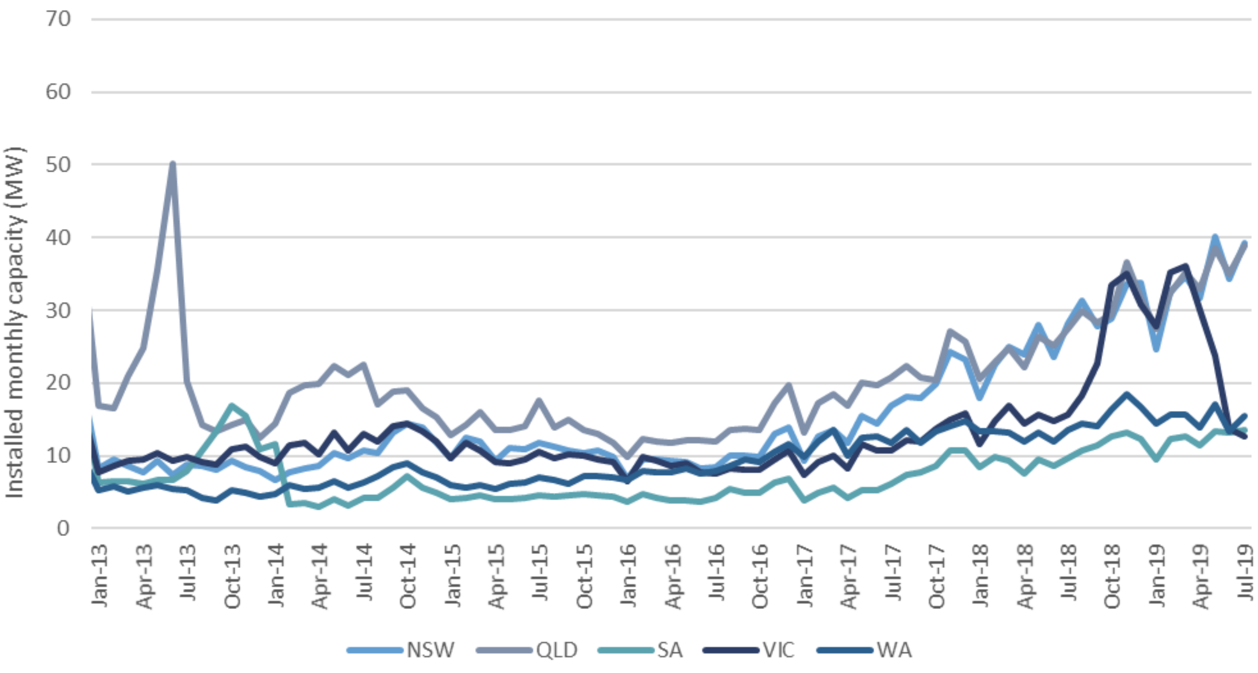


Source: Jacobs' analysis of CER data

2.2 Residential PV Systems

Figure 2 illustrates a surge in the growth of installed residential rooftop PV capacity across the five largest states since 2017. The large spike in installed capacity since August 2018 Victoria is attributed to the new state-based incentives launched by the state Labor government (see section 3.1). This highlights the influence of consumers' response to cash-based subsidies.

Figure 2 Monthly installed capacity, selected states



Source: Jacobs' analysis of CER data

There has been a rise in uptake of rooftop PV installation since 2017 attributed largely 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 occurring 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.

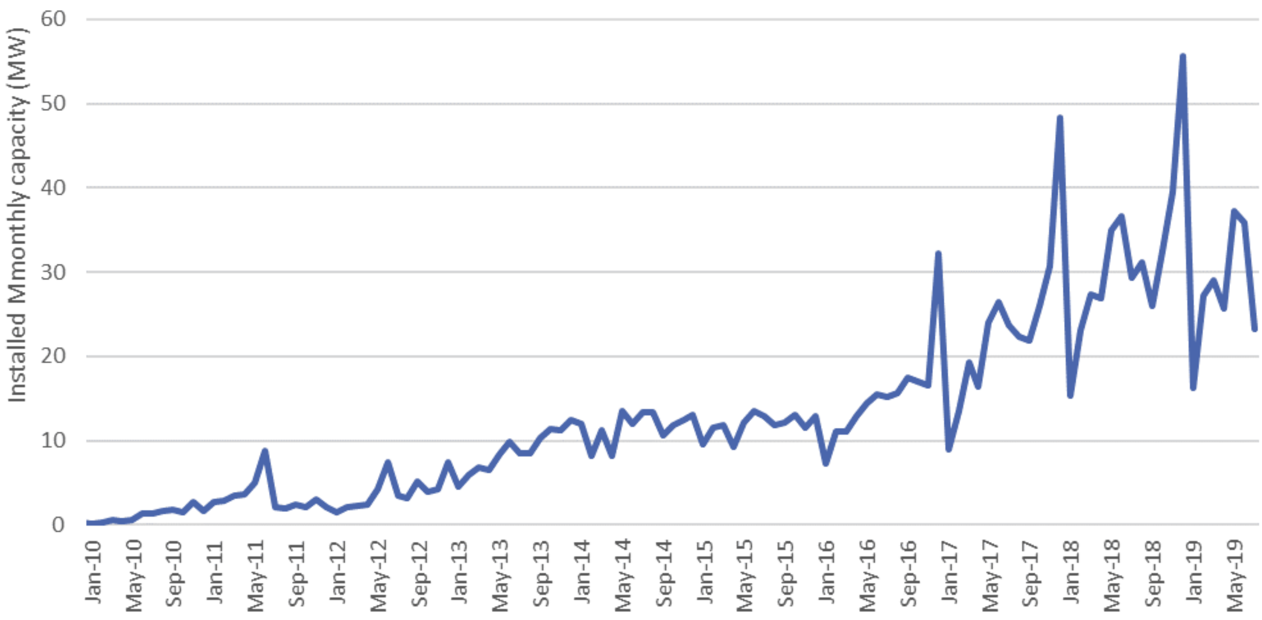
There are several other factors contributing to the rise in rooftop PV installations:

- Continuing lowering of capital cost of installations
- Reducing cash rate
- Increasing environmental awareness

2.3 Commercial PV Systems

Figure 3 illustrates the recent trends in STC creation by schools and businesses. Growth in uptake continued in the first half of 2018, continuing a growth phase that started in 2017. A distinct seasonal trend has emerged as business hastens to commit to installations prior to annual step down in rebates applied to small scale technology. This highlights the sensitivity of commercial installations to economic incentives.

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

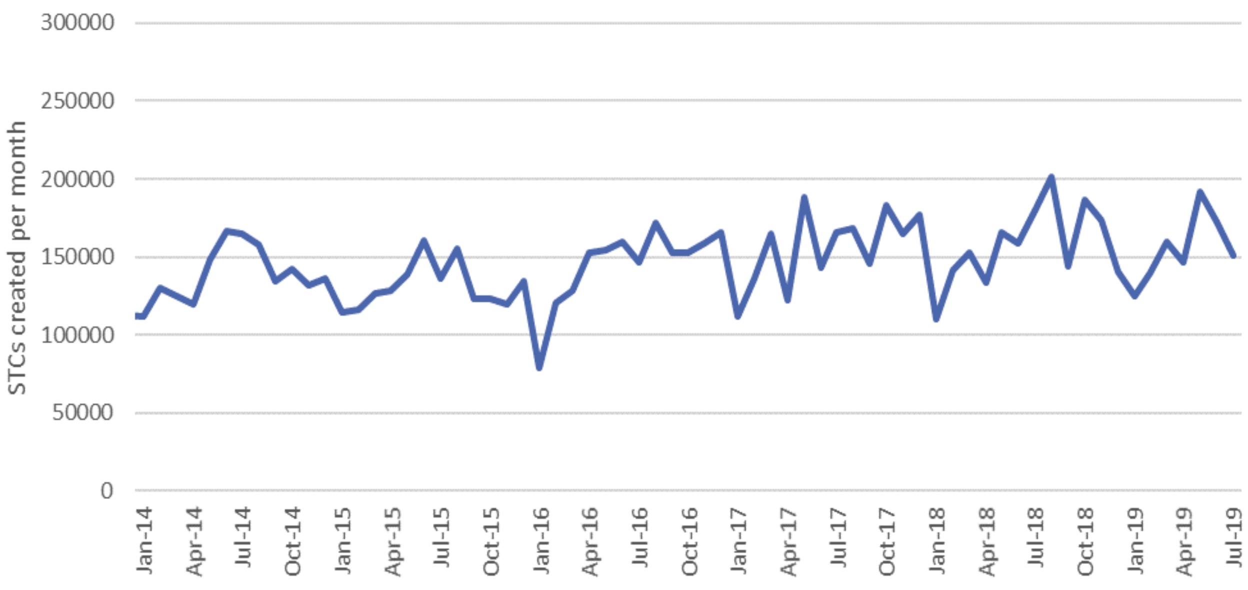


Source: Jacobs' analysis of CER data

2.4 Solar water heaters

Figure 4 shows the trend in creation of STCs by the installation of residential solar hot water systems since 2014. The market had continued to display growth of STC creation in the last few years, with the year 2017 and 2018 having an increase of 7.3% and 0.9% respectively over their previous calendar years.

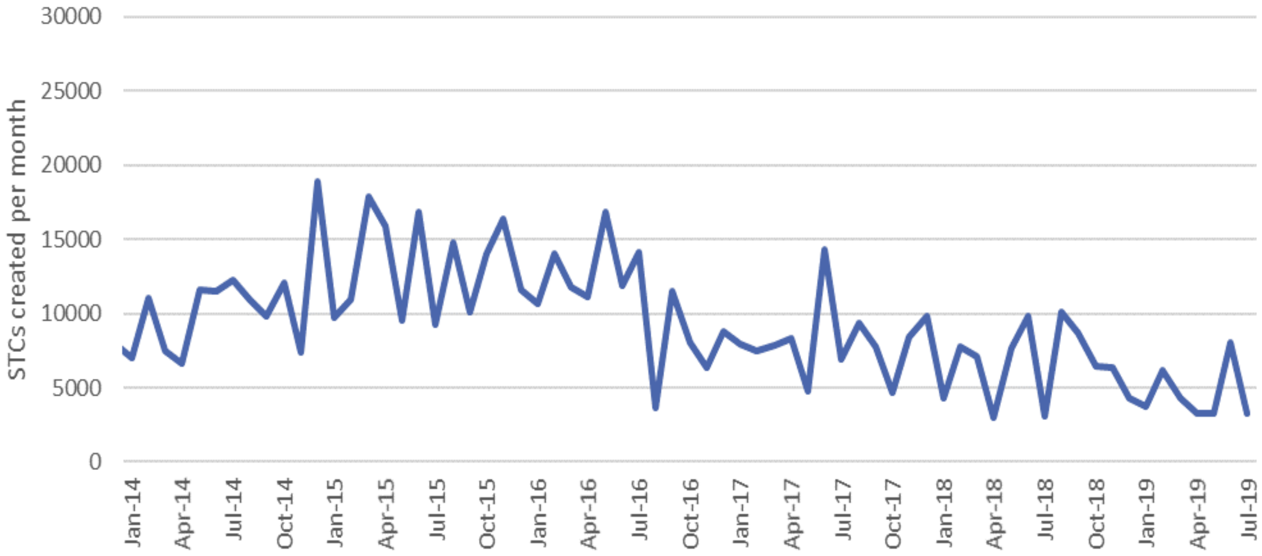
Figure 4: Monthly trend in STC creation from residential SHW



Source: Jacobs' analysis of CER data

Figure 7 illustrates the monthly number of STCs created by commercial sized SHW units since 2014. An increasing trend in monthly STC creation is apparent until mid-2016 where a distinct break in the trend is observed. Since mid-2016, STC creation from commercially sized units has continued to decline with a decrease of 18% in 2016, a 24% reduction in 2017 and a further 19% decrease in 2018.

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 that will be 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.

Amidst a high degree of political uncertainty surrounding federal energy policy and the recent surge in energy prices, both Victorian and South Australian state governments have now initiated rebates for distributed renewable energy production and storage devices.

The state-wide 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.

This section outlines federal and state-based schemes and regulations that could influence the uptake of solar PV and hot water system.

3.1 Solar Homes Program

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 19th 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 to this, 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

The South Australian Home Battery Scheme comprises $100 million in government subsidies available for 40,000 homes for the installation of the 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

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 an approximate 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

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 re-elected NSW Coalition 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-occupier and have an annual household income of up to $180,000. It is expected that the first battery or solar-battery system will be available for installation under this program in the 2019/2020 summer.

3.5 Solar for low income households

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 Affordable Energy Plan

As part of “The Affordable Energy Plan”, the Queensland government currently has 3 initiatives to encourage the uptake of distributed renewable generation and storage.

1) An $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. This was available from June 2018.
2) From 19th of November, 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 for the grant.
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 has allocated $21 million over three years to fund the no-interest loans and rebates. The funding is restricted to 3,500 solar assistance packages and 1,000 solar and battery systems and 500 battery only systems and will be available for Queensland residents until the funding is exhausted or until 30 June 2019.

3.7 Regulations for hot water systems

Since 2010, the Building Code of Australia specifies that all hot water systems installed in new houses are required to comply with minimum greenhouse intensity and/or energy efficiency standards. Now, all Australian states and territories other than Tasmania, Queensland and the Northern Territory have rules restricting the use of greenhouse gas intensive water heaters in new Class 1 buildings (i.e. detached, terrace, row and town houses), either through their own building regulations or by reference to the relevant clauses in the National Construction Code (NCC). These codes have resulted in the reduction of conventional electric resistance water heaters in favour of solar, heat pump and natural gas water heaters.

The National Construction Code was developed to incorporate the Building Code of Australia and the Plumbing Code of Australia into a single code. The Code supports the installation of solar and heat pump water heaters compliant to minimum performance requirements, gas water heaters rated not less than 5 stars and electric resistance water heaters of not more than 50 litres (requirements vary by jurisdiction). Victoria has had a 6-star standard for homes since 2011, which requires the installation of either a solar water heater or a rainwater tank in new homes. In NSW, the BASIX rating scheme, introduced in 2004, allows the use of electric resistance water heaters in new and existing buildings, but imposes such a high penalty that builders must compensate with much stricter levels of ‘thermal performance’ or more energy efficient lighting or fixed appliances.

The NCC does not apply to water heater installations in existing buildings, and each state and territory has its own requirements. South Australia and Queensland have had regulations (metropolitan and nearby areas for South Australia and gas reticulated areas for Queensland) restricting the replacement of electric resistance water heaters since 2008 and 2010 respectively. Since February 2013, Queensland no longer has regulations restricting the replacement of electric resistance water heaters. In South Australia, the water heater installation requirements were changed in January 2014, and the type of water heater that can be installed in an established home depends on the type of dwelling, and whether the property has a reticulated gas connection.

4. Modelling 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 regressed trends in historical data, including testing for inclusion of the use of net economic 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 and population levels.

Last year Jacobs used time-series models specified in R. The most significant change this year is the use of Eviews econometric software for the majority of forecasting, the use of panel regression models (cross-section combined with time-series) and the addition of several economic control variables as external regressors.

Eviews has provided Jacobs with a faster way of specifying and analysing hybrid cross sectional time-series models, as it allows for easier specification of exogenous variables, lagging of independent variables, creation and testing of interaction variables across the different models.

4.2 Time series model

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.

4.3 Hybrid panel regression model

The newly developed model for the forecasting of residential STC creation is a hybrid autoregressive (AR) panel regression model combining autoregressive components with exogeneous economic control variables and cross-sectional dummies capturing the differences between the panel members.

A panel regression model is a time-series model with cross-sectional dependent variables. The cross-sections are the different states in Australia. We have developed two panel models capturing the differences in size of states, as uptake in the three smallest states/territories showed different growth patterns than uptake in the five largest states.

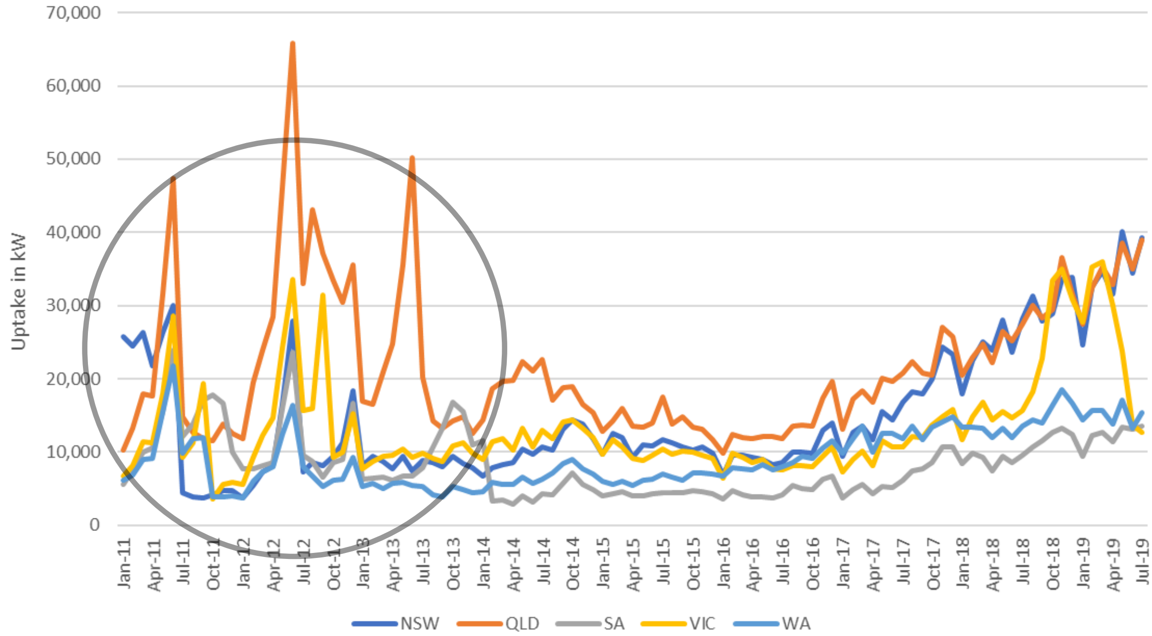
The first panel model with large states include NSW, Queensland, South Australia, Victoria and Western Australia, while the second panel model with small states and territories include the ACT, the Northern Territory and Tasmania. One of the major advantages of a panel regression model is the increased number of observations that can be included in the regression. This will add to the robustness of the model and generates insights into the interrelationship between exogeneous variables and their impact between the different states. It also assists in choosing the appropriate sample size as it can cover a smaller and more relevant period.

4.4 Sample size – residential uptake

We have restricted the sample size for residential uptake to only include data from 2013 onwards for large states and from 2014 onwards for small states and territories. 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.

Figure 6 includes the uptake of small-scale PV in large Australian states and the figure shows large volatility in uptake for all states between 2011 and 2013, as indicated in the circled area. After January 2013 the uptake is less volatile. Therefore, we believe that the most appropriate sample used for forecasting the large states should start no earlier than January 2013.

Figure 6: Small-scale PV uptake for large states in Australia



Source: Jacobs' analysis of CER data

The volatility in the solar PV uptake in the small states and territories showed a longer period of volatility, in particular for Tasmania. We therefore decided to include data from 2014 onwards in the sample.

4.5 Commercial categorisation

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 a number of 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.

4.6 Sample size - commercial uptake

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.

4.7 Data adjustments

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.

4.8 Dependent variable

Using STC creation as the dependent variable in the time series analysis for residential PV uptake was tested. However, this was not considered the best choice due to the solar credits multiplier that was implemented prior to 2013.

The two remaining choices for the dependent variable were installed PV capacity, or number of PV installations. Using installed capacity as the dependent variable avoids having to convert from number of installations to installed capacity. This would have required the prediction of the average installation size which, according to the historical data, is variable over time especially for the smaller states with the sparser datasets.

Installed capacity was therefore used as the dependent variable in the analysis.

4.9 Independent variables in residential SGU modelling

There exists a theoretical 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 uptake drivers are the fundamental building blocks of our models. Furthermore, dummy variables are used 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).

Additional variables that we have tested include: consumer confidence, cash rate, home-loan rate, all ordinaries stock price index, Gross State Product (GSP) and state-based population. Modelling showed that in particular the interest rate variables, GSP and population 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 addition, we have used the home-loan rate rather than the cash-rate as the former is more appropriate for an investment decision made by a residential consumer.

The final set of independent variables we used in the modelling are included in Table 2. The table shows the data sources, a short description of the variable and a short explanation of the use in the model and expected impact on the dependent variable.

In several cases, and only when justifiable, 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 FITs on the uptake of rooftop PV. General economic indicators may also see a lagged impact as economic growth may accelerate future private spending through a multiplier effect.

Table 2: Independent regression variables used in panel regression models.

Independent Variable	Source	Used in	Explanation - impact
Electricity price ($/MWh)	ABS Historical price-index for electricity for each capital city Jacobs' retail and wholesale price forecasting models for projections.	All models (as standalone or part of interaction variable)	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.
State feed-in tariffs (FITs)	Weighted average of feed-in tariffs offered by retailers across Australian states.	Residential models only (as part of an interaction variable only)	The FIT is the second 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 export electricity to the grid and receive a feed-in tariff per kWh for this export. We expect there will be a positive significant correlation between the FIT and the PV uptake, as higher FITs will increase potential benefits of rooftop solar PV. The FIT is less relevant for commercial uptake as many businesses do not have FITs in their retail contracts or will be utilising most of the generated energy themselves, as benefits of self-use are much higher (through avoided retail tariffs).
Electricity Price* State FIT	*Interaction variable, see data sources for respective variables*	*Residential models only*	*The electricity price and state feed-in tariffs are included as an interaction variable only in the residential model to include the dynamic aspect of the two indicators combined. For example, lower electricity prices may affect uptake negatively but can be (partially) offset by higher feed-in tariffs.* *Another reason to include both regressors as an interaction variable is to avoid potential strong cross-correlation and therefore reducing the probability of spurious regression results.*
Net capital cost ($)	Data obtained via Solar Choice website.	All models (as part of an interaction variable only)	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.
Home-loan rate	Derived from the cash-rate published by the Reserve Bank of Australia (RBA). We assumed the cash-rate plus a 2.5% mark-up.	All models (as part of an interaction variable only)	The home-loan rate is an indicator for the 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 home-loan rate correlates negatively with the uptake of small-scale solar PV as higher rates will make the direct cost and/or

Independent Variable	Source	Used in	Explanation - impact
			opportunity cost of taking up small-scale PV higher and therefore should reduce the uptake and vice-versa.
Capital Cost * Home-loan Rate	*Interaction variable, see data sources for respective variables*	*All models*	*We have included the variables for capital cost and home-loan rate as an interaction variable only (not included as separate variables) to include the dynamic aspect of the two indicators combined. For example, higher capital costs may deter investment in solar PV, but if the interest rates are sufficiently low, investing in solar PV may still be an attractive alternative.* *Another reason to include both regressors as an interaction variable is to avoid potential strong cross-correlation and therefore reducing the probability of spurious regression results.*
Gross State Product (GSP), Aggregated Gross State Product	ABS time series 5220 – Australian National Accounts: State Accounts	All models (as part of an interaction variable)	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	All models (as part of an interaction variable)	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.
GSP/ Population	*Interaction variable, see data sources for respective variables*	All models	*For the purpose of estimating residential solar PV uptake we are using a proxy for per capita income, GSP per capita modelled as GSP divided by state population. This provides a better indicator for private consumer driven investment. For example, strong population growth can increase overall GSP, but does not necessarily mean that uptake of small-scale PV will increase, unless the market is saturated (e.g. when every household already has a PV system). In fact, average income levels likely remain the same or can even be temporarily reduced as a result of strong population growth, which may not increase uptake at all.* *Economic output per person is a measure of the average income levels and is more likely to affect small-scale PV uptake, as investment decisions are made based on the individual, commercial or household economic situation.*

4.10 Variables used in commercial SGU modelling

Small scale commercial systems were modelled using an ARMA Maximum Likelihood model (OPG-BHHH) utilising historical PV capacity 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 onwards.

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, the economic output per capita[2]. Dummies were included to control for policy impacts and other exogenous shocks.

4.10.1 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 through assessment of distribution of residuals including assessment of the correlogram of lagged residuals, the Durbin-Watson test, testing for normally distributed random errors. The DW-Statistic is provided as part of the regression output and a statistic of approximately 2 indicates the null hypothesis of random errors holds.

The time series analyses were carried out by either panel estimated generalised least squares (EGLS) regression models for the residential SGUs or ARMA maximum likelihood modelling for the commercial SGUs.

Once the sample size was determined (discussed in section 4.4), 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 R^2, adjusted R^2 and/or 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 residential and commercial modelling was undertaken on monthly data. The regression model structures adopted were:

- Hybrid autoregressive panel regression models (EGLS – with cross-section weighted fixed effects) for the state level residential forecasts.
- A hybrid ARMA maximum likelihood (OPG-BHHH) model for the small-scale commercial forecasting models.
- The developed hybrid regression approach includes independent variables including net upfront cost, system benefit (e.g. electricity price, FITs), economic control variables and (policy) shock dummy variables as regressors and applying auto regression modelling to the residuals of the regression model. This approach allows the modelling to consider external cost functions in developing projections but also allows for appropriate consideration of recent time trends which is useful in time series approaches because of inherent autocorrelation in the dataset. This approach was used to model all states for residential as well as commercial uptake.

The residential models were estimated in a panel regression including the different states and territories as the panel members (cross-sections), while the commercial sector is modelled nationwide as single regressions, albeit for different capacity sizes (as discussed in section 4.5).

4.10.2 Time series model for water heaters[3]

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

[2] Included as aggregated Gross State Products divided by Aggregated State Population of all Australian States and Territories.
[3] The term 'water heaters' refers to solar water heaters and heat pump water heaters

commercial categories for all of Australia. The resulting projection also considers deeming reductions in future years.

4.10.3 STC zoning

CER divides Australia into four regional zones based on the estimate of renewable energy that can be effectively generated by a solar panel in a given area, so installations based in areas with high insolation will create more certificates per kW installed than rooftop installations based in areas in the south of the country. Zones are defined by the postcode. To convert the capacity of solar panels installed in a particular state 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 3 shows the effective multiplier for each state and commercial installations utilised for conversion of the forecast capacity into STCs.

Table 3: 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	17.9
WA	20.7
Commercial	
National	20.2

5. Assumptions

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

5.1 Financial benefits

The financial benefit of installing a PV system remains as one of 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, these include:

- 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

The time-series model utilises historical and forecast calculations of these indicators as potential regressors.

Critical assumptions in the calculation of the upfront cost is 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 also important considerations. Solar PV units are expected to have a life of 15 years.

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, in the near future, with the introduction of small-scale battery storage and EVs, the reliance on export and thus FITs may reduce as a result of the ability for consumers to shift load using their storage device or charge their electric vehicle.

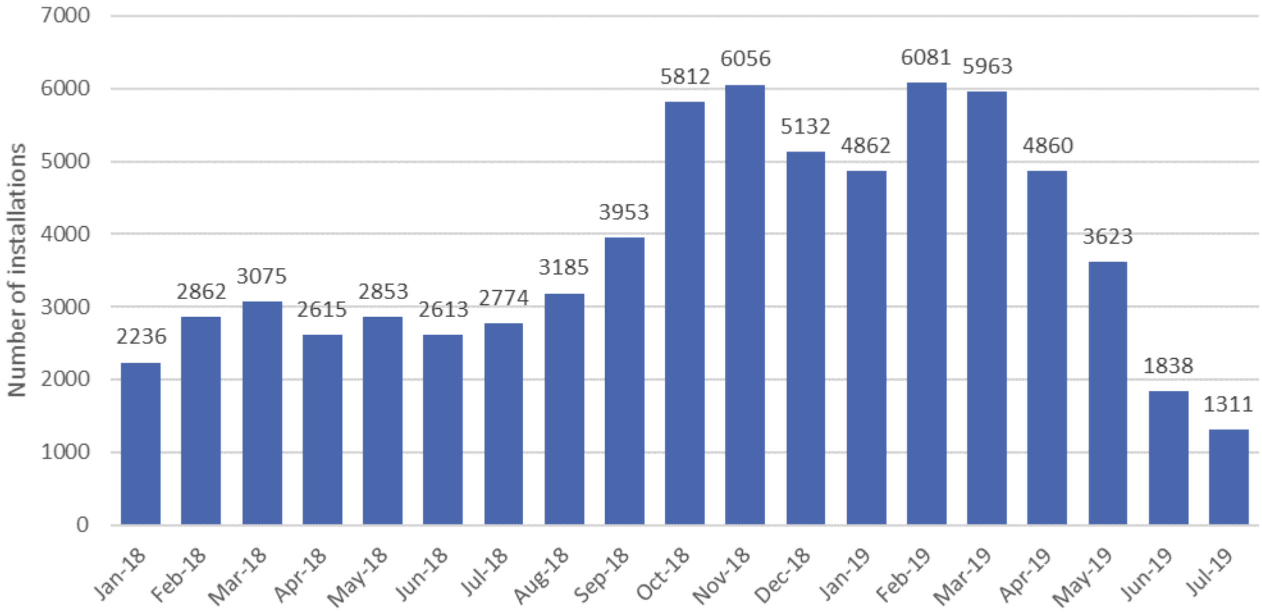
5.2 Rebate assumptions

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 generous state based Victorian solar homes rebate, commencing from August 19th 2018 resulted in a flood of installations of rooftop PV on Victorian homes. Figure 7 shows the number of monthly residential instalments since January 2018 and the large increase in installations highlights the popularity of the subsidy since its introduction in late August 2018.

Figure 7 Number of monthly residential PV installations in Victoria since January 2018



Source: Jacobs' analysis of CER data

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 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. These caps of rebates for the 2020 financial year are outlined in Table 4.

Table 4 Victorian solar homes rebate caps per month, FY2020

Month	Release 1	Release 2	Monthly Total
July	3,333	-	3,333
August	3,333	-	3,333
September	6,500	3,250	9,750
October	3,250	3,250	6,500
November	3,250	3,250	6,500
December	2,500	2,500	5,000
January	2,000	2,000	4,000
February	2,500	2,500	5,000
March	2,500	2,500	5,000
April	2,500	2,500	5,000
May	2,500	2,500	5,000
June	2,500	2,500	5,000

Due to the popularity of these rebates, and the influence that these have had on uptake of residential rooftop solar in Victoria in recent months, it is not suitable to project installations in Victoria utilising our time series models. Projections for the uptake of rooftop solar in Victoria 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.
- It is assumed that 24,000 rebates have been made available until FY 2019 to owner occupied households.
- All 63,416 rebates offered by the Victorian Government in FY 2020 to owner occupied homes will go ahead according to the schedule outlined in Table 4.
- 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.
- 50,000 rebates will be installed on rental properties from 2019 to the end of 2030 with 347 per month, with exception of the 6 months from July to December 2019 when an excess of solar installations on owner – occupied homes is expected to fulfil the backlog.
- It is assumed that 11% on households ineligible for the scheme will continue to install PV systems at a rate of 290 installations per month, with exception of the 6 months from July to December 2019. This is based on the assumption 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.
- The average size of systems installed is 6 kW.

Based on these assumptions, Table 5 outlines the assumed number of installations, capacity installed and STCs produced in Victoria until the end of 2023.

Table 5 Assumptions on Victorian residential PV installations, capacity and STC generation for forecasting period

Time period	Owner Occupied installations	Rental installations	Ineligible owner installations	Capacity (MW)	STCs '000s
Jul – Dec 2019	34,416	-	-	206	2,957
Jan – Jun 2020	29,000	2,083	1,740	197	2,585
Jun – Dec 2020	31,079	2,083	1,740	209	2,749
2021	62,158	4,167	3,480	419	4,998
2022	62,158	4,167	3,480	419	4,498
2023	62,158	4,167	3,480	419	3,998

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 made the assumption 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. The third phase of the scheme involves the installation of a further 49,000 units installed over the next 4-year period. Results from the first two phases of the scheme are being considered prior to the commencement of the third phase of the scheme, and it is possible that a retailer may be required to assist funding for this phase.

For this study, we have assumed that the 49,000 units will be installed evenly across this period beginning from January 2020. STCs are then calculated utilising the approximated number of 5 kW units, the effective STC multiplier for South Australia and the fraction of deeming period associated with each calendar year.

Table 6: South Australian Virtual Power Plant scheme assumptions

Year	Deeming Period	Installations	Capacity (kW)	STC '000s
2020	11	12,250	61,250	925
2021	10	12,250	61,250	841
2022	9	12,250	61,250	757
2023	8	12,250	61,250	673

5.2.3 Queensland Affordable Energy Plan

The first component of the Queensland Affordable energy plan, available to 3,500 households, has been running since June 2018 and is expected to close at the end of June 2019. At such a rate, we have assumed that at least half of these installations have occurred in the 6 months to December 2018, and as such have already been incorporated into the data and that the time series component of the model would have factored this growth into the model.

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 that only households already considering installing PV in 2019 will collect this grant, and therefore may shift the frequency of installations into the first half of 2019 but not have a substantial impact on the overall capacity installed in the calendar year 2019. 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 ARIMA model has factored this scheme into the growth rate of our model outputs.

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 a 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 ARIMA model, it is assumed that the time-series component has factored in the growth rate under this additional scheme, and for these reasons the STC's assumed as part of this scheme will not be added to our time-series model output results.

5.3 Capital cost

System prices are expected to gradually fall over the coming years. The global oversupply on PV module manufacturing capacity has apparently diminished, though trends in global markets such as U.S. import tariffs on Chinese panels and availability of rare elements used in panel manufacturing continue to have the potential to influence the prices paid by Australian installers in the short term.

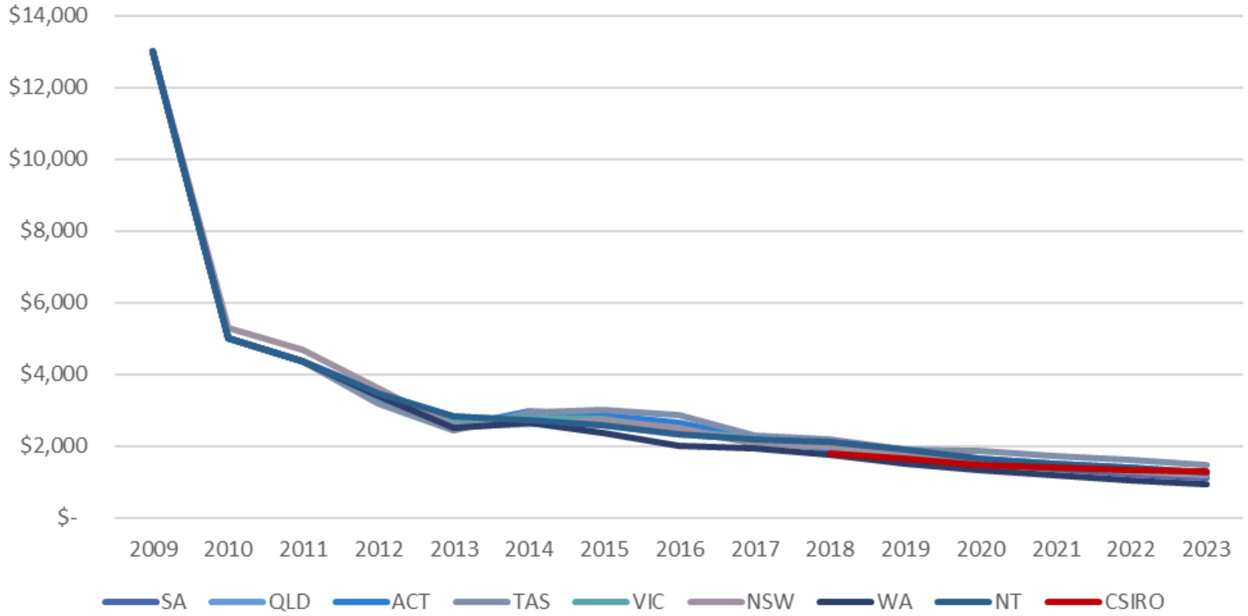
Capital cost assumptions for PVs in 2019 are based on the Solar Choice website's[4] monthly unit pricing overview, which is based on price data from 125 solar installation companies across Australia. These were converted into real dollars using historical CPI data.

For residential systems, the price per system per kW for capacity sizes of 1 to 5 kW was trended over time, and forecasts for each State were performed by fitting exponential functions across the historical data, which were then extrapolated to 2023. Figure 8 shows the average historical and forecast cost for a residential system across all states, with a gradual tapering of prices as consistent with our assumptions. These assumptions have been validated against CSIRO's 2018 GenCost forecasts for national rooftop PV forecasts (also illustrated in Figure 8) and show a similar trend.

An increase in cost per kW is observed for systems of 7 kW, likely due to the fact there are many network restrictions on inverter size up to 5 kW at residential properties, which handles solar panel systems up to 6.6 kW (panels are generally oversized compared to the inverter size). The 7 kW size price projections were utilised to price systems where the average was expected to be between 6.7 kW and 10 kW.

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

Figure 8: Capital cost assumed for residential solar PV systems ($ nominal/kW)



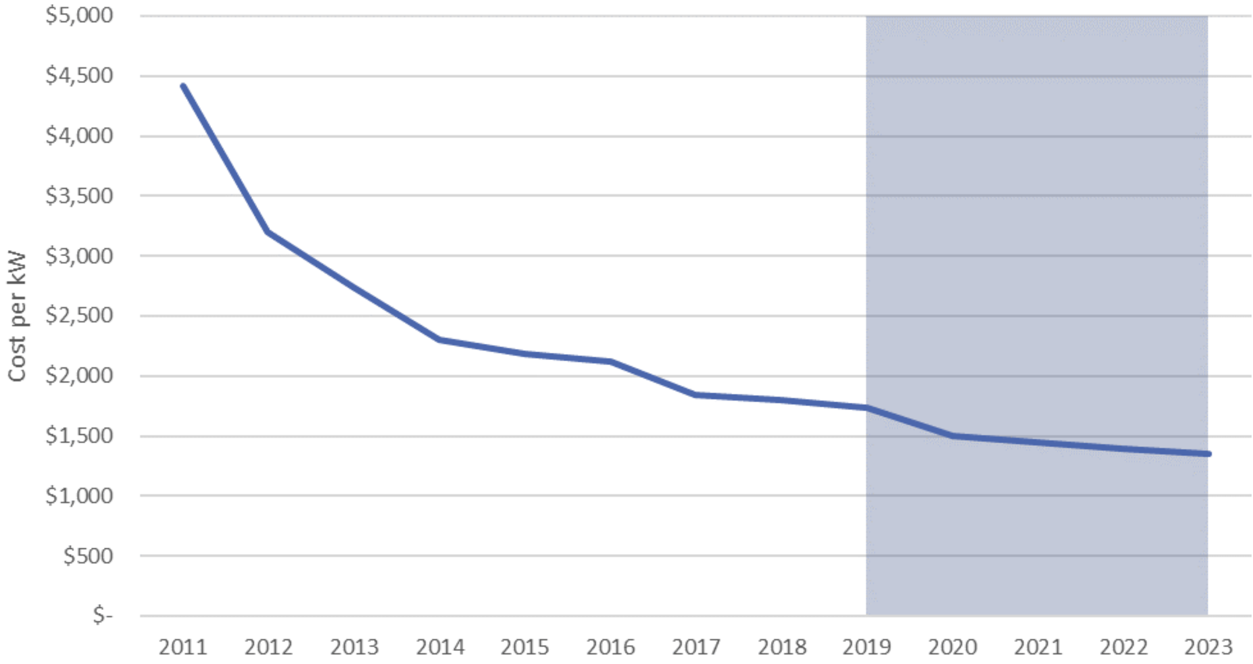
Source: Jacobs' market analysis, Solar Choice monthly system cost estimates 2012 – 2018

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 a power curve fitted for values between 2011 and 2018.

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 9 shows the historical and forecast costs assumed for commercial systems.

Figure 9: Capital costs assumed for commercial solar PV systems ($ nominal/kW)



Source: Jacobs' market analysis, Solar Choice monthly system cost estimates 2012 – 2019

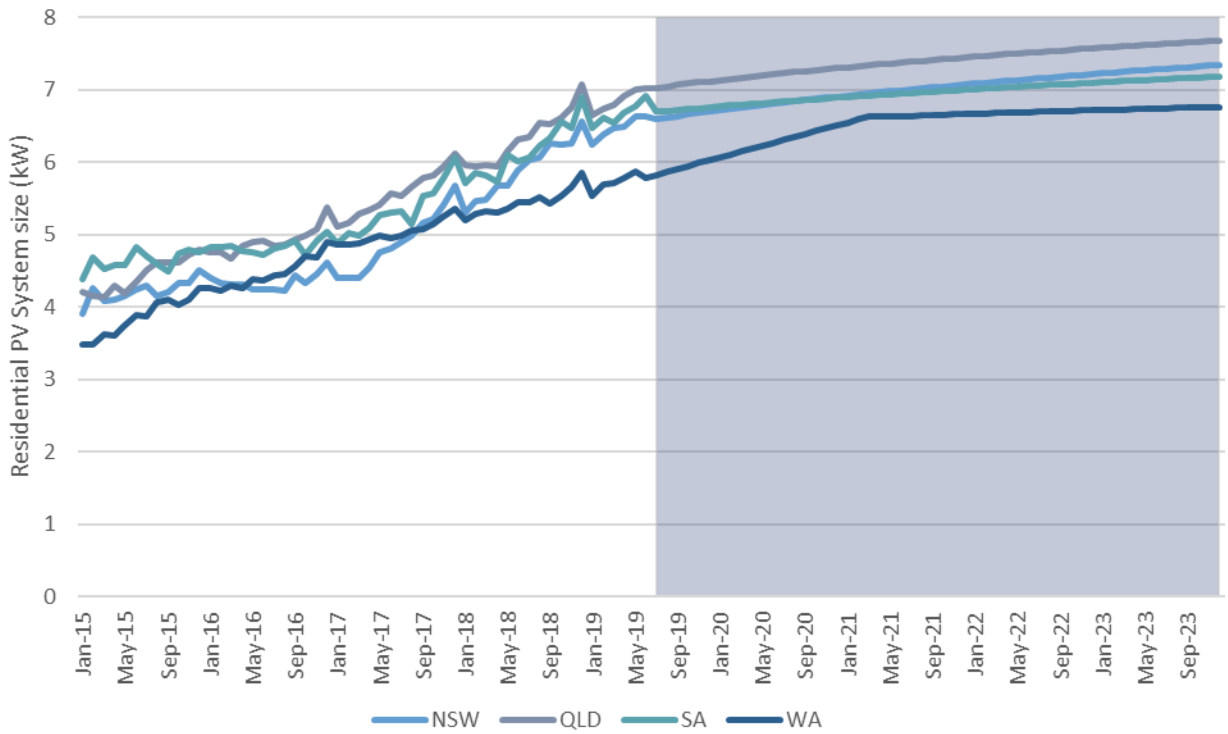
5.4 Residential system size

Figure 10 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.

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 curtail the system size for residential properties.

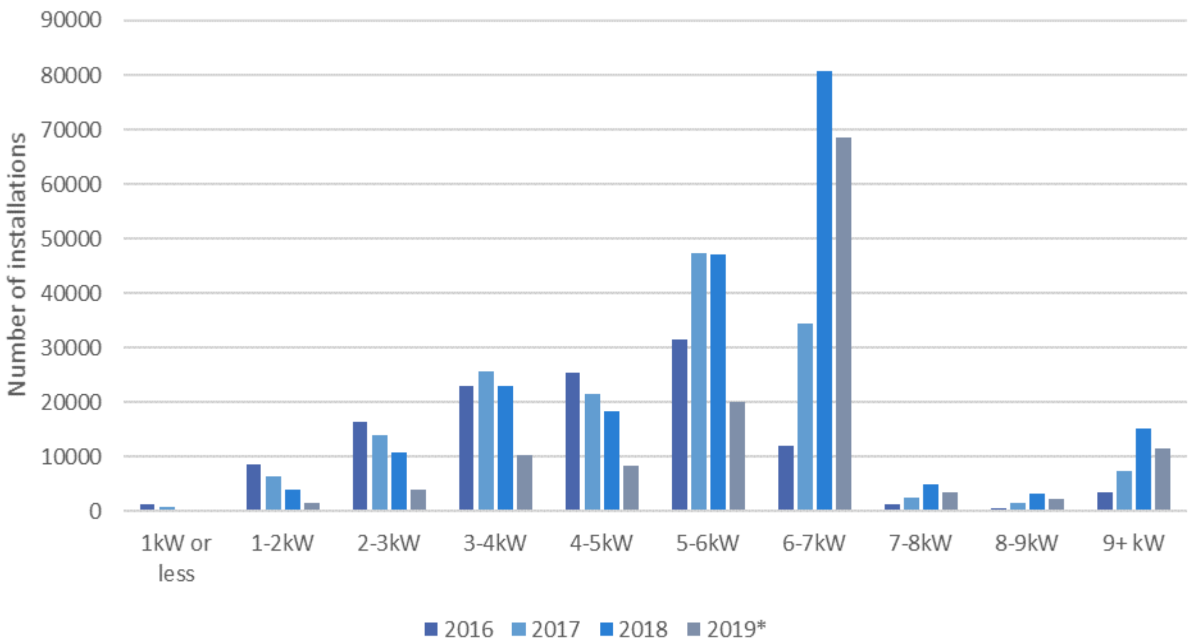
The assumption is that the growth rate will occur at the linear rate observed recently, with the growth rate slowing after a capacity of 6.6 kW is reached. Power curves have been fitted in each state to reflect the assumed reduction in growth rate after a 6.6 kW average capacity is reached.

Figure 10: Monthly trend and forecast for average residential PV solar system size, selected states



Source: Jacobs' analysis of CER data

Figure 11 Residential system size brackets since 2016



Source: Jacobs' analysis of CER data

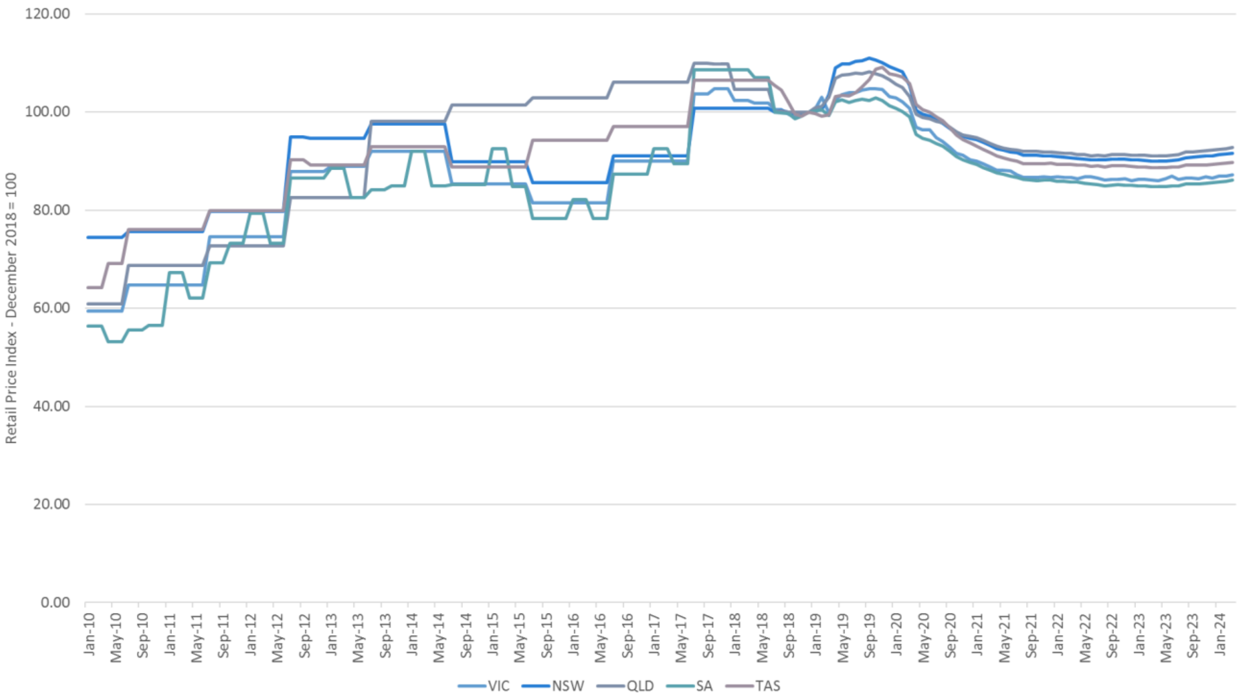
5.5 Electricity price projections

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 (see Appendix C for further details).

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 12 shows the residential electricity price indices 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 2019. A relatively flat forecast of price levels is then projected up to 2024.

Figure 12: Residential retail price index - historical trend and forecast for selected states



Source: 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 ACT, where ActewAGL supplies the bulk of the market, the ActewAGL tariff was selected.

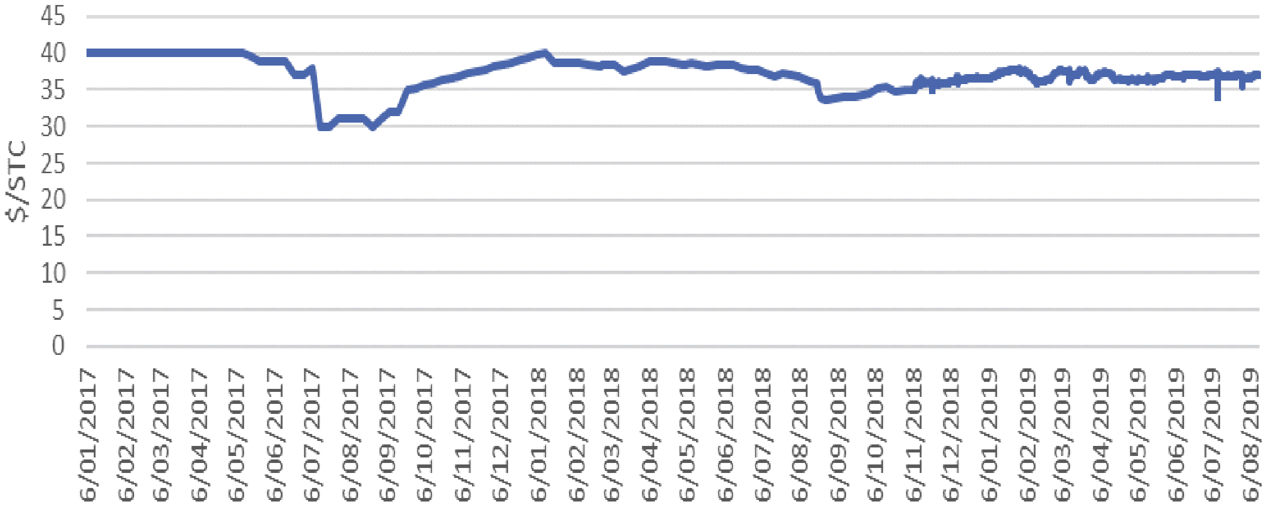
Due to the projected decreases in retail electricity prices over the forecasting period for NEM states, the FIT for each state was then calculated as a percentage of the most recent retail price. Moving forward, the FIT was then assumed to move relative to the retail price based on this initial proportion.

5.7 STC prices

Figure 13 shows the weekly historical STC prices for the period January 2017 to August 2019. During this period the STC prices have continued to hover below the target $40 throughout 2019, indicating that a surplus of STCs is being generated in the market.

The latest forward STC price is $37.70 on 20 October 2019[5], with a settlement date of 15 June 2021. This is largely in line with the historical data and therefore we have used this price to calculate the estimate rebate for solar PV systems installed.

Figure 13 Weekly historical STC price (nominal) Jan 2017 – Aug 2019



Source: Greenmarkets, Demand Manager and Jacobs' analysis

5.8 Interest rate assumptions

The average current mortgage rate sits at approximately 3.5%, or 2.5% above the cash rate. It is assumed that the spread of 2.5% remains constant historically.

5.9 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 how many systems are registered one, two, three, or more months after the system itself was installed.

Data was analysed for the period of calendar year of 2018, with the assumption that all PV systems installed in 2018 were registered by 31st of December 2018. This period was selected as it would reflect current trends whilst still maintaining an adequate sample. Months for the year of 2019 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.

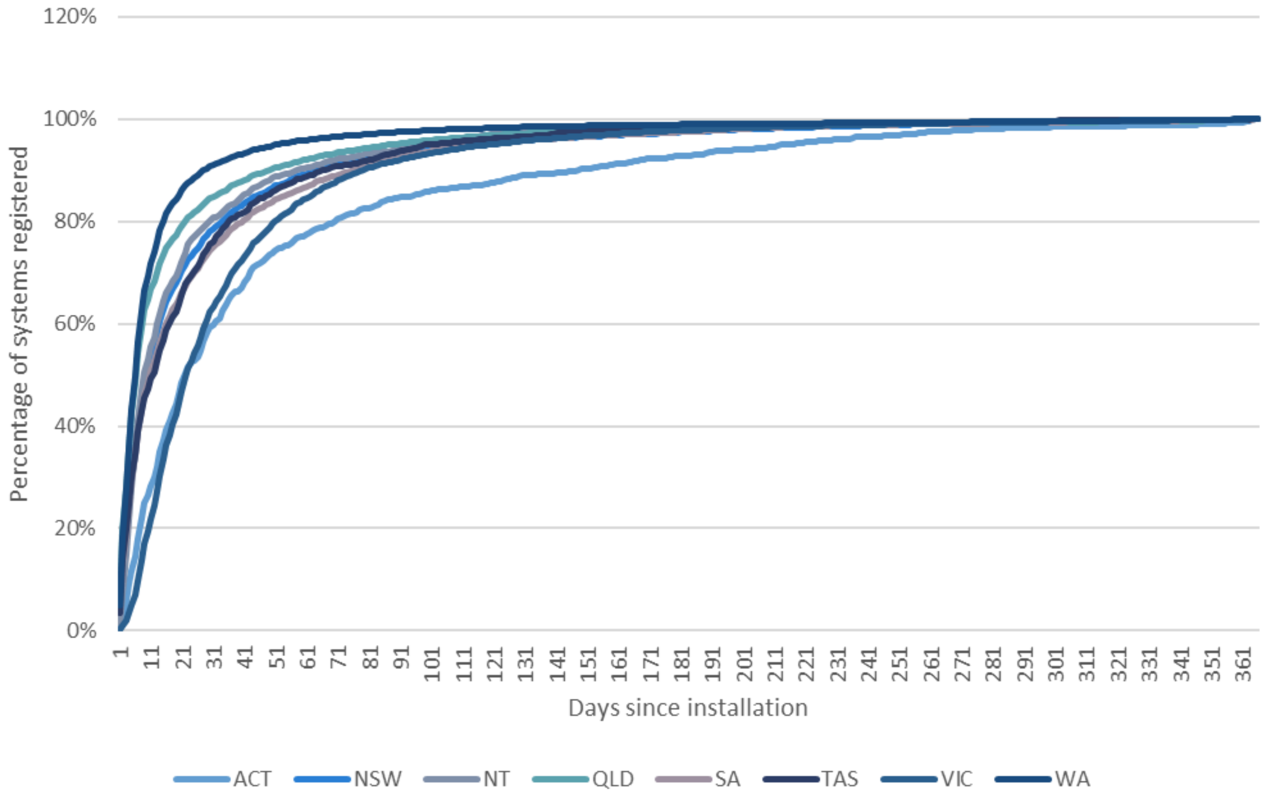
[5] Source: demandmanager.com.au

Figure 14 shows the typical delay in registration for residential system installations, by state.

We have elected not to use registrations for the month of August 2019 in our analysis due to it being an incomplete dataset.

For the months of March through to July 2019, the residential installed capacity was divided by the percentage of registered installations for the expected percentage of installations for the respective month as shown in Table 7.

Figure 14: Delay in STC creation from installation, 2018 residential SGUs



Source: CER data

Table 7: Percentage of installed capacity used in modelling for residential and commercial systems

Month	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	Commercial
Mar 2019	97%	98%	98%	97%	98%	97%	98%	99%	96%
Apr 2019	96%	97%	98%	96%	97%	96%	96%	98%	94%
May 2019	93%	95%	96%	95%	95%	94%	94%	98%	90%
Jun 2019	88%	92%	94%	92%	90%	88%	88%	96%	84%
Jul 2019	73%	84%	84%	85%	80%	77%	69%	91%	70%

6. Small Scale Modelling Results

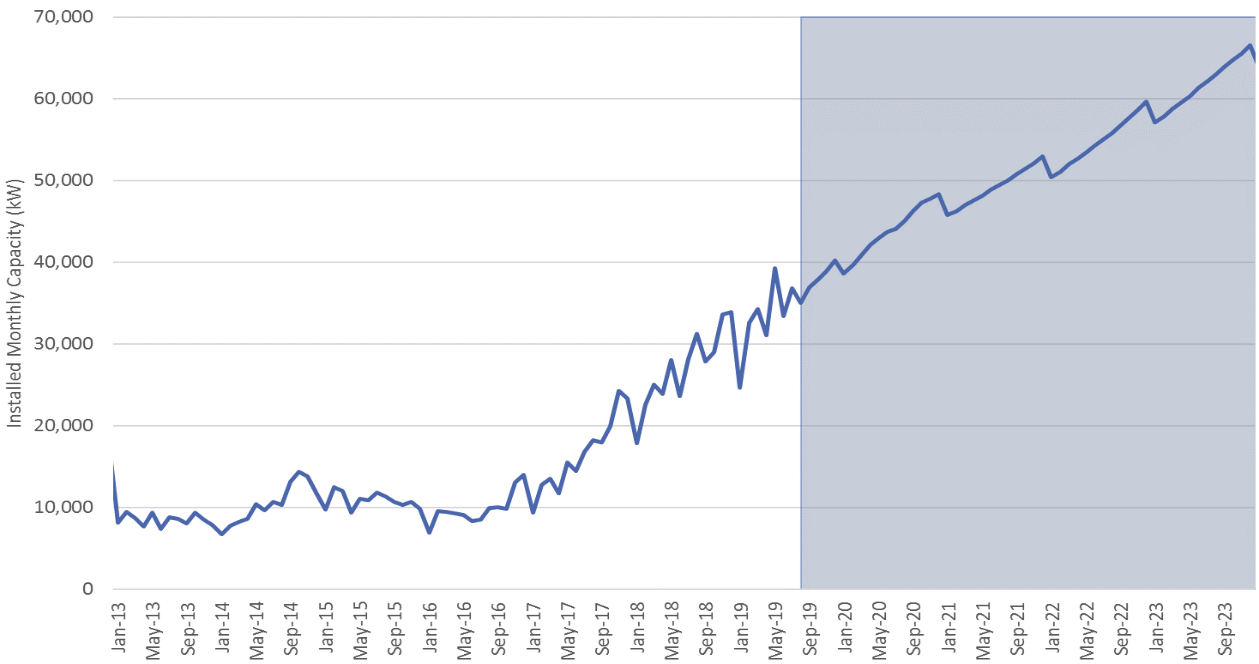
This section presents the results of the modelling for the time series model. In all cases results are presented in calendar years.

6.1 Residential system uptake

The state based residential forecasts were derived by first projecting installed capacity for PV systems and then converting these to STCs by inferring the STCs per unit of installed capacity from historical data.

Figure 15 shows the historical actual and projected total installed capacity for residential systems in New South Wales.

Figure 15: Historical and projected installed capacity for NSW residential properties[6], excluding the NSW solar scheme



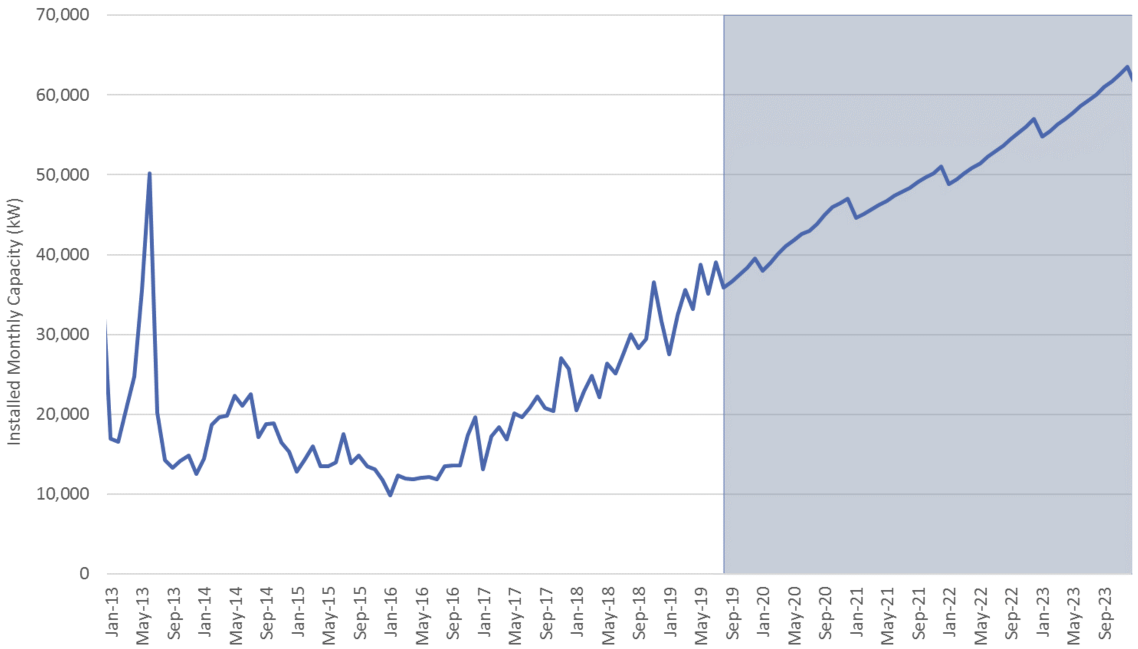
Source: Jacobs Analysis

Figure 16 shows the historical actual and fitted data of installed monthly capacity for residential systems in Queensland. Uptake in Queensland is expected to grow towards 60,000 kW uptake per month. The forecast also shows a subtle seasonal uptake pattern (December – January) resulting from the scaling down of the STCs.

Historical actual and fitted data for the uptake of residential PV in South Australia are shown in Figure 17. This chart does not include the Virtual Power Plant scheme. The data shows growth of uptake over 20,000 kW by the end of 2023 as well as the seasonal uptake pattern.

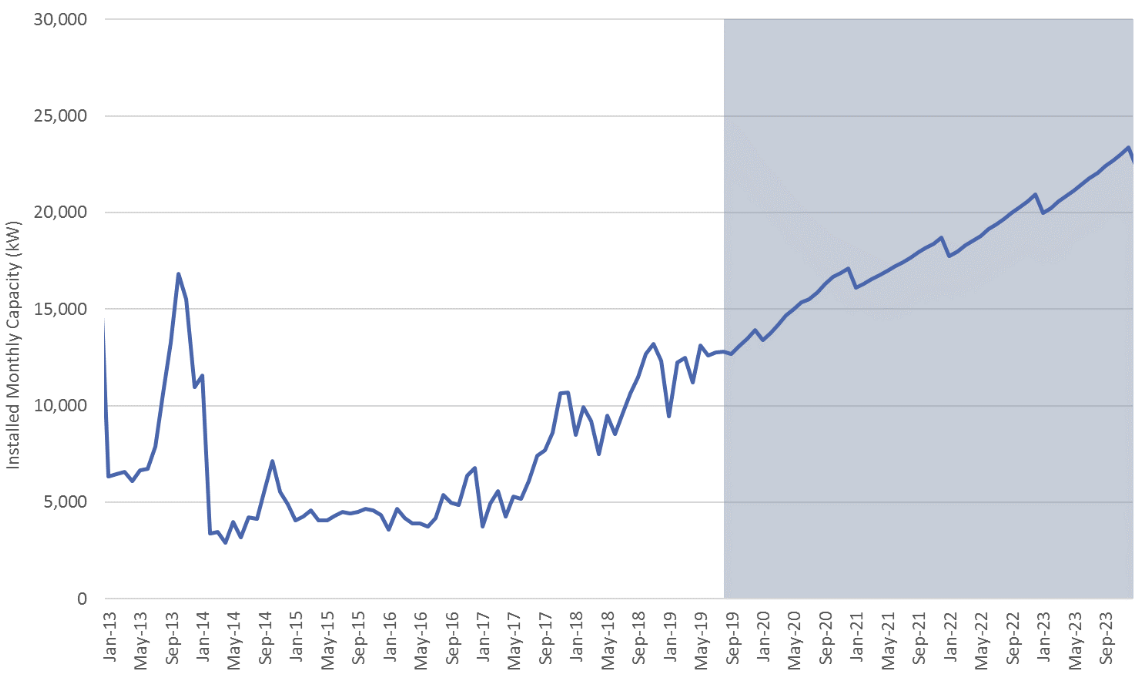
[6] We have excluded the 'NSW Empowering Homes' solar PV and battery scheme as it is geared towards the uptake of batteries (as retrofit to existing PV or additional to planned PV), rather than stimulating the uptake of more solar PV.

Figure 16: Historical and projected installed capacity for Queensland residential properties



Source: Jacobs Analysis

Figure 17: Historical and projected installed solar PV capacity for South Australian residential properties[7]

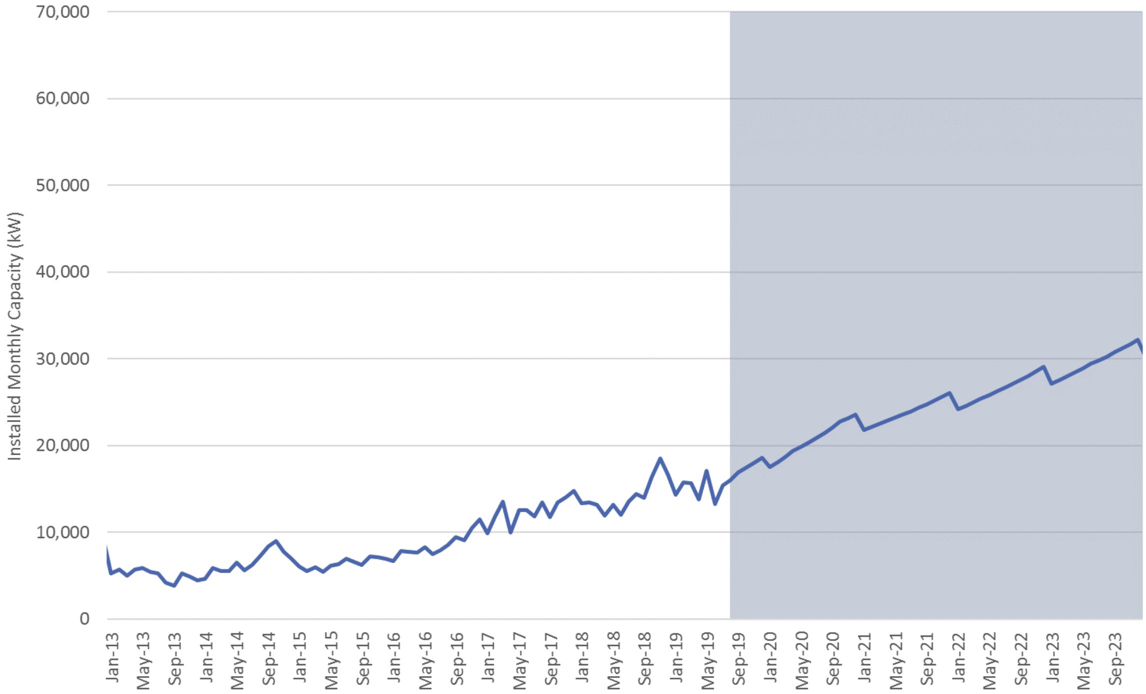


Source: Jacobs Analysis

Figure 18 shows the historical actual and fitted data and projected solar PV uptake for residential systems in Western Australia. Unlike most other states, STC creation is expected to increase in 2019 without the assistance of state-based incentives.

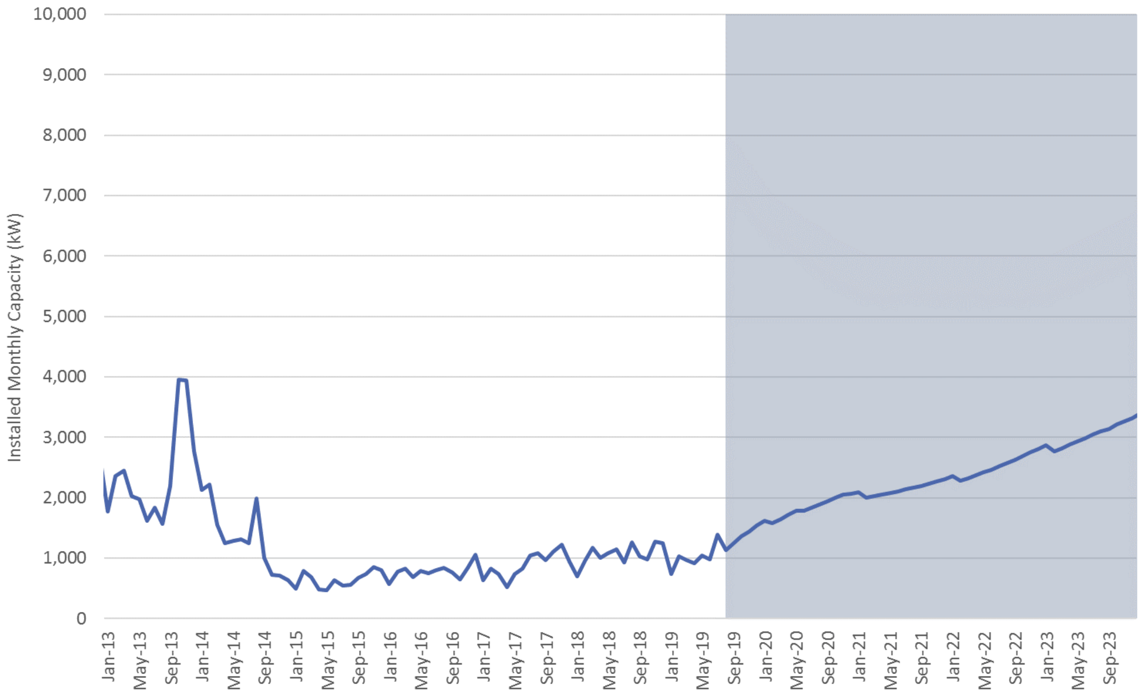
[7] This chart does not include the Virtual Power Plant uptake.

Figure 18: Historical and projected installed solar PV capacity for Western Australian residential



Source: Jacobs Analysis

Figure 19: Historical and projected installed solar PV capacity for Tasmanian residential properties

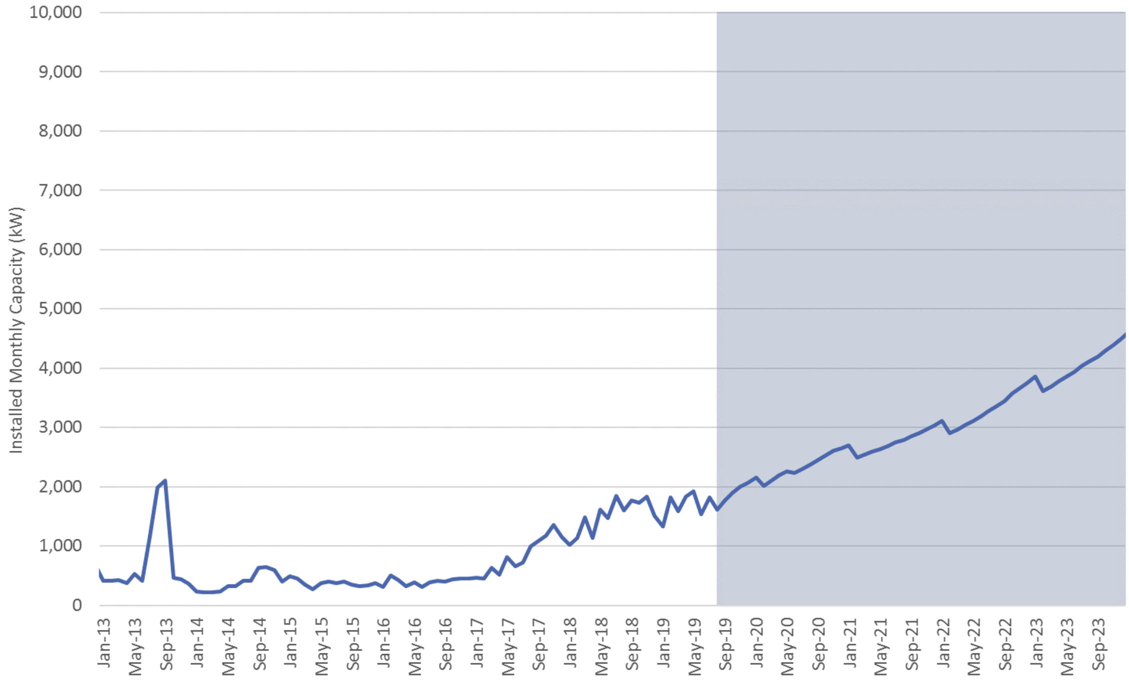


Source: Jacobs Analysis

Figure 19 shows solar PV forecast used for STC creation in Tasmania.

Figure 20 shows the solar PV forecast used for STC creation in the Australian Capital Territory.

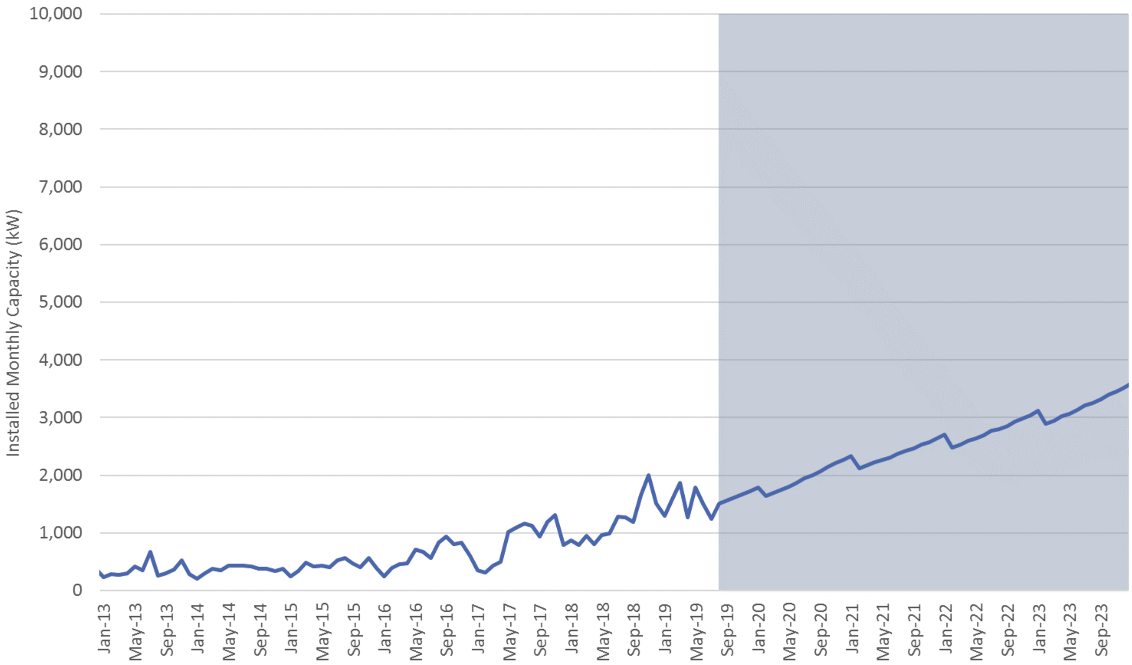
Figure 20: Historical and projected installed capacity and STCs generated for Australian Capital Territory residential properties



Source: Jacobs Analysis

Figure 21 shows the solar PV forecast used for residential STC creation for the Northern Territory.

Figure 21: Historical and projected installed capacity and STCs generated for Northern Territory residential properties



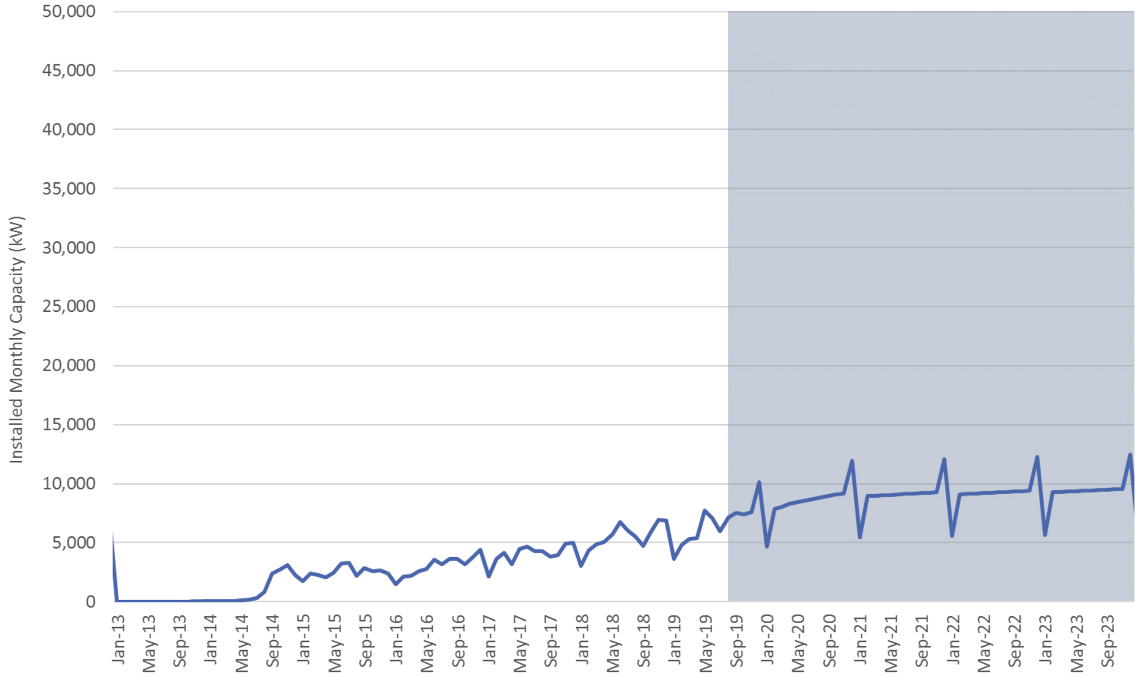
Source: Jacobs Analysis

6.2 Commercial systems uptake

Uptake of commercial solar PV systems has been modelled for three different sizes, as discussed in section 4.5.

Figure 22 shows the historical and projected total installed rooftop PV capacity for commercial systems smaller than 15 kW. The forecast shows some growth up to 2021 before levelling out. There is a more pronounced seasonal uptake (Dec - Jan) than observed at the residential system uptake projections. The latter is as expected, as it is likely that businesses are more aware of and sensitive to the scaling down then residential consumers.

Figure 22: Historical and forecast commercial PV capacity installations by month (kW) – under 15 kW



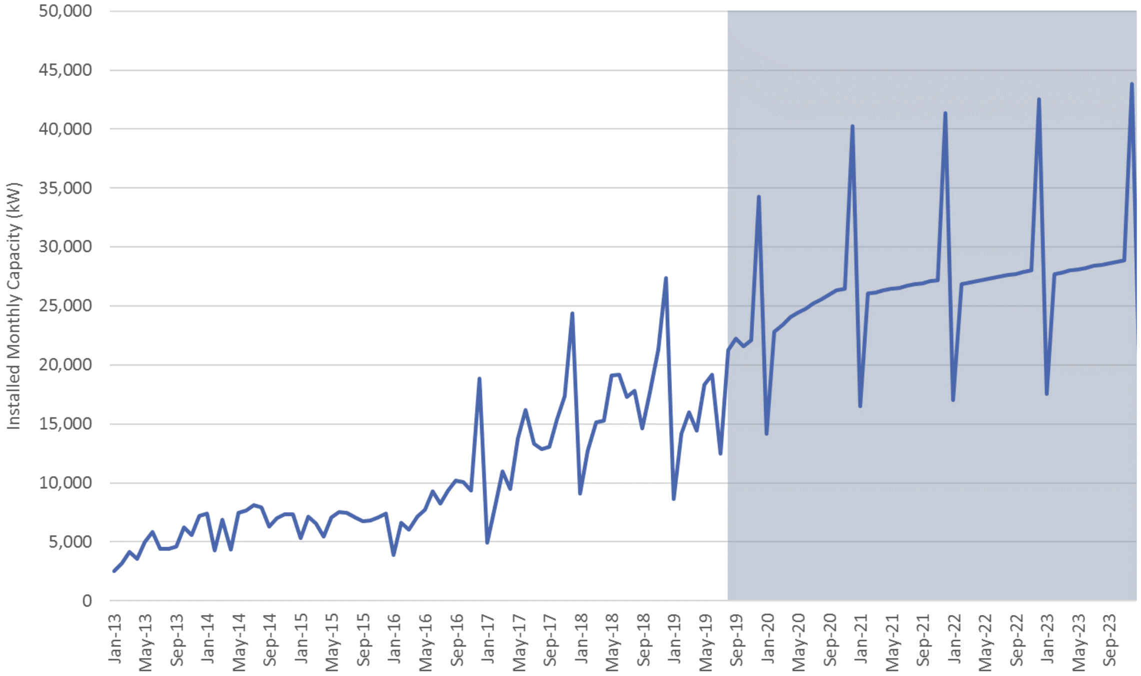
Source: Jacobs Analysis

Figure 23 includes the uptake of solar PV projections for systems between 15 kW and 90 kW, which is the largest category of systems. It shows an even more pronounced seasonal uptake pattern.

The final commercial category includes 90 kW up to and including 100 kW commercial solar PV systems and is displayed in Figure 24. There is a similar seasonal pattern observable as 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.

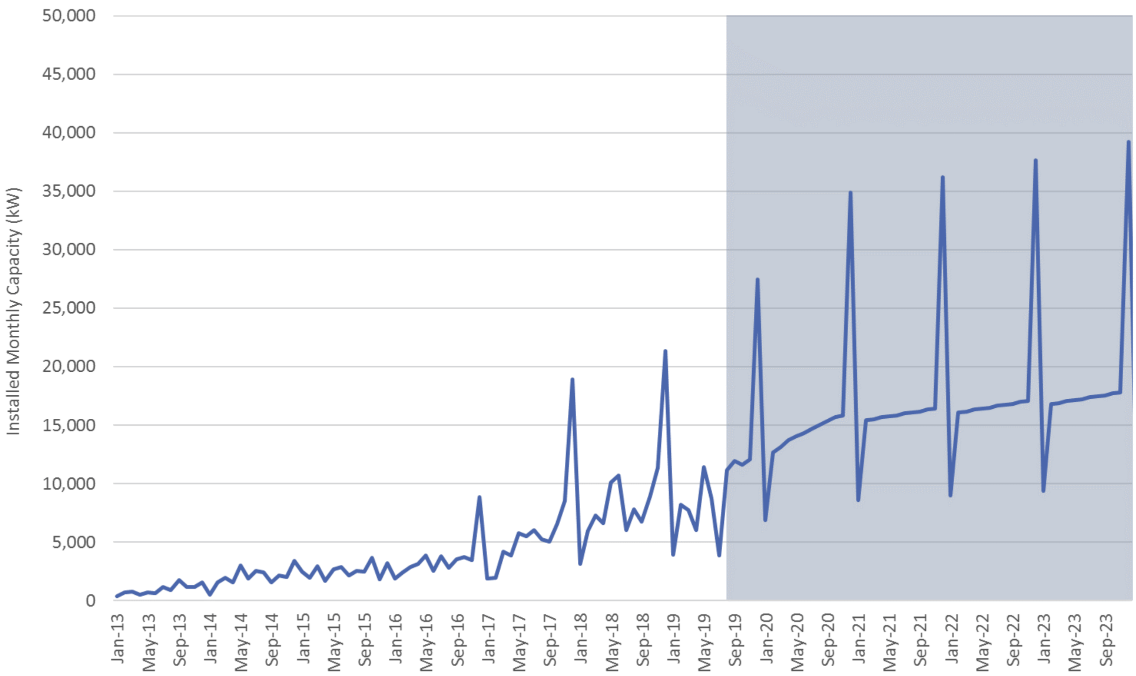
All system sizes above 15 kW show increasing uptake until the end of the projection period, this indicates that larger size systems are becoming more popular for commercial consumers.

Figure 23: Historical and forecast commercial PV capacity installations by month (kW) – 15 kW to 90 kW



Source: Jacobs Analysis

Figure 24: Historical and forecast commercial PV capacity installations by month (kW) – 90 kW to 100 kW

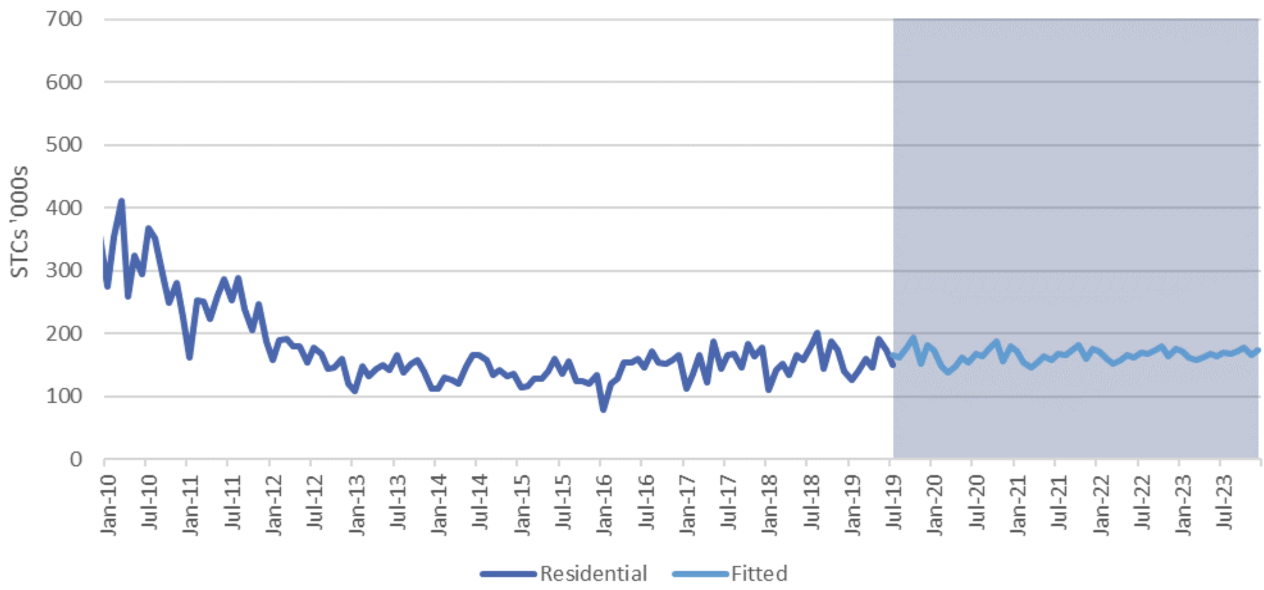


Source: Jacobs Analysis

6.3 SHW systems

Figure 25 shows the historical actual, fitted 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 housing market.

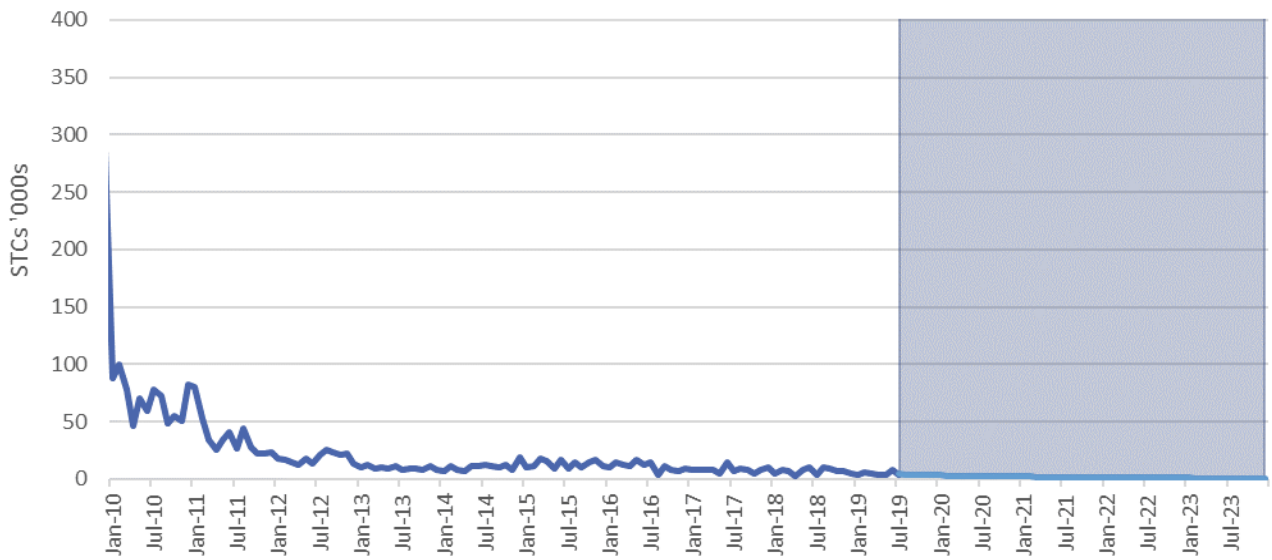
Figure 25: Residential SHW STC creation



Source: Jacobs' analysis

Figure 26 shows the historical actual, fitted 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 small-scale 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 such systems begin to far out-weigh the economic benefit that solar hot water heaters would bring on competing roof space.

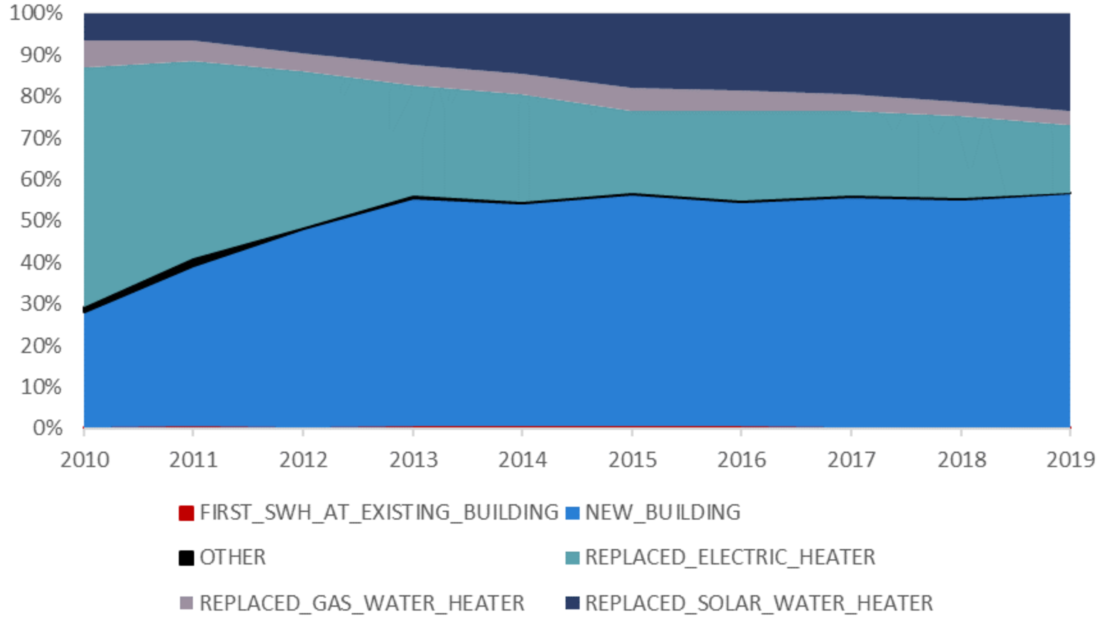
Figure 26: Commercial SHW STC creation, historical and forecast



Source: Jacobs' analysis

Figure 27 shows the proportion of STCs created for hot water systems by the reason for installation. The market is dominated by installations at new buildings, reflecting the regulations on energy efficiency in new homes, with around 55% of the STCs created from solar water heaters are due to installations in new buildings. Replacement of solar systems is the next most dominant category followed by replacement of electric solar hot water systems. This is further evidence that the uptake of solar hot water systems is driven more by building regulations or the need to replace a faulty system rather than necessary the economic benefits.

Figure 27: Solar water installations by category



Source: Jacobs' analysis of CER solar water heater data

7. Results Summary

Time series projections, including our estimates of the STCs created via the South Australian Virtual Power Plant Scheme, are summarised in Table 8. These projections include STCs created through both solar PV and hot water systems (wind and hydro STCs make up a negligible portion). In 2019, we project a total of 33.23 million STCs generated despite the STC scheme entering another year of scaling down by a ratio of 1/15 or 6.7% when compared with 2018.

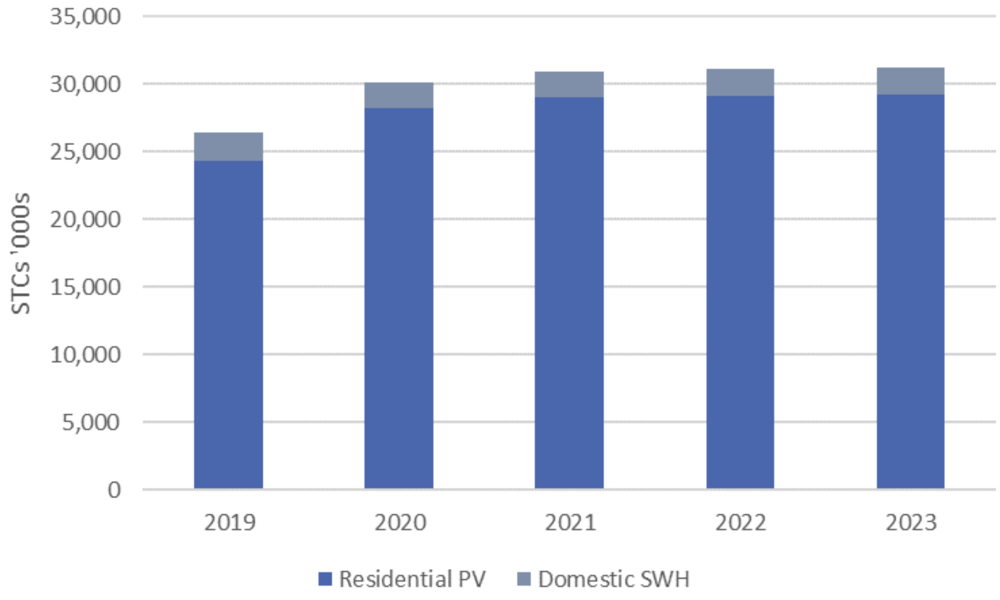
STC creation is expected to top-out in 2022 after which the downscaling is catching-up on the growth of commercial solar PV uptake.

Table 8: Summary of STC forecasts, '000s

	2019	2020	2021	2022	2023
Commercial STCs	**6,793,285**	**8,730,344**	**8,524,083**	**7,904,982**	**7,253,789**
Residential STCs	**26,436,800**	**30,180,932**	**30,963,690**	**31,156,029**	**31,244,673**
ACT	336,646	421,341	452,541	486,924	530,314
NSW	6,844,830	7,983,218	8,135,409	8,152,306	8,166,029
NT	341,968	394,447	439,649	459,939	473,866
QLD	7,004,635	7,776,730	7,871,008	7,832,344	7,797,732
SA	2,428,420	2,784,033	2,853,090	2,851,897	2,844,406
TAS	189,799	283,312	301,404	319,529	341,903
VIC	4,018,131	3,914,719	4,164,719	4,366,937	4,503,599
WA	3,154,029	3,746,438	3,928,644	3,935,023	3,906,625
VPP STCs	-	925,000	841,000	757,000	673,000
Residential Solar Hot Water	2,118,342	1,951,694	1,976,225	1,994,129	2,007,198
Commercial <15 kW	1,253,926	1,507,357	1,451,165	1,326,374	1,199,116
Commercial 15 kW-90 kW	3,532,560	4,456,176	4,328,187	4,012,126	3,678,056
Commercial 90 kW – 100 kW	1,953,589	2,736,350	2,724,898	2,553,559	2,368,196
Commercial Solar Hot Water	53,210	30,460	19,833	12,923	8,420
All STCs	**33,230,085**	**38,911,276**	**39,487,773**	**39,061,011**	**38,498,461**

Source: Jacobs' analysis

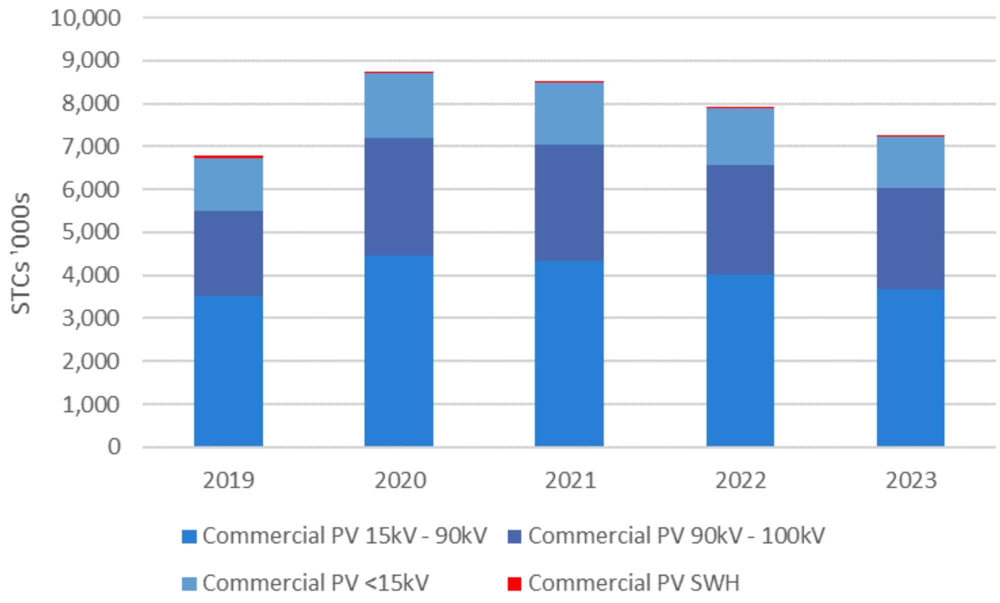
Figure 28: Summary of STC forecasts Australia, 2019 to 2023 – Residential



Source: Jacobs' analysis

Figure 28 includes the residential PV and domestic hot water STC forecasts, showing a flatting out of the numbers of STCs from 2021 onwards as a result of the scaling down. For the commercial STCs shown in Figure 29, the STC creation is expected to top-out and slowly decline from 2020 onwards as a result of scaling down.

Figure 29: Summary of STC forecasts Australia, 2019 to 2023 – Commercial



Source: Jacobs' analysis

Appendix A. Regression outputs and justification

Regression model details for large Australian states - residential

Data for Victoria, New South Wales, Western Australia, South Australia and Queensland was aggregated into a single panel to improve robustness of the model. The similarity of the behaviour of regressors allowed these states to be combined in a single panel.

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

The final variables selected for this model are:

- The natural log of the Electricity Price multiplied by the Feed-in Tariff – *log(EPRICE(-3)*FIT(-3))*

  This variable was tested applying several lags as we are expecting that residential customers have based their considerations on tariffs that are part of a fixed or variable contract with a retailer. In some cases the prices are locked-in for a longer period, while other price arrangements are more flexible. Therefore, we expect to see some lag of the impact of price and FIT levels on the uptake of rooftop PV. A three-month lag is not unreasonable as it also represents standard billing cycles in many states in Australia. As anticipated, the impact of the price on the PV uptake is positive and relatively large with a 0.24 coefficient. The latter means that any increase in price of 1 unit will change the uptake by approximately 0.24 unit.

- The natural log of The Home Loan Rate multiplied by Net Capital Cost of residential systems – *log(HL_RATE*NET_CAPITAL)*.

  The Net Capital Cost includes the benefits from direct government rebates like STCs and state uptake programs (where relevant). The Home Loan Rate is instrumental in determining the opportunity value of an investment in small-scale solar PV as the resident will have to make a decision to finance the investment (the Net Capital Cost) as part of the mortgage or using their savings. Therefore, the resident will either forgo bank interest rates or will have to pay more interest on their mortgage. It is expected that capital costs and mortgage rates, very close to the time of uptake, will have a strong negative impact on the uptake of small-scale solar PV. The model in the table below confirms this expectation, with an -0.50 significant coefficient.

- The natural log of the Gross State Product divided by the State Population – *log(GSP(-5)/POP(-5))*.

  This variable is included to provide a general regressor for the state of the economy and/or business cycle. Increasing per capita state income levels will provide the trend-based increase to the small-scale PV uptake levels. The coefficient is positive and large as anticipated because higher income levels would stimulate uptake and vice-versa, but at the same time increases in per capita income for developed countries are generally small compared to average income levels. We have found that a 5-month lagged regressor provided the best model fit. The lagged impact of GSP per capita can be related to the multiplier effect, as it generally takes a few periods before a change in state or national income level flows through into the investment and consumption levels of individuals and businesses.

- Two dummies to represent high and low outliers in the input sample – *Dummy_L1* and *Dummy_H1*.

  These dummies represent low and high outliers and any policy anomalies[8] we have identified to improve the underlying structural regression model.

- Two autoregressive terms – *AR(1)* and *AR(3)*

  Residual analysis showed first and third order serial correlation (autoregression), this indicates non-seasonal correlated error terms one (monthly) and three periods (quarterly) apart. This basically indicates that levels of uptake from the previous month and quarter are positively correlated to the uptake in the

[8] Limited policy anomalies have been picked up as a result of excluding some high impact events from pre 2013.

current period. It is very common to find first order autocorrelation in a timeseries model and not uncommon to find higher order autocorrelation in data sets with shorter time intervals (e.g. monthly, weekly).

The variables utilised and their corresponding coefficients and predictive statistics are outlined in **Table 9**.

Table 9: Panel regression model of large Australian states – residential small-scale PV uptake

Variable	Coefficient	Standard error	t-Statistic	Probability
C	32.95660	9.333841	3.530872	0.0005
LOG(EPRICE(-3)*FIT(-3))	0.241941	0.071664	3.376035	0.0008
LOG(HL_RATE*NET_CAPITAL)	-0.508534	0.117277	-4.336198	0.0000
LOG(GSP(-5)/POP(-5))	8.242845	3.518969	2.342403	0.0197
Dummy_L1	-0.404447	0.050272	-8.045140	0.0000
Dummy_H1	0.616501	0.066810	9.227612	0.0000
AR(1)	0.595056	0.052812	11.26747	0.0000
AR(3)	0.251404	0.050319	4.996231	0.0000

The equation of the regression model is:

*LOG(CAP_PV_KW) = 32.9565989192 + 0.241940522054*LOG(EPRICE(-3)*10*FIT(-3)) - 0.508534204411*LOG(HL_RATE*NET_CAPITAL) + 8.24284523166*LOG(GSP(-5)/POP(-5)) - 0.404446988585*D_L1 + 0.616500999831*D_H1 + [AR(1)=0.59505556627,AR(3)=0.251403633006]*

Regression statistics are as below:

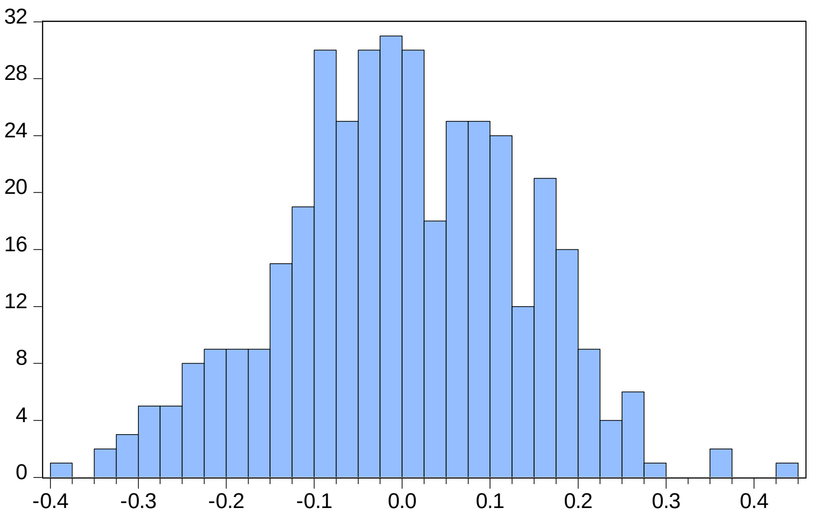
Weighted Statistics

R-squared	0.941415	Mean dependent var	9.548406
Adjusted R-squared	0.939733	S.D. dependent var	1.295578
S.E. of regression	0.137357	Sum squared resid	7.226064
F-statistic	559.5037	Durbin-Watson stat	1.985425
Prob(F-statistic)	0.000000		

The upper chart in **Figure 30** shows the fitted data against the actuals and the residuals (blue lines) for each state where 1 is NSW, 2 is Qld, 3 is SA, 4 is Victoria and 5 is Western Australia.

The lower chart displays the distribution of the standardised residuals and statistical indicators of normality, including skewness and kurtosis. The Jarque-Bera statistic indicates (based on skewness and kurtosis) whether the null-hypothesis of a normally distributed residuals can be accepted. In this case the probability is greater than zero therefore the standardised residuals are most likely normally distributed.

Figure 30 Fitted data against actuals and associated residuals (above), distribution of residuals (below)



Series: Standardized Residuals
Sample 2013M01 2019M07
Observations 395

Mean	3.53e-08
Median	-0.001410
Maximum	0.447363
Minimum	-0.390294
Std. Dev.	0.135426
Skewness	-0.071300
Kurtosis	2.920996
Jarque-Bera	0.437406
Probability	0.803560

Regression model details for small Australian states – residential

Data for Northern Territory, the Australian Capital Territory and Tasmania was aggregated into a single panel to improve robustness of the model. The similarity of the behaviour of regressors allowed these states to be combined in a panel.

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

The final variables selected for this model are:

- The natural log of the Electricity Price multiplied by the Feed-in Tariff – *log(EPRICE(-2)*FIT(-2))*

  This variable was tested applying several lags as we are expecting that residential customers have based their considerations on tariffs that are part of a fixed or variable contract with a retailer. In some cases the prices are locked-in for a longer period, while other price arrangements are more flexible. Therefore, we expect to see some lag of the impact of price and FIT levels on the uptake of rooftop PV. A two-month lag is not unreasonable as it is within one billing cycle. As anticipated, the impact of the price on the PV uptake is positive and is greater than in the large Australian states with a coefficient of approximately 0.62. The latter means that any increase in price of 1 unit will change the uptake by approximately 0.62 unit.

- The natural log of The Home Loan Rate multiplied by Net Capital Cost of residential systems – log(HL_RATE(-1)*NET_CAPITAL(-1)).

  The Net Capital Cost includes the benefits from direct government rebates like STCs and state uptake programs (where relevant). The Home Loan Rate is instrumental in determining the opportunity value of an investment in small-scale solar PV as the resident will have to make a decision to finance the investment (the Net Capital Cost) as part of the mortgage or using their savings. Therefore, the resident will either forgo bank interest rates or will have to pay more interest on their mortgage. We assume that capital costs and mortgage rates, very close to the time of uptake (in this case with a lag of just 1 month), will have a strong negative impact on the uptake of small-scale solar PV. The model in the table below confirms this expectation. With an -0.76 significant coefficient.

- The natural log of the Gross State Product divided by the State Population – log(GSP(-5)/POP(-5)).

  This variable is included to provide a general regressor for the state of the economy and/or business cycle. Increasing per capita state income levels will provide the trend-based increase to the small-scale PV uptake levels. The coefficient is positive and large as expected because we are assuming higher income levels will stimulate uptake and vice-versa, but at the same time increases in per capita income for developed countries are generally small compared to average income levels. We have found that a 5-month lagged regressor increased the model fit most significantly. The lagged impact of GSP per capita can be related to the multiplier effect, as it generally takes a few periods before a change in state or national income level flows through into the investment and consumption levels of individuals and businesses.

- Two dummies to represent high and low outliers in the input sample – Dummy_L1 and Dummy_H1.

  These dummies represent low and high outliers and any policy anomalies[9] we have identified to improve the underlying structural regression model.

- Three autoregressive terms – AR(1), AR(3) and AR(12)

  Residual analysis showed first, third and twelfth order serial correlation (autoregression), this indicates non-seasonal correlated error terms one (monthly), three (quarterly) and twelve periods (yearly) apart. This basically indicates that levels of uptake from the previous month, quarter and year are positively correlated to the uptake in the current period. It is very common to find first order autocorrelation in a timeseries model

[9]Limited policy anomalies have been picked up as a result of excluding some high impact events from pre 2013.

and not uncommon to find higher order autocorrelation in data sets with shorter time intervals (e.g. monthly, weekly).

Table 10: Panel regression model of small Australian states – residential small-scale PV uptake

Variable	Coefficient	Standard error	t-Statistic	Probability
C	40.91704	10.03636	4.076879	0.0001
LOG(EPRICE(-2)*FIT(-2))	0.619840	0.135303	4.581139	0.0000
LOG(HL_RATE(-1)*NET_CAPITAL(-1))	-0.762609	0.157190	-4.851517	0.0000
LOG(GSP(-5)/POP(-5))	13.71654	4.029734	3.403833	0.0008
Dummy_L1	-0.538616	0.096777	-5.565514	0.0000
Dummy_H1	0.584087	0.152519	3.829614	0.0002
AR(1)	0.522637	0.060129	8.691991	0.0000
AR(3)	0.155303	0.056009	2.772842	0.0061
AR(12)	0.144888	0.028968	5.001596	0.0000

The equation of the regression model is:

*LOG(CAP_PV_KW) = 40.9170438334 + 0.619839627844*LOG(EPRICE(-2)*FIT(-2)) - 0.762609376612*LOG(HL_RATE(-1)*NET_CAPITAL(-1)) + 13.7165416875*LOG(GSP(-5)/POP(-5)) - 0.538615510193*D_L1 + 0.584087316487*D_H1 + [AR(1)=0.522637036752,AR(3)=0.155302740814,AR(12)=0.144887594538]*

Regression statistics are as below:

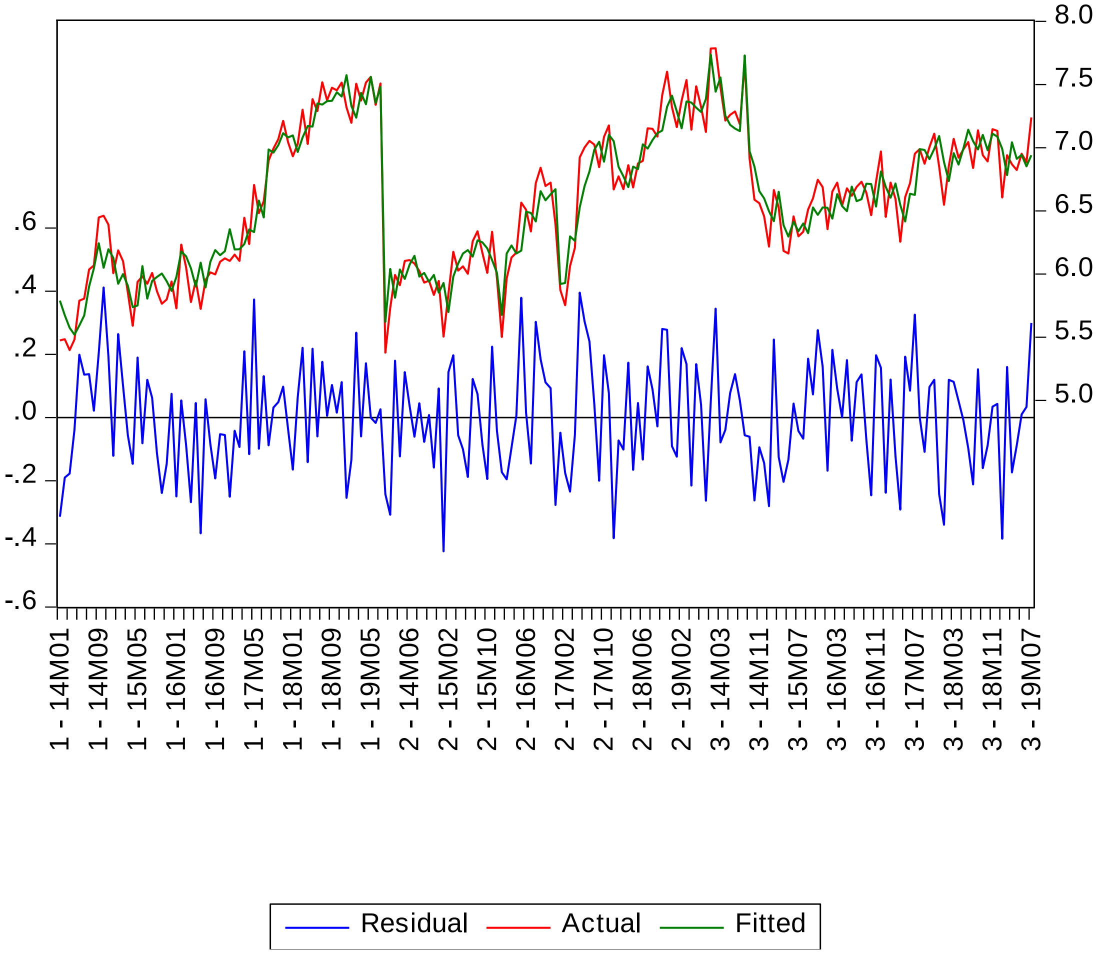
Weighted Statistics

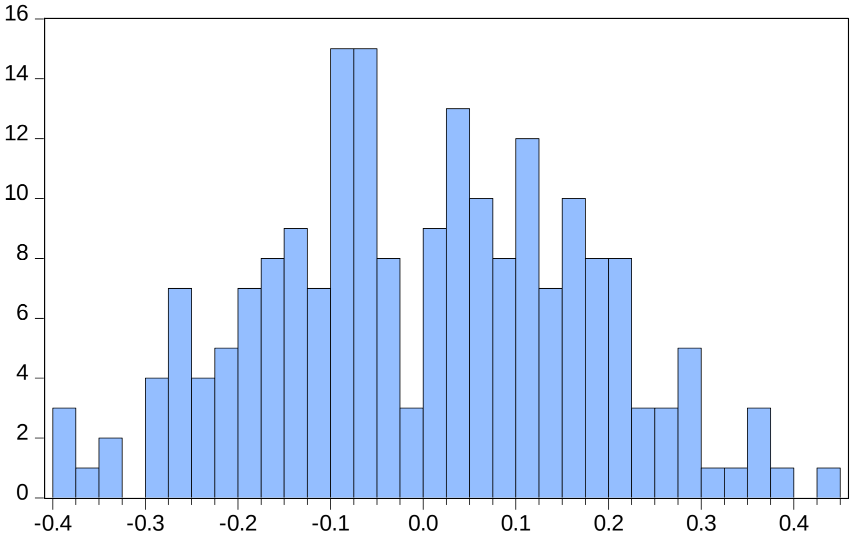
R-squared	0.908865	Mean dependent var	6.618228
Adjusted R-squared	0.904068	S.D. dependent var	0.675255
S.E. of regression	0.177755	Sum squared resid	6.003367
F-statistic	189.4815	Durbin-Watson stat	1.971916
Prob(F-statistic)	0.000000		

The upper chart in Figure 30 shows the fitted data against the actuals and the residuals (blue lines) for each state/territory where 1 is ACT, 2 is NT and 3 is Tasmania.

The lower chart displays the distribution of the standardised residuals and statistical indicators of normality including skewness and kurtosis. The Jarque-Bera statistic is greater than zero therefore the standardised residuals are most likely normally distributed.

Figure 31 Fitted data against actuals and associated residuals (above), distribution of residuals (below)





Series: Standardized Residuals
Sample 2014M01 2019M07
Observations 201

Mean	1.95e-07
Median	0.005204
Maximum	0.431789
Minimum	-0.396698
Std. Dev.	0.173254
Skewness	0.005402
Kurtosis	2.448617
Jarque-Bera	2.547169
Probability	0.279827

Regression model details for commercial uptake

Commercial systems were aggregated into a single national dataset and then split-up by system size categories for under 15 kW, between 15 kW and 90 kW and from 90 kW up to and including 100 kW systems.

A range of variables were tested. The final models were selected based on a number of parameters including goodness of fit tests (e.g. the adjusted R-squared value, AIC), residual analysis (e.g. Durbin-Watson statistic) and significance of included independent variables.

The final variables selected for these models are:

- The natural log of the Commercial Electricity Price – log(EPRICE_COM(-6))

  This variable was tested applying several lags as we are expecting that commercial customers have based their considerations on tariffs that are part of mostly fixed longer term (e.g. 1 year) contract with a retailer. Therefore, we would expect to see longer lags of the impact of price levels on the uptake of small-scale commercial rooftop PV than with residential customers. A six-month lag is not unreasonable if assumed longer terms of fixed prices for commercial customers are more common. As anticipated, the impact of the price on the commercial PV uptake is positive and large (highly elastic) with coefficients ranging from approximately 2.3 to 3.6. The latter means that any increase in price of 1 unit will change the uptake by a maximum of approximately 3.6 units. This high elasticity is as expected because commercial solar PV owners are mostly aiming to reduce their electricity costs by displacing grid purchased electricity rather than exporting to the grid.

- The Home Loan Rate multiplied by Net Capital Cost of commercial systems – HL_RATE*NET_CAPITAL.

  The Net Capital Cost includes the benefits from direct government rebates like STCs and state uptake programs (where relevant). The Home Loan Rate is instrumental in determining the opportunity value of an investment in small-scale solar PV as the business will have to make a decision to finance the investment (the Net Capital Cost) as part of a mortgage or cost of equity. Jacobs expects that capital costs and mortgage rates, very close to the time of uptake, will have a negative impact on the uptake of small-scale solar PV, albeit less strong as for residential uptake. This is because businesses will have easier access to capital and have larger returns due to the high self-usage. The model in the table below confirms this expectation.

- The natural log of the Gross State Product divided by the State Population – log(GSP(-5)/POP(-5)).

  This variable is included to provide a general regressor for the state of the economy and/or business cycle. Increasing per capita state income levels will provide the trend-based increase to the small-scale PV uptake levels. The coefficient is positive and large as expected because we are assuming higher income levels will stimulate uptake and vice-versa, but at the same time increases in per capita income for developed countries are generally small compared to average income levels. We have found that a 5-month lagged regressor increased the model fit most significantly. The lagged impact of GSP per capita can be related to the multiplier effect, as it generally takes a few periods before a change in state or national income level flows through into the investment and consumption levels of individuals and businesses.

- Several dummies to represent high and low outliers in the input sample.

  These dummies represent low and high outliers and any policy anomalies[10] we have identified to improve the underlying structural regression model.

- Residual analysis did not point to strong autoregression in these models and thus no AR terms were included. However, in the model for systems between 15 kW and 90 kW we did detect a first order moving average and included the required MA(1) regression term.

All regression model outputs for the three commercial models are included in the figures and tables below.

[10]Limited policy anomalies have been picked up as a result of excluding some high impact events from pre 2013.

Table 11: Regression model for commercial uptake – systems under 15 kW

Variable	Coefficient	Standard Eerror	t-Statistic	Probability
LOG(EPRICE_COM(-6))	2.321294	0.163356	14.21002	0.0000
HL_RATE*NET_CAPITAL	-0.000237	1.97E-05	-12.01243	0.0000
LOG(SUM_GSP(-5)/POP(-5))	1.522500	0.376333	4.045620	0.0002
Dummy_L1	-0.491658	0.042032	-11.69732	0.0000
Dummy_H1	0.262754	0.036814	7.137278	0.0000

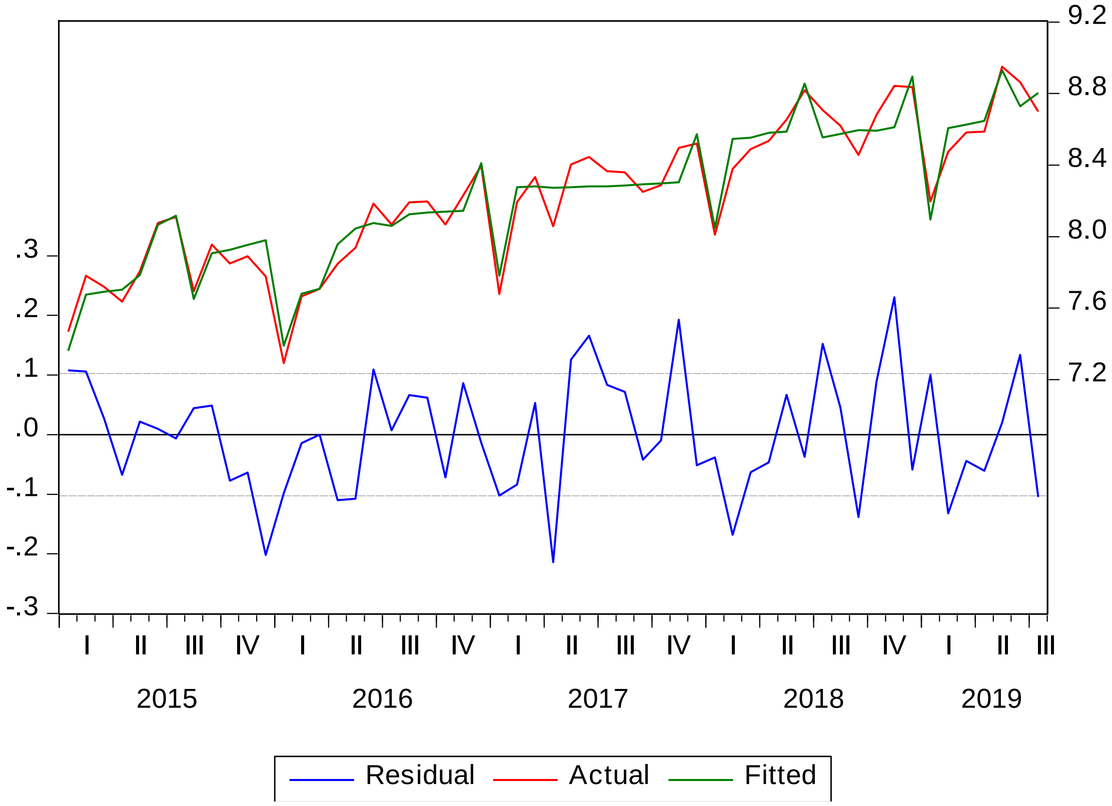
The equation of the regression model is:

*LOG(CAP_U15) = 2.32129379684*LOG(EPRICE_COM(-6)) - 0.000236545019*HL_RATE*NET_CAPITAL + 1.52250012553*LOG(SUM_GSP(-5)/POP(-5)) - 0.491657733337*D_L1 + 0.262754096671*D_H1*

Regression statistics are as below:

R-squared	0.937529	Mean dependent var	8.224096
Adjusted R-squared	0.932531	S.D. dependent var	0.395127
S.E. of regression	0.102633	Akaike info criterion	-1.628807
Sum squared resid	0.526677	Schwarz criterion	-1.446322
Log likelihood	49.79218	Hannan-Quinn criter.	-1.558238
Durbin-Watson stat	1.888227		

Figure 32 Fitted data against actuals and associated residuals (above), distribution of residuals (below) – commercial model for systems below 15 kW



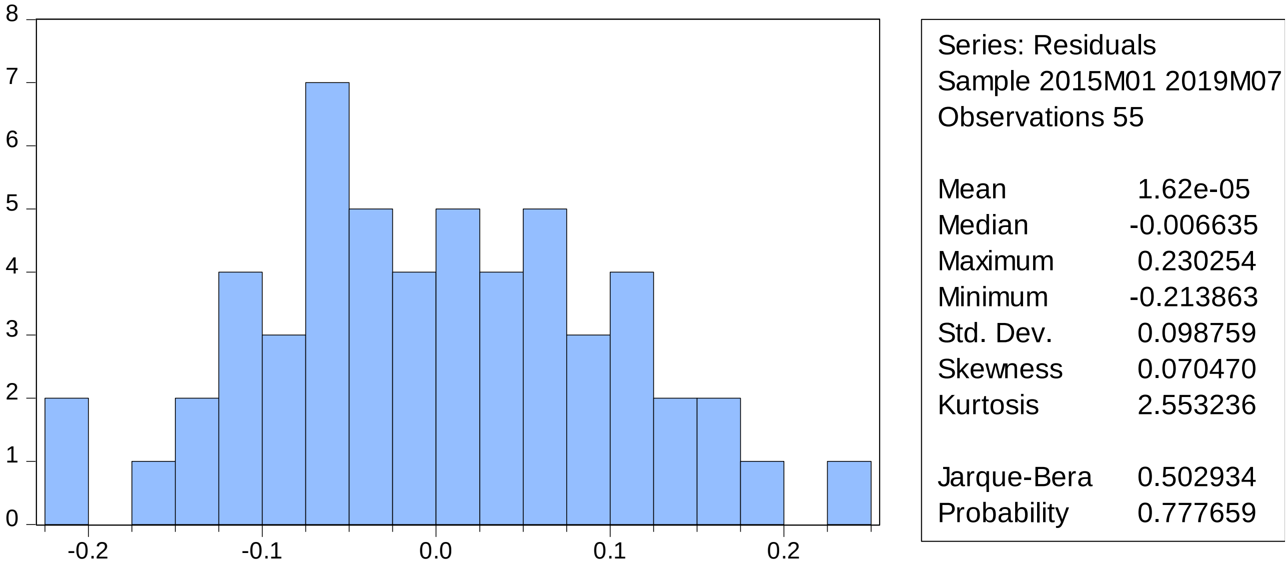


Table 12: Regression model for commercial uptake – systems between 15 kW and 90 kW

Variable	Coefficient	Standard Eerror	t-Statistic	Probability
LOG(EPRICE_COM(-6))	3.138124	0.328473	9.553676	0.0000
HL_RATE*NET_CAPITAL	-0.000210	1.10E-05	-19.03152	0.0000
LOG(SUM_GSP(-5)/POP(-5))	2.957294	0.734500	4.026268	0.0001
Dummy_L2	-0.453579	0.041930	-10.81746	0.0000
Dummy_H2	0.414467	0.056111	7.386540	0.0000
MA(1)	0.375298	0.093004	4.035271	0.0001

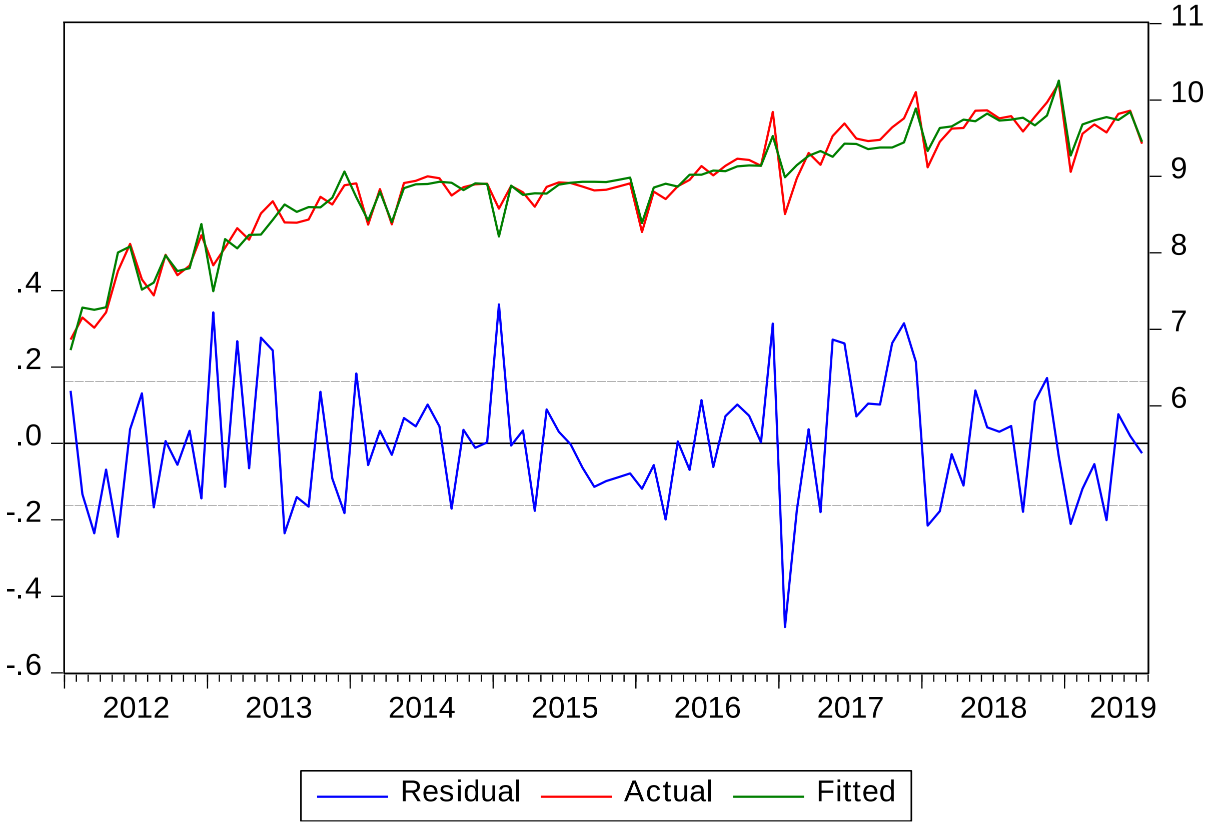
The equation of the regression model is:

*LOG(CAP_15_90) = 3.1381243039*LOG(EPRICE_COM(-6)) - 0.000210134373594*HL_RATE*NET_CAPITAL + 2.95729404866*LOG(SUM_GSP(-5)/POP(-5)) - 0.453579205234*D_L2 + 0.414466805917*D_H2 + [MA(1)=0.375297721953,UNCOND,ESTSMPL="2012M01 2019M07"]*

Regression statistics are as below:

R-squared	0.952977	Mean dependent var	8.886752
Adjusted R-squared	0.949619	S.D. dependent var	0.721567
S.E. of regression	0.161961	Akaike info criterion	-0.727447
Sum squared resid	2.203443	Schwarz criterion	-0.534304
Log likelihood	40.09883	Hannan-Quinn criter.	-0.649526
Durbin-Watson stat	1.936210		

Figure 33 Fitted data against actuals and associated residuals (above), distribution of residuals (below) – commercial systems between 15 kW and 90 kW



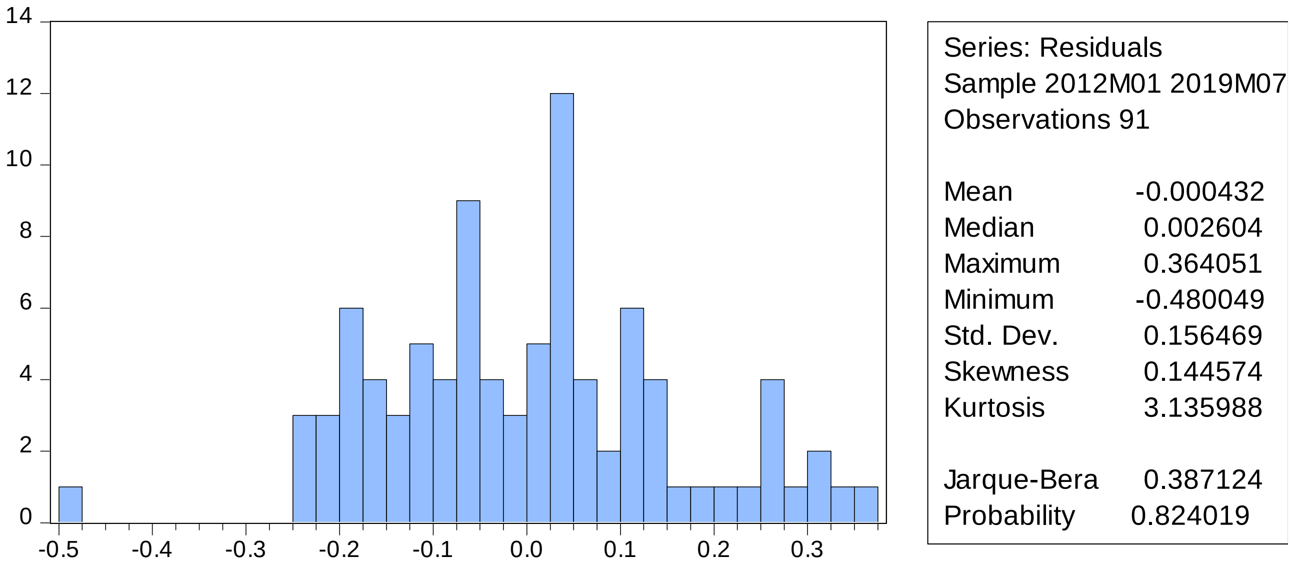


Table 13: Regression model for commercial uptake – systems from 90 kW up to and including 100 kW

Variable	Coefficient	Standard Eerror	t-Statistic	Probability
LOG(EPRICE_COM(-6))	3.574551	0.340404	10.50092	0.0000
HL_RATE*NET_CAPITAL	-0.000319	1.53E-05	-20.88037	0.0000
LOG(SUM_GSP(-5)/POP(-5))	4.051326	0.757293	5.349749	0.0000
Dummy_L3	-0.575819	0.071679	-8.033295	0.0000
Dummy_L3A	-1.398912	0.237129	-5.899381	0.0000
Dummy_H3	0.785331	0.100439	7.818964	0.0000

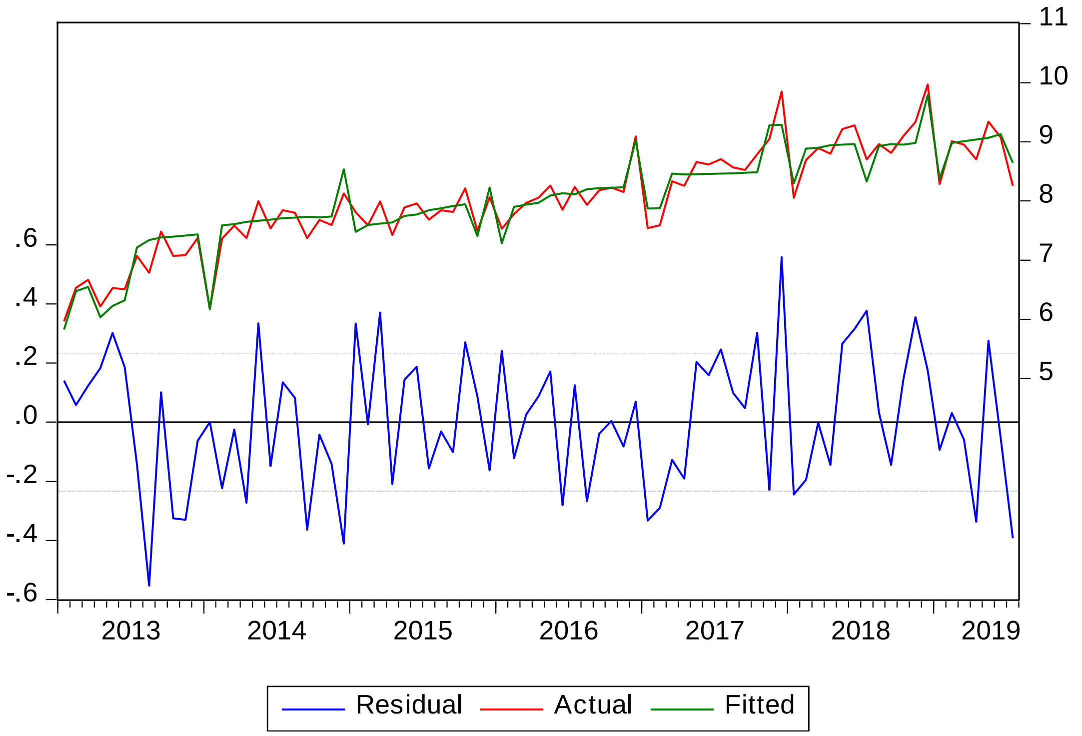
The equation of the regression model is:

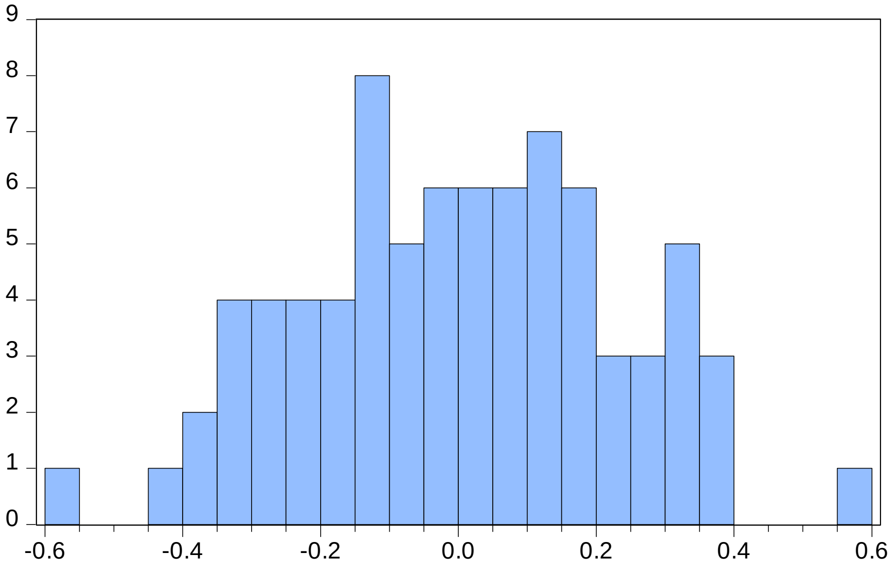
*LOG(CAP_O90) = 3.57455089003*LOG(EPRICE_COM(-6)) - 0.000318604115099*HL_RATE*NET_CAPITAL + 4.05132572557*LOG(SUM_GSP(-5)/POP(-5)) - 0.575818630861*D_L3 - 1.39891229*D_L3A + 0.785331446435*D_H3*

Regression statistics are as below:

R-squared	0.928333	Mean dependent var	8.033649
Adjusted R-squared	0.923424	S.D. dependent var	0.843238
S.E. of regression	0.233344	Akaike info criterion	0.000305
Sum squared resid	3.974812	Schwarz criterion	0.180264
Log likelihood	5.987934	Hannan-Quinn criter.	0.072402
Durbin-Watson stat	2.045153		

Figure 34 Fitted data against actuals and associated residuals (above), distribution of residuals (below) – commercial systems from 90 kW up to and including 100 kW





Series: Residuals
Sample 2013M01 2019M07
Observations 79

Mean	0.000153
Median	-2.66e-15
Maximum	0.558805
Minimum	-0.552832
Std. Dev.	0.225741
Skewness	-0.041281
Kurtosis	2.453375
Jarque-Bera	1.005983
Probability	0.604719

Appendix B. Historical Feed-in-Tariff assumptions

Table 14 Detailed historical feed-in tariff assumptions

State/Territory	Historical Feed-In Tariffs and Schemes	Jacobs assumptions (c/kWh)
Victoria	The Victorian Government introduced a premium feed-in tariff of 60 c/kWh in 2009 and closed it to new applicants at the end of 2011. The transitional feed-in tariff was then introduced at a rate of 25 c/kWh until the end of 2012. The Essential Services Commission (ESC) in Victoria is required to determine the minimum electricity feed-in tariff that is paid to small renewable energy generators. In 2013 this was set to be 8 c/kWh, 6.2 c/kWh in 2015 and 5 c/kWh in 2016, 11.3 c/kWh in July 2017. As of 1 July 2018, a mandatory minimum net feed-in tariff rate of 9.9 c/kWh for systems up to 100 kW in size, offered by the retailers.	1/1/2009 to 31/12/2011 60c 1/1/2012 to 31/12/2012 25c 1/1/2013 to 31/12/2014 8c 1/1/2015 to 31/12/2015 6.2c 1/1/2016 to 30/6/2017 5c 1/7/2017 to 30/6/2018 11.3c 1/7/2018 to 30/6/2019 9.9c
New South Wales	The NSW Solar Bonus scheme began in 2009 offering payment of 60 c/kWh on a gross basis, which reduced to 20 c/kWh after October 2010. This program closed to new customers in May 2011. The independent Pricing and Regulatory Tribunal's assessment for the 2013-2014 financial year is that a fair and reasonable value for net electricity exported to the grid was in the range of 6.6 to 11.2 c/kWh. IPART determined Fit for 2014-2015 net Fit be 5.3 c/kWh, 2015-2016 should be 4.4-4.8 c/kWh. In June 2016, IPART made decision for 2016-2017 should be 5.5-7.2 c/kWh. In FY2018, net FiTs offered by retailers range from 9 c/kWh to 12 c/kWh and in CY2018 average range was 13.97 c/kW.	1/1/2009 to 31/10/2010 60c 1/11/2010 to 30/4/2011 20c 1/5/2011 to 30/6/2014 6.6c 1/7/2014 to 30/6/2015 5.3c 1/7/2015 to 30/6/2016 4.4c 1/7/2016 to 30/6/2017 5.5c 1/7/2017 to 30/6/2018 11.6c 1/7/2018 to 30/6/2019 13.97c
Queensland	Queensland solar bonus scheme provided a 44c feed-in tariff for customers before 10 July 2012. This was replaced with a minimum 8c Feed-in tariff until 30 June 2014. From 1 July 2014 retailers are required to provide a feed-in tariff that represent benefit that the retailer receives in South East Queensland. The feed-in tariff provided in 2015-2016 to customers in the Essential Energy network was 6.348 c/kWh. In 2017 – 2019 net FiTs offered by retailers for SE Queensland ranged from 7 c/kWh to 16 c/kWh. Mandatory minimum of 10.1 c/kWh for regional customers.	1/1/2011 to 30/6/2012 44c 1/7/2012 to 30/6/2014 8c 1/7/2014 to 30/6/2017 6.348c 1/7/2017 to 30/6/2018 10.6c 1/7/2018 to 30/6/2019 10.9c
Northern Territory	Net 1-for-1 FiT, where consumer is paid for all electricity exported to grid at their consumption tariff.	Retail rate
Australian Capital Territory	In July 2008 the feed-in tariff was 50.05 c/kWh for systems up to 10 kW in capacity for 20 years and 45.7 c/kWh for systems up to 30 kW in capacity. The feed-in tariff scheme closed on 13 July 2011.	1/1/2011 to 30/6/2011 50.05c 1/7/2011 to 30/6/2013 retail rate 1/7/2013 to 30/6/2017 6c

State/Territory	Historical Feed-In Tariffs and Schemes	Jacobs assumptions (c/kWh)
	One for one Feed in Tariff for applications submitted prior to June 30 2013. From July 2011 to June 2017, Feed-in tariff assumed to range between 6 and 7.5 c/kWh for systems up to 10 kW in capacity. No mandatory retailer contribution. Net FiTs offered by retailers range from 9 c/kWh to 17 c/kWh.	1/7/2017 to 30/6/2018 11.0c 1/7/2018 to 30/6/2019 9.8c
Western Australia	On August 1 2010, the net feed-in tariff offered by the state government was 40 c/kWh, while Synergy offered 7 c/kWh via the Renewable Buyback Scheme. Customers were eligible for both incentives. On August 1 2011, the government suspended all new applications. From July 2012, a minimum buyback rate of 10 c/kWh and applied to Horizon customers. No mandatory retailer contribution. Regional areas of WA who have Horizon have two 2 Solar Buyback Schemes in place with varied rates from 7.135 c/kWh to 50 c/kWh – depending on location.	1/1/2011 to 30/6/2011 40c 1/7/2011 to 31/7/2011 20c 1/8/2011 to 30/6/2014 8.0c 1/7/2014 to 30/6/2015 8.9c 1/7/2015 to 30/6/2019 7.135c
South Australia	In July 2008 the South Australian government introduced a feed-in tariff scheme providing 44 c/kWh for 20 years. In 2011 this rate was reduced to 16 c/kWh. This scheme was closed to new customers in September 2013. For the remainder of 2013, the minimum retailer tariff set by the SA regulator (Essential Service Commission of South Australia) was 9.8 c/kWh. For the first half of 2014, this rate reduced to 7.6 c/kWh. From 1 of July 2014, a minimum of 6.0 c/kWh was set, from January 2015 this was reduced to 5.3 c/kWh and in 2016 set to 6.8 c/kWh. As of 1 of January 2017 no minimum amount has been set. Net Feed-in tariffs in 2017 to 2018 from retailers ranged from 7 c to 22 c/kWh. No mandatory retailer contribution. Net FiT offered by retailers range from 7 c/kWh to 22 c/kWh.	1/7/2013 to 31/12/2013 9.8c 1/1/2014 to 20/6/2014 7.6c 1/7/2014 to 31/12/2014 6.0c 1/1/2015 to 31/12/2015 5.3c 1/1/2016 to 31/12/2016 6.8c 1/1/2017 to 30/6/2017 7.6c 1/7/2017 to 30/6/2018 15c 1/7/2018 to 30/6/2019 15.3c
Tasmania	Aurora offered a feed-in tariff one for one (27.785) at regulated electricity tariff for residential customers. This closed in August 2013 and was replaced with transitional feed-in tariff of 20 c/kWh. Tasmanian regulator stipulated smaller rates which were 8.282 c/kWh for first half of 2014, then 5.551 c/kWh for FY2015 and 5.5 c/kWh for FY2016. From July 2016, the rate was 6.671 c/kWh. For FY2018 solar buyback available through Aurora Energy of 8.9 c/kWh for systems up to 10 kW.	1/1/2011 to 30/8/2013 27.785c 1/9/2013 to 31/12/2013 20c 1/1/2014 to 30/6/2014 8.282c 1/7/2014 to 30/6/2015 5.551c 1/7/2015 to 30/6/2016 5.5c 1/7/2016 to 30/6/2017 6.671c 1/7/2017 to 30/6/2018 8.9c 1/7/2018 to 30/6/2019 8.5c

Sources: https://www.treasury.wa.gov.au/uploadedFiles/Site-content/Public_Utilities_Office/Solar_PV/Feed-in-Tariff-Frequently-Asked-Questions.pdf; https://www.energymatters.com.au/rebates-incentives/feedintariff/; https://wattever.com.au/retailer-solar-feed-in-tariffs-by-state-and-territory/; https://www.solarquotes.com.au/systems/feed-in-tariffs/wa/

Appendix C. Electricity Pricing Model

Jacobs has prepared our retail price projections using a bottom up approach identical to the approach we provided for AEMO in 2017 (Jacobs-Retail-electricity-price-history-and-projections_Final-Public-Report-June-2017.pdf).

This approach involves developing projections for each cost component that retailers face. These include network charges, wholesale charges, environmental scheme costs, market operator charges and retailer charges and margins.

The wholesale prices were developed using Jacobs' market modelling tools which combine the use of Strategist software integrated with Jacobs' databases and models collected over the last 3 decades.

The market forecasts account for regional demand forecasts, generating plant performance, timing of new generation including embedded generation, existing interconnection limits, and the potential for interconnection development. Jacobs used its Strategist and REMMA models to develop long-term time weighted prices to the year 2050. Strategist is a model of the NEM and the WEM, whilst REMMA models the details of the renewable energy market subject to the Large-scale Renewable Energy Target (LRET).

The dynamic programming method in Strategist selects new capacity on a least-cost basis. In Jacobs' experience the model is generally accurate in the prediction of the future generation mix, with the main deviations from predicted investment the result of:

- Economies of scale.
- Pre-emptive new entry.
- Fuel supply arrangements.
- Interconnection upgrades are included in the Strategist modelling as development options in competition with new generation capacity.

Future wholesale electricity prices and related market outcomes are essentially driven by the supply and demand balance, with long-term prices being effectively capped near the cost of new entry on the assumption that prices above this level provide economic signals for new generation to enter the market. Consequently, assumptions on the fuel costs, unit efficiencies, and capital costs of new plant and emissions intensity threshold will have a noticeable impact on long-term price forecasts. Year-to-year prices will deviate from the new entry cost level based on the timing of new entry. In periods when new entry is not required, the market prices reflect the cost of generation to meet regional loads, and the bidding behaviour of the market participants as affected by market power.

Key assumptions used in the modelling include:

- Capacity is installed to meet the target reserve margin for the NEM in each region. Some of this peaking capacity may represent demand side response rather than physical generation assets. It is assumed that this is already included in the demand forecasts provided by AEMO.
- Wind generation is based on observed wind power generation profiles for each region.
- Generators behaving rationally, with uneconomic capacity withdrawn from the market and bidding strategies limited by the cost of new entry. This is a conservative assumption as there have been periods when prices have exceeded new entry costs when averaged over 12 months.
- Infrequently used peaking resources are bid near Market Price Cap or removed from the simulation to represent strategic bidding of these resources when demand is moderate or low. Torrens Island A capacity is an example when some plant is never indicated to be required for median peak demand.
- The LRET target is for 33,000 GWh of renewable generation by 2020.
- Additional renewable energy is included for expected GreenPower and desalination purposes.

Appendix D. References

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