Clean Energy Regulator
Stage 2: Small-scale Technology Certificate Projections

Revision no: 3

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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 programs, including the Renewable Energy Target (RET). One of its functions is to administer the Small-scale Renewable Energy Scheme (SRES).

The SRES creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems to reduce emissions of greenhouse gases in the electricity sector and ensure that renewable energy sources are ecologically sustainable. It does this through the creation of small-scale technology certificates (STCs), which Renewable Energy Target (RET) liable entities have a legal obligation to buy and surrender to the CER on a quarterly basis.

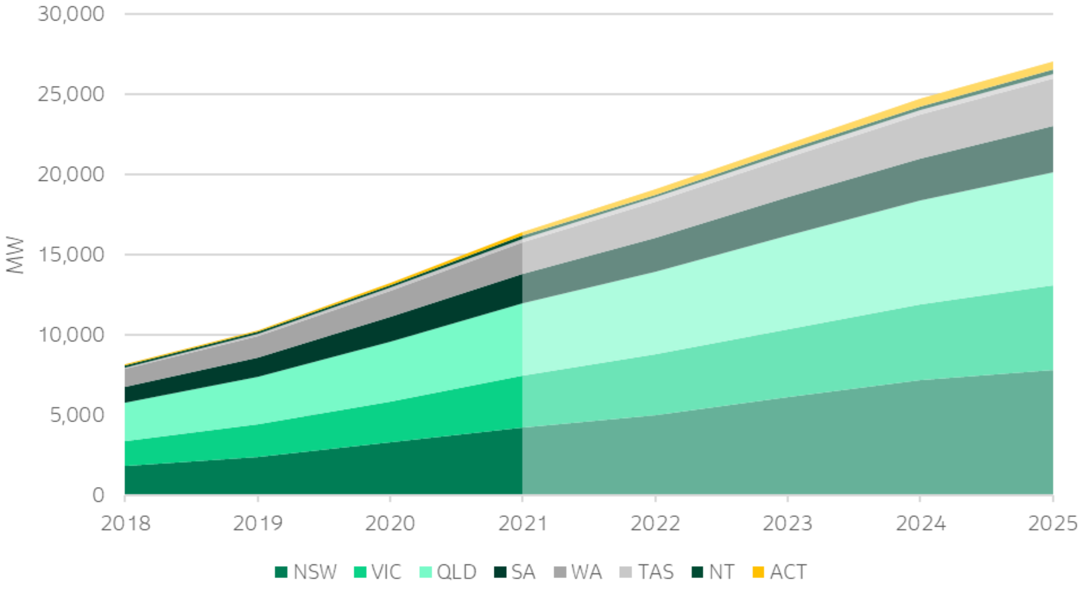
The SRES offers small-scale technology certificates (STCs) at a price of $40 per certificate through the STC clearing house to purchasers of eligible solar water heaters (SWH), air-sourced heat pumps (ASHP), and small-scale solar photovoltaic (PV), wind, and hydro systems. STCs are also traded on the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

Jacobs has been engaged by the CER to forecast the number of STCs and the installed capacity of small-scale solar PV systems in the calendar years of 2022 to 2025, inclusive. This will assist the CER to determine the number of STCs electricity retailers are obligated to surrender.

Forecasting the installation of distributed energy resources (DER) is complex, and uptake occurs at different rates in residential and commercial sectors of the market. To project the uptake of DER in both sectors, Jacobs has employed an in-house agent-based model. Agent-based modelling is a bottom-up approach that models unique agents at the micro-level to simulate customer level decision making. The agents represent Australian households and businesses that are autonomous, have internal behaviours and characteristics, and make decisions in response to exogenous and endogenous factors. To forecast the creation of STCs for SWH and ASHP Jacobs has used a time-series ARIMA model.

As illustrated in Figure 1, the projected cumulative installed rooftop PV capacity increases over the forecast period, rising from 19,068 MW at the end of 2022 to 27,009 MW at the end of 2025.

Figure 1: Small-scale PV state forecasts, cumulative installed capacity

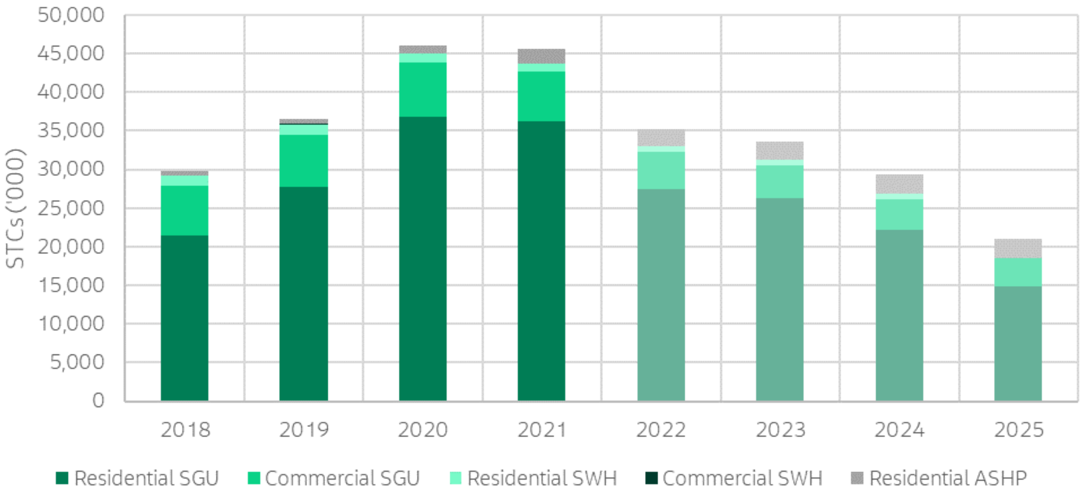


The significant growth in installed capacity that has occurred in the last few years has halted, with an estimated 28% reduction in uptake in the first half of 2022 compared with the same period in 2021, partially from stable or higher costs of solar PV systems and continued decreases in feed-in tariff (FiT) rates. Other factors that could be influencing the reduction in 2022 compared to 2021 include: a shift in household expenditure from home improvements to recreation and leisure (e.g., travel, hospitality) because of the lifting of Covid-19 pandemic restrictions; scarcity of available installers and tradespeople; and cost of living pressures limiting capital spend. However, in the second half of 2022, small-scale solar installations rebounded in response to rising electricity prices.

In 2023, annual uptake is expected to rebound to recent highs, with 2,839 MW and 2,789 MW of small-scall PV capacity expected to be installed across Australia in 2023 and 2024, respectively. This trend varies across states but is driven mostly by the expected rise in retail electricity prices, which has a delayed correlation to wholesale electricity prices. Wholesale prices are forecast to remain at high levels due to continued high international coal and gas prices and an increasing number of unplanned coal outages that force more expensive generation (i.e., gas peakers) to be dispatched more frequently.

Figure 2 illustrates the STC creation projections by sector, including STCs created from installations of solar PV and hot water systems (wind and hydro STCs make up a negligible portion). In 2023, it's projected that a total of 33.7 million STCs will be created, which despite having an increase in SGU capacity, is less than 2022 due to the scheme's deeming period declining by another year, compared to the previous year.

Figure 2: Total STC annual projections



Overall trends in STC forecasts are largely linked to residential rooftop PV installations, which comprise the largest portion of STCs created. Commercially sized solar hot water units are expected to maintain their relatively low level of uptake with little influence on STC creation over the forecasting period. It is expected that domestic solar hot water systems will continue modest negative growth. However, the recent climb in uptake of air-sourced heat pumps is expected to continue for the remainder of the forecast horizon.

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Tables and figures

Acronyms and abbreviations

ABS	Australian Bureau of Statistics
ABM	Agent based model
ACT	Australian Capital Territory
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ASHP	Air-sourced heat pump
BESS	Battery energy storage systems
CER	Clean Energy Regulator
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DER	Distributed energy resources
DLF	Distribution loss factor
ESC	Essential Services Commission (Victoria)
ERA	Economic Regulation Authority (Western Australia)
FiT	Feed-in tariff
FY	Financial year
IPART	Independent Pricing and Regulatory Tribunal
kW	Kilowatt
kWh	Kilowatt-hour
LRET	Large scale renewable energy target
LV	Low voltage
MW	Megawatt
MWh	Megawatt-hour
NEM	National Electricity Market
NSW	New South Wales
NT	Northern Territory
OTTER	Office of the Tasmanian Economic Regulator
PA	Per annum

PV	Photo-voltaic
PWC	Power and Water Corporation
QCA	Queensland Competition Authority
QLD	Queensland
RET	Renewable energy target
SA	South Australia
SA3	Statistical Area Level 3
SGU	Solar generation unit
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale technology certificate
SWH	Solar water heaters
TAS	Tasmania
TLF	Transmission loss factor
VIC	Victoria
VPP	Virtual power plant
WA	Western Australia
WEM	Wholesale Electricity Market

1. Introduction

The Clean Energy Regulator (CER) is responsible for administering legislation that reduces greenhouse gas emissions and increases the use of renewable energy. One of its functions is to administer the Small-scale Renewable Energy Scheme (SRES). The SRES is designed to achieve the following objectives:

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

The SRES creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems such as solar panel systems, small-scale wind systems, small-scale hydro systems, solar water heaters and air source heat pumps. It does this through the creation of small-scale technology certificates (STCs), which Renewable Energy Target (RET) liable entities have a legal obligation to buy and surrender to the CER on a quarterly basis.

The SRES offers small-scale technology certificates (STCs) at a fixed price of $40 per certificate through the STC clearing house to installers of eligible solar water heaters (SWH), air-sourced heat pumps (ASHP), and small-scale solar photovoltaic (PV), wind, and hydro-electric systems. STCs are also traded on the open market, usually at a discount to the clearing house price.

There is no cap on the number of STCs that can be created. STC creation is based on an estimate of the amount of electricity that will be generated or displaced by the renewable energy sources over their economic lifetime. Because of this, the number of STCs created is influenced by the geographical location of the asset.

Up until 2017, each installed system could create certificates equivalent to 15 years of expected generation from the system for small generating units and equivalent to 10 years for a renewable water heater. From 2017, the number of STCs generated per unit is one year less than the previous years, with the intention being that the scheme tapers off in a gradual linear manner.

The purpose of this report is to provide forecasts of the number of STCs that will be generated in the calendar years 2022 to 2025, inclusive. This will assist entities that are liable to surrender certificates to anticipate the extent of their upcoming liability. In developing this report, Jacobs has executed following tasks:

- Modelled expected small-scale technology installations (≤100 kW) and provided updated SRES forecasts for 2022-2025, inclusive, comprising projections of the number of STCs and installed solar PV capacity for 2022 and the three compliance years of 2023 to 2025.
- Identified key factors affecting the type, number, and size of small-scale system installations and the trends in STC creation for various categories of systems, including residential and commercial uptake across Australian states and territories.
- Reviewed and updated previously developed models and methodologies to improve the accuracy of projections. Jacobs has identified and analysed changes to circumstances and trend breaks, and/or including alternative estimators. In addition, Jacobs has introduced a new modelling approach founded on agent-based modelling, designed to better capture the impact of structural changes in the STC market.

To assist the forecasting, historical data on the number of STCs created and registered from April 2001 to October 2022, including the type and location of units installed, were supplied by the CER. All analysis and forecasts in this study are based on STCs created in the month of installation (including an estimate of additional STCs for that month to be created over the next 12 months), and STCs are only considered if they have passed validation. This report commences in Section 2 with an analysis of trends in the uptake of small-scale systems, followed in Section 3 by a description of current government incentives and solar PV policies. Section 4 describes the method of forecasting STCs, and the assumptions used are described in Section 5. Section 6 presents the results.

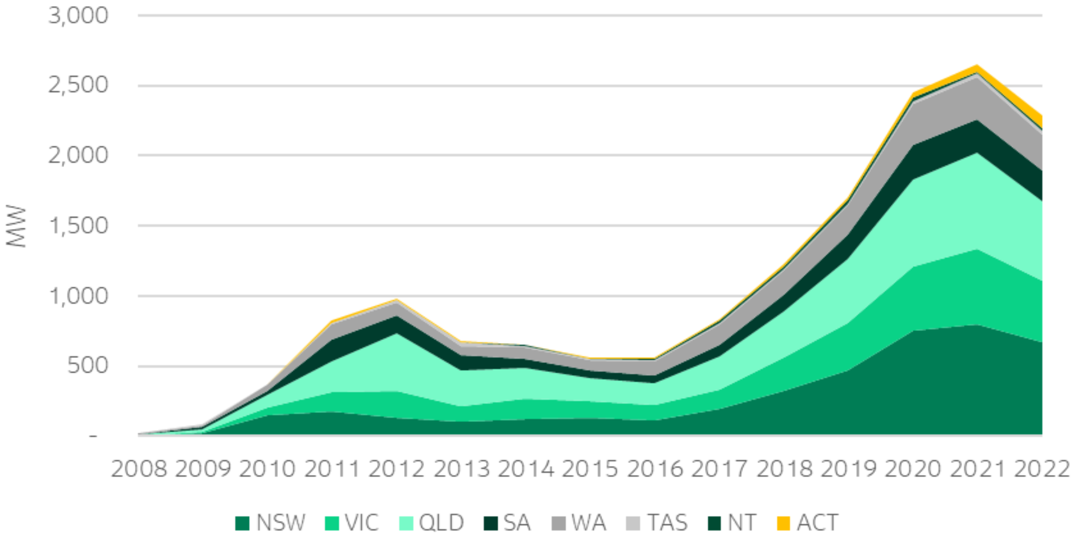
2. Trends in uptake

This section provides commentary on trends in the uptake of small-scale PV systems, which comprise the main element of STC creation.

2.1 Small-scale PV Systems

Figure 3 illustrates historical annual installed capacity of residential rooftop PV from (calendar year) 2008 to 2022, inclusive.

Figure 3: Installed residential capacity



Source: Jacobs' analysis of CER data, 2022 estimate

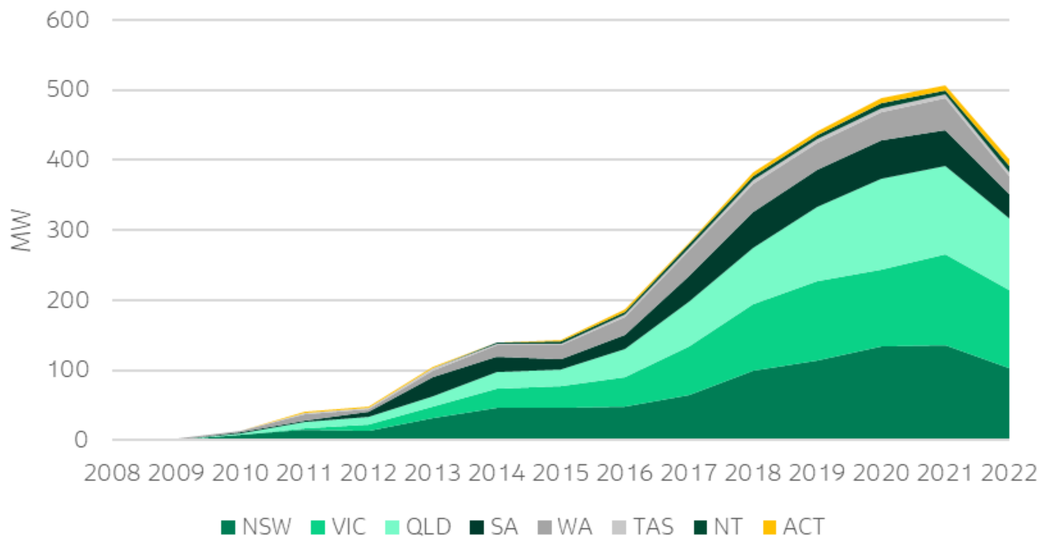
For the six years from 2016 to 2021, there has been an increase each year in annual small-scale PV uptake, including over 2020-2021, defying disruptions from the COVID-19 pandemic. However, based on data from the first 10 months of 2022, this year is estimated to be the first in recent times to see a reduction in installed PV capacity. This is likely the result of a range of factors, some of which are expected to be temporary, including:

- The stagnation of capital cost decline.
- Lower FiT rates.
- A shift in household expenditure from home improvements to recreation and leisure as a result of the lifting of Covid-19 pandemic restrictions.
- Higher than average and persistent wet weather.
- Increased consumer uncertainty and cost of living pressures.
- Scarcity of available installers and tradespeople due to work restrictions and supply chain constraints.

Figure 4 illustrates the recent trends in installed PV capacity by schools and businesses. As with residential installations, strong growth in uptake has occurred since 2016. A distinct seasonal trend has emerged as businesses hasten to commit to installations prior to annual steps down in rebates applied to small scale technology. The COVID-19 pandemic also appeared not to affect the trend in commercial PV installations, despite the temporary closure of many small-medium sized enterprises (SMEs). This may be attributable to government incentives that promote solar PV installations (such as the instant tax write-off) and growth in

SME’s that have benefitted from COVID-19 lock downs, such as data centres and online retailers. However, as with the residential data, there are indications of a strong slowdown in the rate of growth of commercial solar installations in 2022 for similar reasons to those described above.

Figure 4: Annual installed commercial capacity

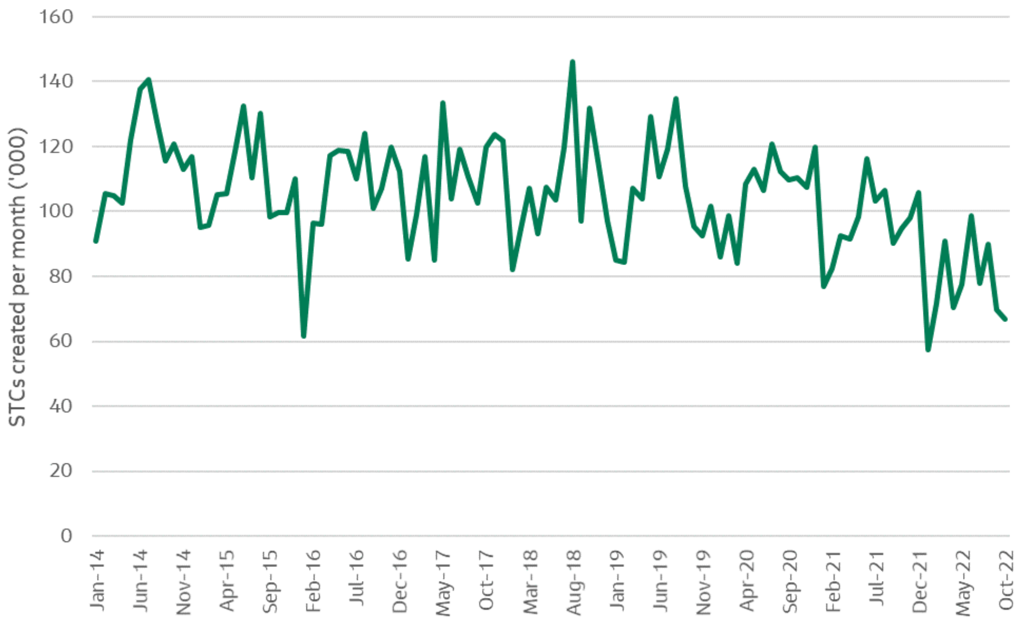


Source: Jacobs’ analysis of CER data, 2022 estimate

2.2 Solar water heaters

Figure 5 shows the historical trend in the creation of STCs from installations of residential SWH from January 2014 to October 2022. There is a mild decline evident over the last seven years, punctuated by some pauses. COVID-19 appears to have had a mildly negative impact on the sector, although the decline for 2020 coincides with the acceleration of ASHP (see section 2.3).

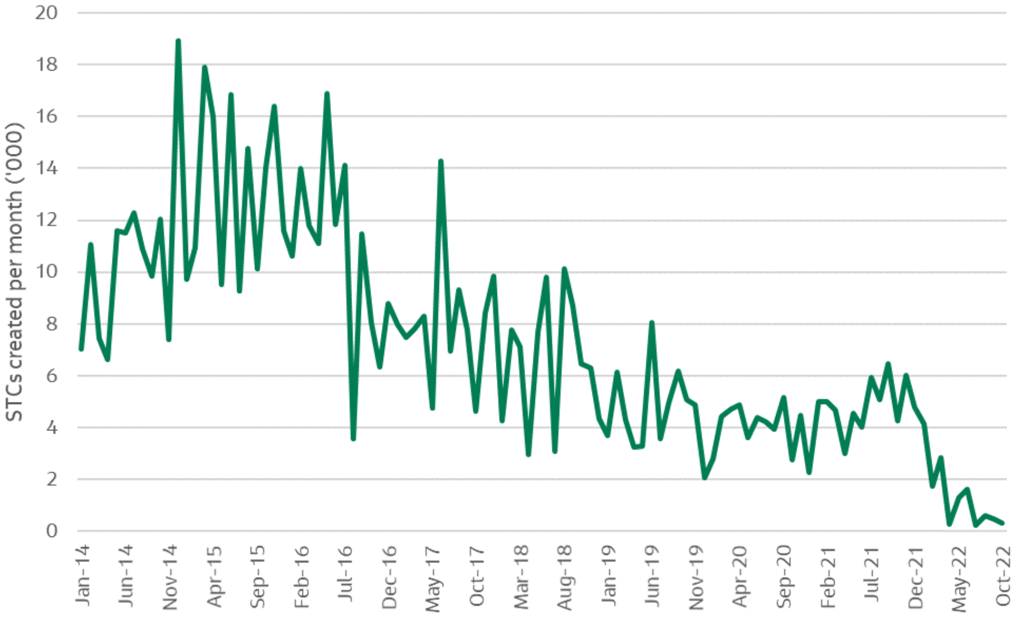
Figure 5: Monthly trend in STC creation from residential SHW



Source: Jacobs’ analysis of CER data

STC creation from commercially sized units continues to decline with a decrease of 29% in 2019 and a 14% reduction in 2020, as can be seen in Figure 6. Monthly STCs dropped to a 20-year low in July 2022, most likely due to the factors affecting solar PV installations, particularly those relating to capital cost and availability of installers. In addition, business expenditure for 2022 may have likely been brought forward to 2021, as well as ASHP also gaining popularity within the commercial sector.

Figure 6: Monthly trend in STC creation from commercial SHW



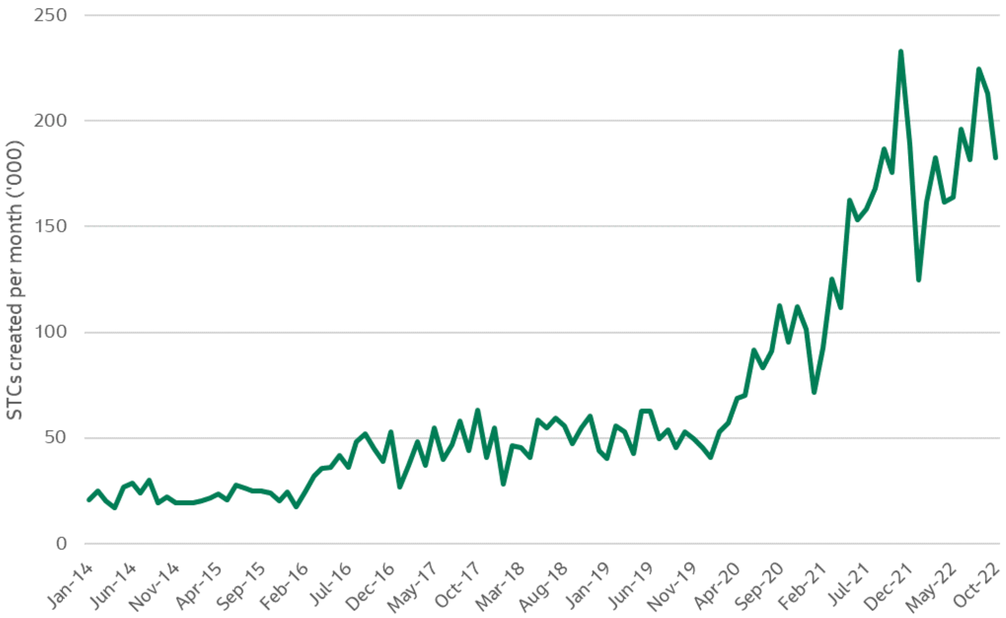
Source: Jacobs' analysis of CER data

2.3 Air-sourced heat pumps

Historically, there was a brief period around 2011 when ASHPs were installed at commercial sites. However, no such units have been awarded STCs since 2013 and all units generating STCs presently are exclusive to the residential sector. Therefore, commercial installations of ASHPs have not been forecast.

Figure 7 shows the monthly trend in uptake of residential ASHP. Uptake has been trending up since 2014, but a rapid acceleration has occurred since mid-2020, initially due to funds diverted to equipment spend during the wider outbreak of COVID-19 and periods of lock down and additional incentives for uptake provided by state governments.

Figure 7: Monthly trend in STC creation from residential ASHP



Source: Jacobs' analysis of CER data

The uptake of ASHP has continued to accelerate throughout 2021 and 2022, with November 2021 being the highest month on record for STC creation from this technology.

Drivers for the uptake of ASHP appear to be:

- A growing acceptance of electric based ASHP, particularly in new housing estates.
- Additional support from some state governments.
- The fact that they do not take up roof space, allowing households to install both solar panels and low emission water heaters. This fits in with the trend towards larger PV sizes, allowing households to reserve roof space for solar panels.

3. Government incentives and policies

The number of STCs generated is dependent on uptake of eligible technologies by households and businesses, which is in turn influenced by financial incentives and regulations such as federal and state rebates, state-based FiT schemes, and building standards. The energy efficiency building standards impact the choice of water heaters installed in new houses. The forecasts provided by Jacobs (section 6) account for government policies and programs explicitly or implicitly.

3.1 Government policies

In terms of policies, the state-wide blackout in South Australia during September 2016 resulted in the South Australian Government shifting from providing energy saving incentives based on renewable generation to ones based on energy storage, such as the residential BESS program described below in Section 3.2.2. South Australia has also given the Australian Energy Market Operator (AEMO) authority to curtail rooftop solar when necessary for system benefit. New inverter standards for new rooftop solar installations have been enforced to enable AEMO more visibility and control of rooftop systems. However, it is expected that curtailment of rooftop solar will only occur under extreme circumstances, and therefore it is likely these new rules will not have considerable impact on the uptake of PV in South Australia.

Western Australia and the Northern Territory have significantly reduced their standard FiT rates in a move to reduce incentives for exports of solar generated power from rooftop systems, due to concerns of the impact of high PV penetration on grid stability. This is discussed further in Section 5.2.4.

3.2 Government programs

In terms of programs, in all jurisdictions in Australia except Tasmania there is in place at least one scheme to encourage the uptake of DER including rooftop solar PV and household batteries. The state-based schemes that may influence the uptake of solar PV and hot water systems are summarised below.

3.2.1 Victoria – Solar Homes Program

In August 2018, the Victorian Labor Government announced a new solar rebate scheme for the installation of rooftop solar PV on eligible dwellings. The plan is means tested to households of income less than $180,000 and is expected to fund the installation of rooftop PV systems on 720,000 homes over a 10-year period. According to the 2016 Australian Bureau of Statistics (ABS) Census, approximately 11% of Victorian households would be ineligible for the program as their annual household income exceeds $180,000.

Since July 2021, the offer has been open to Victorian households and small businesses who may receive a rebate to cover half the cost of a solar PV system up to a maximum of $1,400 for households and $3,500 for small businesses. Since July 2019, eligible Victorian residents have also been able to receive an interest free loan for a period of four years to finance the remainder of the cost of installation up to the value of their rebate. Rebates of up to $2,950 and $1,000 are also being offered to install a solar-battery system or SWH unit, respectively, in eligible dwellings that have not previously received a Solar Homes rebate.

In addition, the Victorian Government has pledged to support uptake of rooftop 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. As of August 2022, the rebate is of $1,400 value.

3.2.2 South Australia – Home Battery Scheme

The South Australian Home Battery Scheme, introduced in 2018, comprised up to $100 million in government subsidies available for 40,000 homes for the installation of a BESS. Participating households were eligible to apply for finance to the Clean Energy Finance Corporation.

The battery subsidy was based on the size of the battery and was set at $300 per kWh storage for energy concession holders and $200 per kWh for all other households, with a maximum of $3,000 provided per battery installation. Strict specifications were required to ensure the batteries could also be aggregated to a Virtual Power Plant (VPP), although the participating household could choose whether to operate their battery as part of this system. The subsidy was open to households from October 2018 but was closed for applications in June 2022 due to low participation.

While the batteries themselves do not contribute to STC creation, they increase the benefit to households of load shifting and may encourage the installation of rooftop PV and battery packages.

3.2.3 New South Wales – residential solar and battery incentive schemes

In September 2018, the New South Wales 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 'living rebate' deduction off their energy bill in exchange for the installation of a 3 kW rooftop solar system. The scheme is available for up to 3,000 eligible households, with an expectation that they will be up to $600 better off per year by accepting this offer.

The New South Wales Government also announced early in 2019 interest-free loans for solar batteries and solar and battery storage systems through a 10-year Empowering Homes program, commencing in the summer of 2019/20. This program intended to provide almost 300,000 homes with 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 were required to be an owner-occupier and have an annual household income of up to $180,000. However, the program was closed at the end of July 2022.

3.2.4 Australian Capital Territory – Home Energy Support program

In March 2022, the Australian Capital Territory (ACT) Government launched its Home Energy Support Program, which commits $50 million over four years. Eligible households can receive a rebate of up to $2,500 for the installation of a rooftop PV system and the option to finance the remaining costs with an interest-free loan. The second phase of the program offers an additional $2,500 rebate for heating and cooling systems, hot water heat pumps, and other energy efficiency products.

4. Methodology

Forecasting DER is complex, and its uptake occurs at different rates, in different locations, and across different customer segments. Subject to exogenous constraints such as technical limits, technology choice, and environmental and regulatory factors, DER uptake is based on a combination of economic return and non-economic behavioural factors.

Economic return depends on a range of price and cost factors such as income, underlying energy demand, electricity tariffs, and the cost of DER systems (both upfront capital and ongoing operation and maintenance), which together produce an accepted payback period for uptake.

The non-economic factors that can accelerate or decelerate an investment decision are largely behavioural and societal, such as additional value placed by an individual or a business on ‘doing the right thing’ for the environment, becoming energy independent or ‘being seen to be contributing’ to better community outcomes. In some cases, particularly for established technology, these influences are captured in historical data on decision making. In other cases, and particularly for newer technologies, these influences need to be assumed.

Overlaying this, some factors may have more permanent effects and others may be temporary or change over time. For example, the impact of COVID-19 has resulted in some persistent work-from-home trends that have the impact of increasing residential electricity use while mostly reducing commercial use. But recessionary impacts or those that relate to consumer confidence are generally temporary.

To account for all these factors, a bespoke agent-based model was employed to represent the households in each State across Australia to project their uptake of solar PV systems. However, for the projection of solar water heaters, and air-sourced heat pumps, a secondary time-series ARIMA model is utilised. Both models are partly based on expected payback periods from installing new systems, as the main driver of uptake, with the payback periods influenced by projected trends in the cost of systems, level of government subsidy and expectations around future revenue streams, namely retail and feed-in tariffs. Transient or temporary drivers observed recently are reflected in trends on installation costs (with a return to long term trends projected), and an assumption that current shortfall in labour material dissipate over a two-year period. In the ARIMA model the impact of transient factors are captured through the residuals. And to the extent these have been changing it will be observed in changes in the residuals over time.

Under the SRES scheme, small generation units cover rooftop PV, wind, and hydro systems up to 100 kW in capacity. However, small-scale wind and hydro units have historically represented a negligible proportion of STCs (less than 0.02%), so only the future uptake of rooftop PV systems are considered in this study.

4.1 Agent based modelling

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

Unlike traditional modelling approaches, agent-based modelling creates heterogeneity between agents, and may enable interaction among agents to influence behaviour and outcomes. This approach is especially suitable for modelling intricate, non-linear, and interrelated parameters in unstable and complex environments.

In the context of Australia’s energy market and rooftop PV uptake, agent-based modelling can allow agents representing Australian households, businesses, and schools, to respond to price signals, such as electricity price increases and falling technology costs, and macro-economic, technological, policy, and electricity-related variables to simulate the magnitude of DER installation over the next six years.

There are several steps to creating an agent-based model, as are described in the following sections, starting with setting up, or initialising, the agents in the model.

4.2 Agent initialisation

Agents are split into two broad groups – residential and commercial. Basic attributes are assigned to agents to proportionately reflect the real world, such as whether they are a renter or an owner-occupier. These exogenous variables are held fixed across the modelling time horizon for existing agents. However, the proportion of these variables may change over time. Therefore, new agents that are created as population grows may be assigned attributes in differing proportions to those assigned to the initial set of agents.

4.2.1 Residential agents

Residential agents are initialised with the following parameters:

- Location.
- Dwelling type (e.g., detached house, townhouse, apartment).
- Tenure type (e.g., owner-occupier, renter).
- Solar PV penetration status.

Parameters are initialised using available local information and/or ABS data and are allocated to agents based on cumulative probability distributions. Heterogenous location assignment is important because it allows agents from different regions to have different behaviours and characteristics. Within a region, it is assumed all agents share the same characteristics.

The dwelling and tenure type probability distributions are unique to each region. That is, each region has a dwelling and tenure type profile that is particular to that area.

In terms of rooftop suitability, this can be determined in different ways and depends on the circumstances of the environment being modelled. In some cases, there is publicly available satellite data to inform the proportion of rooftops and types of dwellings that have the potential to take rooftop solar panels. In most cases, an assumption is made based on which dwelling types can take solar, and upper saturation limits are applied. A common assumption is that only homeowners living in a detached dwelling (i.e., house, townhouse, or terrace) are likely to adopt a rooftop solar PV system, with renters and/or those living in apartments, flats, caravans, and so forth assumed to not purchase these systems.

To account for current penetration levels, the appropriate number of agents is assigned a rooftop PV system at the commencement of the model.

4.2.2 Commercial agents

Unlike residential households, businesses do not have the same degree of behavioural variation across regions. Rather, it is the size of a business that presents a better point of differentiation. Therefore, while commercial agents are initialised with a region in the model, they are also assigned to an 'underlying demand segment' and are assumed to make decisions relating to their size.

Within commercial agents, businesses are separated into schools, small businesses, and large businesses, depending on the availability of data. These groups of agents are modelled separately to each other because they are associated with different levels of demand, DER capacity, and retail tariffs, and sometimes subject to different regulation.

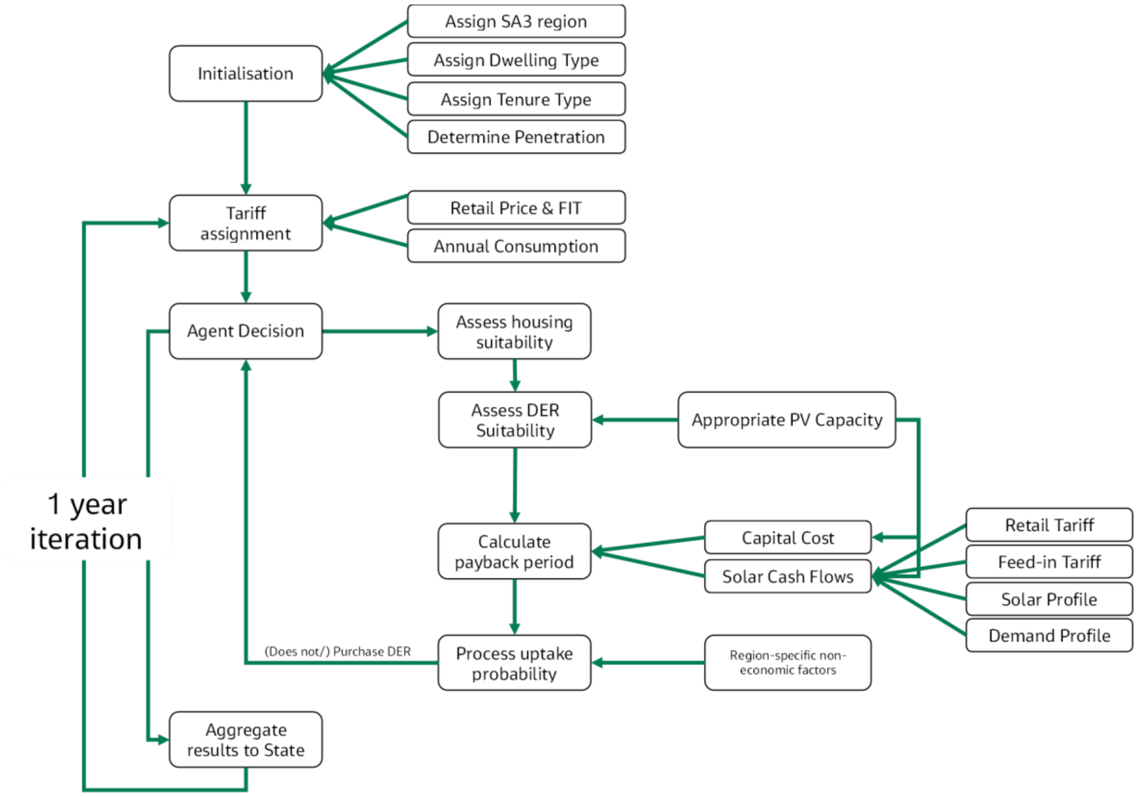
Like residential agents, the current penetration level for commercial agents is assigned at the commencement of the model based on available data.

Businesses tend to act in a more economically rational way relative to households. Therefore, it is assumed that commercial rooftop PV systems are optimised to their electricity consumption and are not oversized. Under this assumption, every commercial customer is assigned a system capacity based on their individual electricity consumption, not on their region's historical average capacity.

4.3 Economic agent decisions

Once agents are initialised, electricity tariffs are assigned, including retail prices for grid consumption and FiTs for electricity exports to the grid (from solar PV). Subsequently, a range of other price and non-price factors affecting an agent's decision of whether to take up solar systems are incorporated in the model, such that each agent follows a defined set of decisions. This set of decisions is illustrated in Figure 8 for a residential agent, and a commercial agent follows a similar path.

Figure 8: Residential agent framework



After an agent has been initialised, if it does not currently own a rooftop solar PV and/or battery system and is eligible to take one up, it is assigned the following data at the commencement of each year:

- Retail tariff.
- Feed-in tariff.
- Annual consumption.
- Hypothetical PV system capacity.
- Hypothetical BESS capacity.

- Associated capital costs.
- Operational and maintenance costs are assumed to be zero.

Using these assigned values, the agent calculates the average net cashflow that its system will provide over its assumed life, accounting for factors such as PV degradation. In these calculations, the retail tariffs and FiTs that reflect the customers' current situation are typically used. However, agents may also consider how these tariffs are anticipated to change in subsequent years. This is discussed in further detail in Section 4.4.

The equation to calculate the cash flow earned in year, n for a PV system is:

$$CF_{pv,n} = (Deg_{PV})^{n-1} \times \left[\left(\sum_{i=1}^{17520} (PVo_i - PVs_i) \right) (T_r) + \left(\sum_{i=1}^{17520} PVs_i \right) (T_{fi}) \right]$$

All equation variables and constants are summarised in Table 1 and Table 2, respectively.

Table 1: Cash flow equation variables

Variable	Description	Unit
$CF_{pv,n}$	The cash flow earned in year, n for a rooftop PV system	$
T_r	Retail tariff	$/kWh
T_{fi}	Feed-in tariff	$/kWh
PVo_i	PV output during 30-min interval, i	kWh
PVs_i	PV surplus during 30-min interval, i	kWh

Table 2: Cash flow equation constants

Constant	Description	Value
Deg_{PV}	PV degradation factor	0.993

Using these cash flow values, each agent then calculates the corresponding payback period of the nominated system for the respective year across the system's assumed 20-year life. This is represented by the following equation, with the variables described in Table 3:

$$PB_n = \frac{20 \times C_s(1 + r)}{\sum_{i=1}^{20} CF_i}$$

Table 3: Payback period equation variables

Variable	Description	Unit
PB_n	The payback period of a system for year, n	Years
C_s	The total capital cost of a system	$
r	The discount rate	%

4.4 Uptake functions

Hundreds of thousands of households and businesses may calculate the same payback period for rooftop solar PV, yet they do not all make the same purchasing decisions. Despite sharing similar economics, people make different DER investment decisions due to factors like socioeconomic conditions, neighbourhood influence, beliefs, or different levels of awareness and understanding of the technology.

An uptake function is created and used to calculate the probability of uptake based on key economic parameters (e.g., payback period) to account for these real-world behavioural differences.

A solar uptake function analyses the historical rooftop PV uptake of eligible households and businesses in each region and plots the corresponding historical payback periods during each historical year. Various regressions are conducted to model different behaviours using a mix of linear and exponential equations. These behaviours include responsiveness to a certain level of DER economics or capturing the 'fear of missing out' (FOMO) effect from reducing feed-in tariffs and solar cash flows. With every timestep in the model, each agent calculates the payback period for a solar PV system. These metrics become an input to the relevant uptake function to calculate the probability of solar PV uptake.

4.5 Time-series modelling

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.

The water heater data were modelled by the number of STCs registered since, unlike PV, these time series were not distorted by a multiplier[1] and they were also directly reflective of water heater uptake volumes.

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

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

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[1] The SRES scheme in the past applied a multiplier to the STCs created by a rooftop PV system, thereby increasing the subsidy offered for these systems. For example, from 1 July 2011 until 30 June 2012 each MWh of generation was awarded 3 STCs. As a result of this "distortion" Jacobs avoids performing time series analysis on the STC variable for rooftop PV systems. Instead, Jacobs chooses either to model installation numbers in combination with average capacity installed or to model capacity directly.

5. Inputs and assumptions

This section discusses the key assumptions used in the agent-based forecasting model. The model was built to forecast solar uptake for Australia's 336 SA3 regions, which are then aggregated to the state level. A range of de-identified rooftop PV data was supplied by CER, which informed historical, and future rooftop PV uptake.

5.1 Initialisation assumptions

As discussed in Section 4.2, agents are segmented into residential or commercial customers. The initialisation assumptions for each group are described in the following sub-sections, and Table 4 provides a summary of the data sources.

Table 4: Customer initialisation data sources

Category	Assumption	Source	Granularity
Residential demographics	Residential customer numbers and location	ABS Census 2021	SA3
	Dwelling type and tenure type	ABS Census 2021 microdata	
	Existing solar PV penetration	CER 2022	
Commercial demographics	Network system business customer numbers	AER, ESC, ERA, PWC	State
	Existing solar PV penetration	CER 2022	
School demographics	Existing solar PV penetration	CER 2022	
	Number of schools and location	ABS	
Historical residential energy characteristics	Energy consumption	AER, ESC, AusGrid, Essential Energy, Energex, Ergon Energy	SA3, Climate Zone
	Retail tariff	AER, ERAWA, ESC	State
	Feed-in tariff	IPART, ESC, QCA, Synergy, OTTER, NT Gov	
	Average retail bill	AER	
	Solar profile	AEMO NemWeb	
	Capital costs	Solar Choice	
	Demand profile	CSIRO	National

5.1.1 Residential demographics

Information on residential customer numbers, location, dwelling type, and tenure type were sourced from the latest 2021 ABS census.

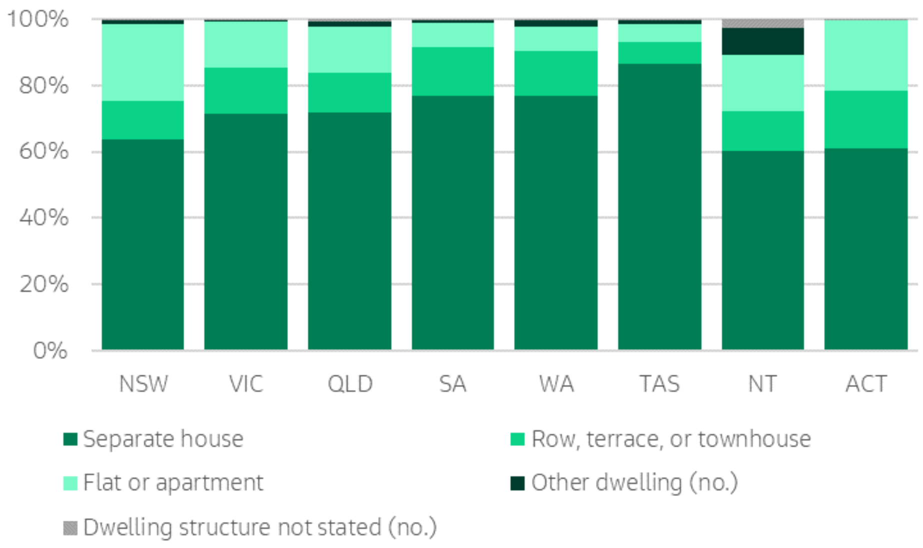
5.1.1.1 Residential dwelling type and tenure type

The ABS census details the proportion of dwelling type for each SA3 region, and tenure type. Only dwellings characterised as a separate house, or a semi-detached dwelling (terrace house, townhouse) are assumed eligible to adopt a rooftop solar PV system. Similarly, it is assumed only owner-occupiers can uptake a system due to constraints on renters' ability to modify their home.

Although households have different dwelling characteristics and electricity consumption behaviours, the trends in a region's average installed capacity are relatively homogenous; it is therefore acceptable to assign residential agents with their region's average capacity size because the standard deviation is small.

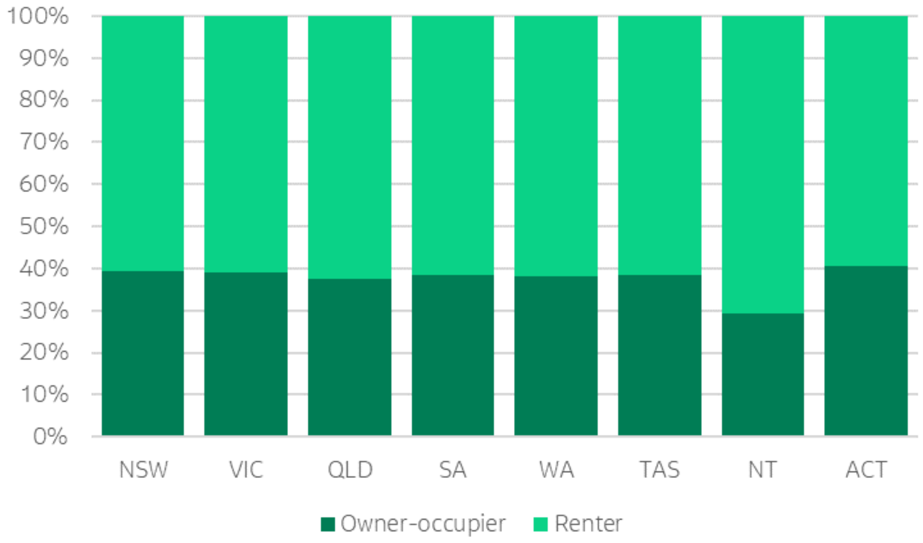
The state aggregated proportions of each dwelling type are illustrated in Figure 9. Out of the mainland states, New South Wales has the lowest proportion of detached dwellings, and the highest proportion of residents living in apartments or flats. Northern Territory, and the Australian Capital Territory also have a low proportion of detached dwellings. Tasmania has the highest share of houses and other detached dwellings.

Figure 9: State dwelling proportions



The state aggregated proportions of each tenure type for detached dwellings are illustrated in Figure 10. All states have similar home ownership rates, except for the Northern Territory which is lower.

Figure 10: Detached dwelling tenure proportions per state/territory



5.1.2 Commercial demographics

Information on commercial customer numbers and location were sourced from various sources, depending on the state.

5.1.2.1 Commercial customer numbers and classification

Commercial agents are assigned to a state or territory based on the number of business customers for each region. Small and large business customer numbers were sourced from the Australian Energy Regulator (AER) for New South Wales, Queensland, South Australia, Tasmania, and the ACT), Essential Services Commission (ESC) for Victoria, and Economic Regulation Authority (ERA) for Western Australia and used for all regions except the Northern Territory. 'Low Voltage' non-residential customer numbers were sourced from Power and Water Corporation and used for NT. However, each state has a different definition of the customer classifications as outlined in Table 5.

Table 5: Business customer definitions

Business customer	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Small	≤ 100 MWh pa	≤ 100 MWh pa	≤ 100 MWh pa	≤ 160 MWh pa	≤ 150 MWh pa	≤ 150 MWh pa	-	≤ 100 MWh pa
Large	> 100 MWh pa	> 100 MWh pa	> 100 MWh pa	> 160 MWh pa	> 150 MWh pa	> 150 MWh pa	-	> 100 MWh pa
Low Voltage	-	-	-	-	-	-	≤ 750 MWh pa	-

An analysis of historical commercial installations (excluding schools) indicates a consistent distribution of installed capacity sizes over the years, as shown in Figure 11, which is assumed to remain constant throughout the forecast period. It is assumed that commercial rooftop PV systems are optimised to the electricity consumption of the business and are not oversized. Under these assumptions, systems within the same capacity segment, as displayed in Figure 12, belong to businesses with similar electricity consumption to each other. While residential agents are assigned proportionately to SA3 regions, commercial agents are assigned to a system capacity segment (representing business consumption and size), based on their business customer type. This segmentation is outlined in Table 6.

Figure 11: Historical distribution of commercial capacity segments, Australia

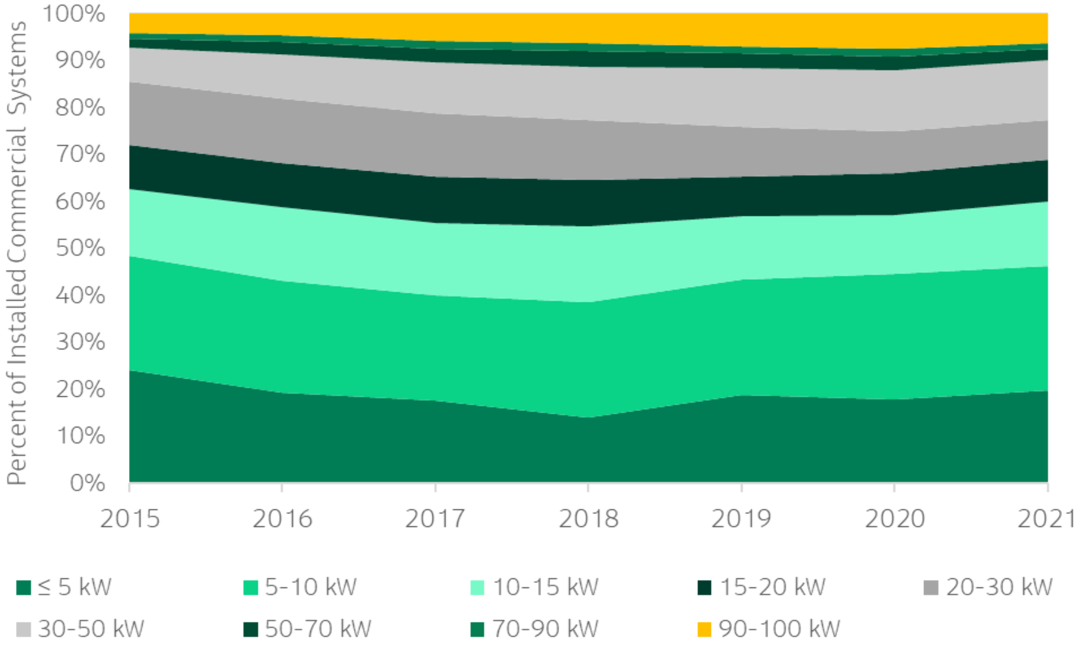


Figure 12: Commercial capacity segment distribution (2021)

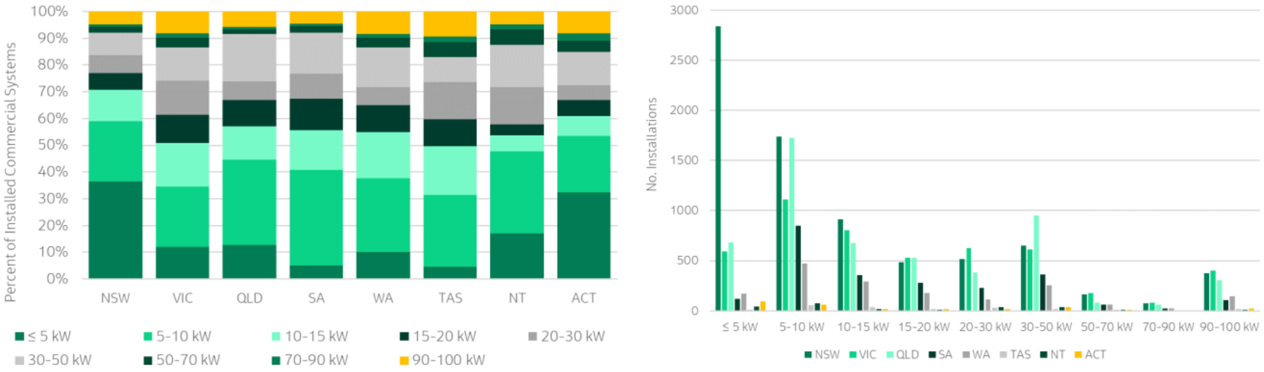


Table 6: Business customer segmentation

Capacity segment	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
≤ 5 kW	Small	Small	Small	Small	Small	Small	LV	Small
5-10 kW								
10-15 kW								
15-20 kW								
20-30 kW								
30-50 kW	Large	Large	Large					Large
50-70 kW				Large	Large	Large		
70-90 kW								
90-100 kW								

School agents are assigned to a state or territory based on school numbers from the ABS. The current penetration level for commercial and school agents are initialised using CER historical postcode data. Both agents subsequently follow a decision process like that illustrated in Figure 8.

5.1.3 Historical energy characteristics

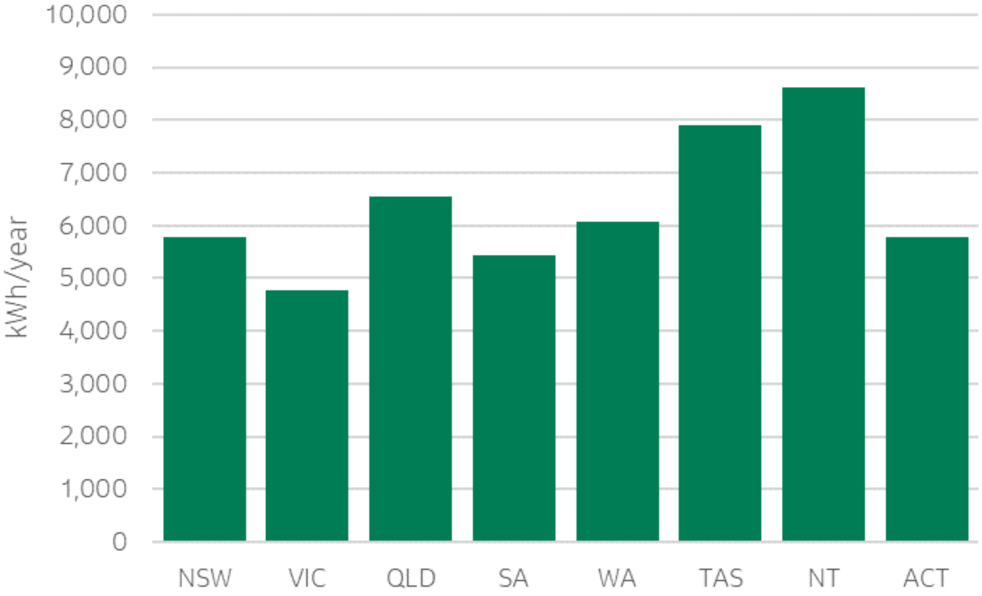
As well as current data on customer demographics, a range of historical data was used to inform forward projections of underlying demand and solar and battery uptake, including:

- Energy consumption.
- Retail tariffs.
- Feed-in tariffs.
- Average retail bills.
- Demand profiles.
- Solar generation profiles.
- Capital costs (provided by SolarChoice[2]).
- Installed rooftop PV capacity.

5.1.3.1 Electricity demand

Energy consumption is a critical component of calculating the potential savings for households and businesses of investing in rooftop solar PV. The average electricity consumption per year for each state is shown in Figure 13.

Figure 13: Average residential electricity consumption per annum



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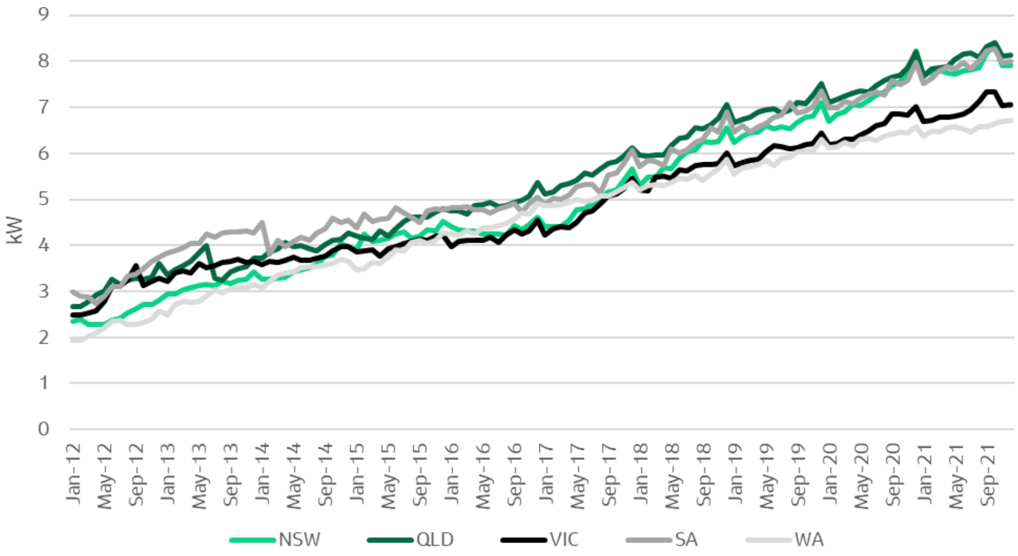
[2] See https://www.solarchoice.net.au/blog/solar-power-system-deals-perth-wa

5.1.3.2 Rooftop PV system sizes

Figure 14 shows the trends in average PV system sizes being installed since January 2012. The graph indicates that average system size has continued to grow at a steady rate over the last six months, consistent with growth patterns since mid-2016.

Figure 14: Monthly trend of average residential PV solar system size, selected states



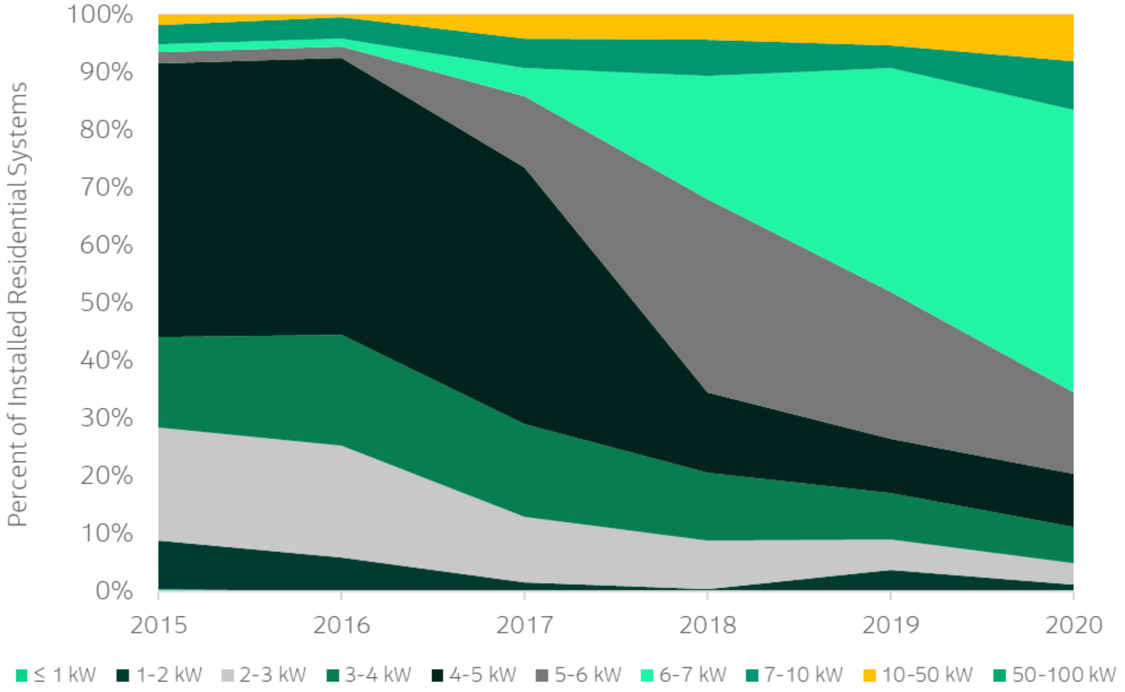
Source: Jacobs' analysis of CER data

Consumers have continued to install larger PV systems, now averaging above the 6.6 kW limit imposed by many distribution network service providers. This results in the average household that consumes about 15 kWh/day to export approximately 70% of energy produced from their solar system to the grid. For illustrative purposes, Figure 15 shows the historical capacity distribution in the Latrobe Valley, which indicates a strong emergence in systems of between 6-7 kW in recent years, and a slowly increasing uptake in larger systems of between 7-14 kW.

The tendency to oversize could be driven by several reasons including:

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

Figure 15: Historical residential system capacity distribution, Latrobe Valley



Source: Jacobs' analysis of CER data

It is expected that average system sizes will not continue to 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 residential PV systems to a capacity of about 6.6 kW. This restriction combined with limited roof space, is expected to eventually curtail the average system size for residential properties. Power curves have been fitted in each SA3 region to reflect this assumed reduction in growth rate.

5.1.4 Time lag to registration

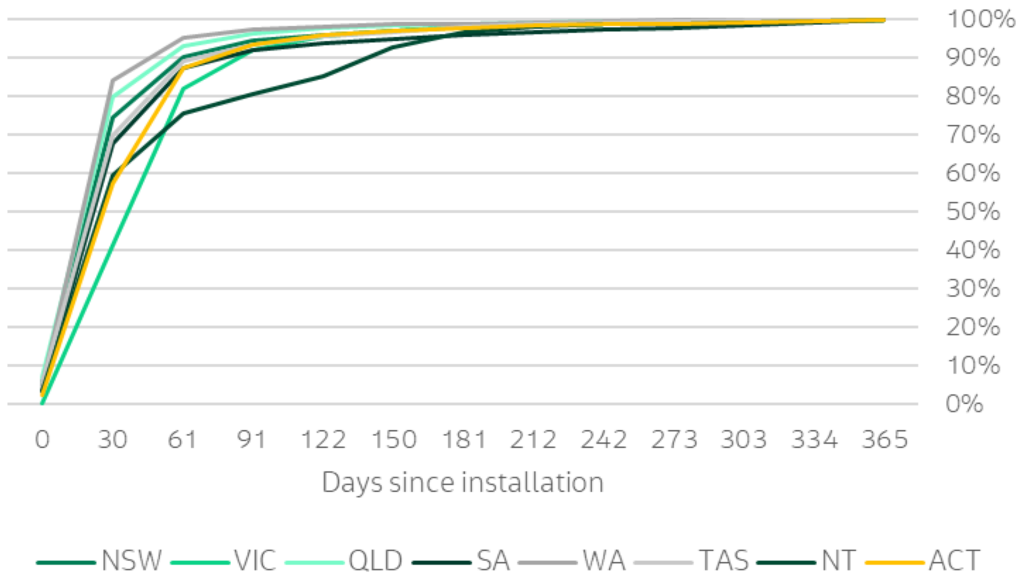
As there is a 12-month window from the date of installation in which to register eligible systems, the most recent registrations database will be missing records of systems that have already been installed, but which have not yet been registered. If not corrected, this will lead to an underestimate in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

The average duration between system installation, and the date of STC registration was examined. The data provided by the CER includes both the date of system installation and of the STC creation, so it is possible to calculate how many systems are registered one, two, three, or more months after the system was installed.

Residential data was analysed for the calendar year 2019, with the assumption that all PV systems installed in 2019 were registered by 31 December 2019. This period was selected to reflect current trends without being distorted by effects from the COVID-19 pandemic. For commercial systems, installation data from 2015 to 2019 was analysed to incorporate a larger sample size. Months for the years 2021 and 2022 were not incorporated due to the bias that would occur in favouring the population of customers who install early rather than later, resulting in an underestimate of time taken to register PV systems.

Figure 16 shows the typical delay in registration for residential system installations by state.

Figure 16: Delay in STC creation from date of installation, 2019 residential SGUs



Source: Jacobs' analysis of CER data

For December 2020 through to June 2022, the residential installed capacity was divided by the percentage of registered installations to create an expected percentage of installations for the respective month, as shown in Table 7.

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

	ACT	NSW	NT	QLD	SA	TAS	VIC	WA
1/10/2021	100%	100%	100%	100%	100%	100%	100%	100%
1/11/2021	99%	100%	99%	100%	99%	100%	100%	100%
1/12/2021	99%	99%	99%	100%	98%	100%	99%	100%
1/01/2022	99%	99%	99%	100%	98%	99%	99%	100%
1/02/2022	99%	99%	99%	99%	97%	99%	99%	99%
1/03/2022	98%	98%	98%	99%	97%	99%	98%	99%
1/04/2022	98%	98%	97%	99%	96%	98%	98%	99%
1/05/2022	97%	97%	93%	98%	95%	97%	97%	99%
1/06/2022	96%	96%	85%	98%	94%	95%	95%	98%
1/07/2022	93%	94%	81%	96%	92%	93%	92%	97%
1/08/2022	87%	90%	76%	93%	87%	89%	82%	95%
1/09/2022	57%	75%	60%	80%	68%	70%	41%	84%

5.1.5 Solar PV uptake function

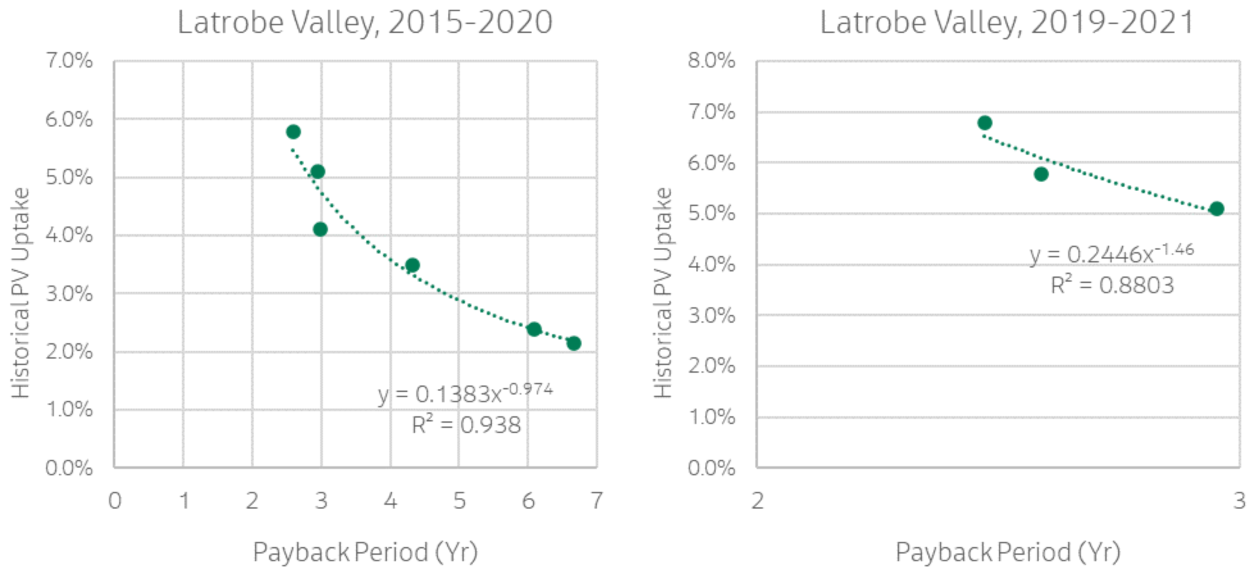
In reality, thousands of households may calculate the same payback period for a rooftop solar PV system, yet they do not all make the same purchasing decisions. Despite sharing similar economics, people respond differently due to factors like socioeconomic conditions, neighbourhood influence, beliefs, or different levels of awareness and understanding of the technology. An uptake function is used to calculate the probability of uptake based on a given payback period to account for these real-world behavioural differences. For residential agents, this function is unique to each SA3 region; for commercial agents, it is unique for each state/territory capacity segment.

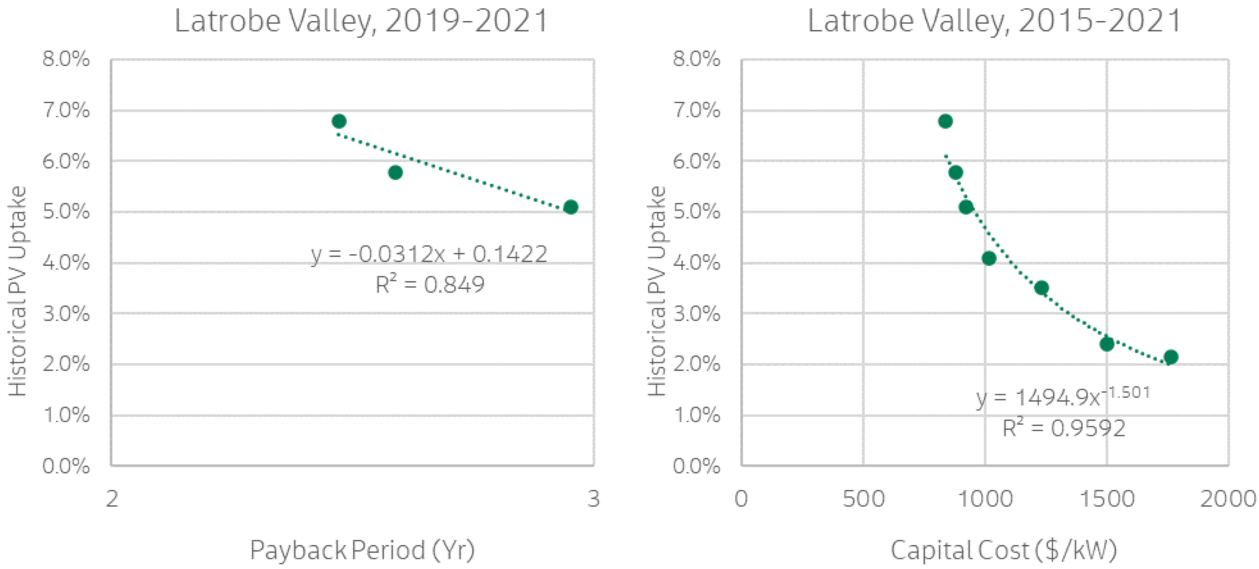
The uptake function analyses the historical rooftop PV uptake of eligible households in each region and plots the corresponding historical payback periods during each historical year. A power regression is conducted for all data sets to provide a power equation (Figure 17). If the relationship's R^2 value is greater than 0.70, the agent inputs their calculated payback period to calculate the probability of uptake. However, the payback/uptake relationship is not necessarily perfect for every region. For this reason, multiple regression equations are computed for each SA3 region, and the uptake function chooses which one to use based on the R^2 value, and the resultant probability.

Due to the uncertainty of 2020, as well as the possible shift in behaviour in the last four years in some areas, the following relationships are used in the uptake function:

- Power equation: Payback period vs. historical uptake, 2015 – 2020.
- Power equation: Payback period vs. historical uptake, 2019 – 2021.
- Linear equation: Payback period vs. historical uptake, 2019 – 2021.
- Power equation: Capital cost vs. historical uptake, 2015 – 2021

Figure 17: Rooftop PV uptake functions





5.2 DER uptake assumptions

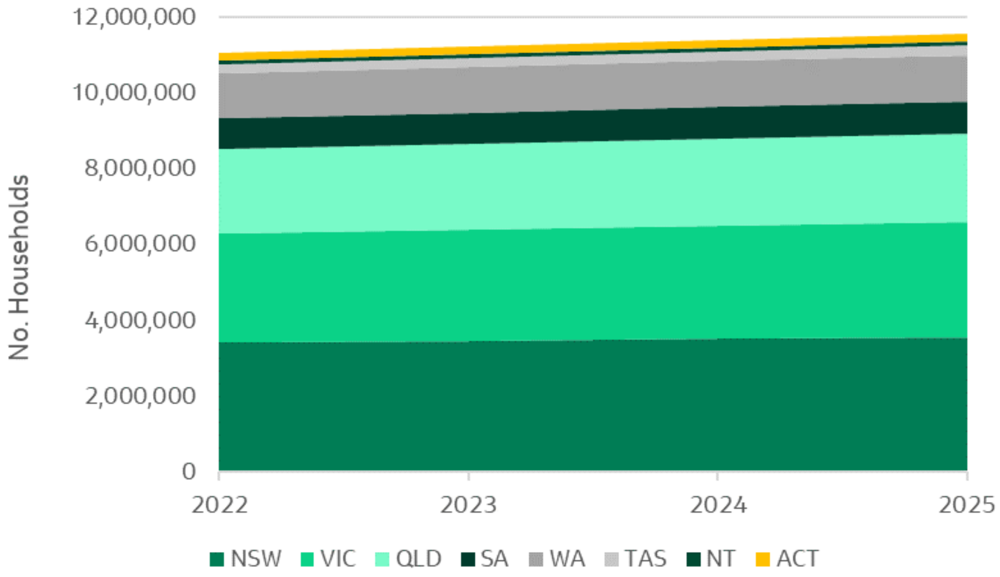
This section describes the assumptions that underpin the uptake forecasts for solar PV. While some of these measures have been discussed in the initialisation assumptions described in Section 5.1, they differ in the fact that in the previous section they referred to historical data used to set up and initialise agents, whereas in this section they refer to data used in forecasts of future years. Further, the assumptions in this section are the key economic and financial drivers that influence payback calculations used by customers to decide whether to take up rooftop solar systems, as well as the assumptions used to forecast changes in population.

5.2.1 Household growth

Household growth was indexed to the SA3 population or household growth forecasts from the respective state and territory governments (except Tasmania and Northern Territory). Using SA3 household numbers from the latest ABS 2021 Census, household growth followed the trend of its corresponding SA3 household/population forecast using its state government's central case. Where an SA3 region experiences negative growth during a given year, zero growth is assumed. This is due to the uncertainty in attributing outflows of agents in one location to inflows of agents in another.

The total household growth forecast is shown in Figure 18. Within the agent-based model, the appropriate number of agents are introduced every year to account for household growth. These new agents are initialised using the initial assumptions discussed in section 4.2.1, and subsequently follow the same decision process. Due to accounting for only 3% of Australian households, the number of dwellings in Tasmania and Northern Territory are assumed constant.

Figure 18: Household growth forecast



5.2.2 Solar PV system capital costs

The global oversupply on PV module manufacturing capacity has diminished. This has put upward pressure on system prices, but at the same time there is also a restructuring of the industry which is seeing large capacity manufacturing plant replacing the older and smaller manufacturing facilities. The larger plants allow for the capture of economies of scale in production and have minimised increases in system costs and may even lead to further decreases in costs.

Recently there has been a shortage on manufacturing capacity (due to greater than anticipated global demand for solar PV systems), which have also been coupled with higher costs of module raw materials and higher costs of freight. The impact of raw material costs is being ameliorated by an increase in demand for alternative module materials that were being phased out. However, increases in freight costs are not expected to decline in 2022. They have been caused by volatile global demand for goods driven by the imposition and easing of lockdowns due to COVID-19. This volatility has challenged logistic supply chains, and as a result freight costs have increased by a factor of 3-4 for shipments from China. Delivery times have also been stretched because of these issues, which puts upward pressure on system prices. As a result of this, industry commentators have flagged the possibility that global average year on year capex for solar systems in 2022 may not decline.

Capital cost assumptions for PVs in 2022 are based on the Solar Choice website's[3] monthly unit pricing overview, which is based on price data from 125 solar installation companies across Australia. These were converted into real dollars using historical CPI data.

For residential systems, the price per system per kW for capacity sizes of 5 to 10 kW was trended over time, and forecasts for each State were performed by utilising the expected learning curve extrapolated from CSIRO's 2021-22 GenCost[4] forecasts for rooftop PV. These forecasts are illustrated in Figure 19. The diminishing STC discount largely offsets the yearly cost reductions throughout the forecast period.

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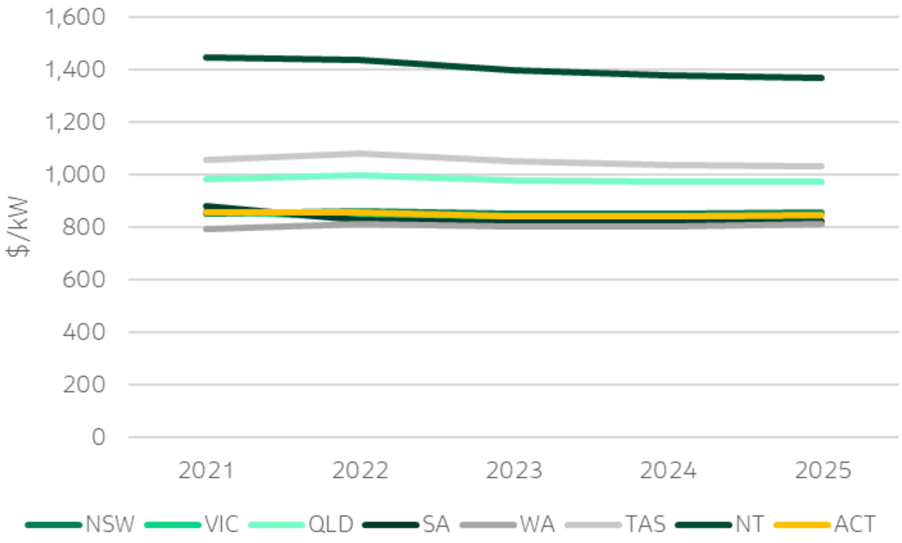
[3] http://www.solarchoice.net.au/blog/

[4] https://data.csiro.au/collection/csiro:44228

Figure 19: Capital cost assumed for residential solar PV systems ($/kW 2021)

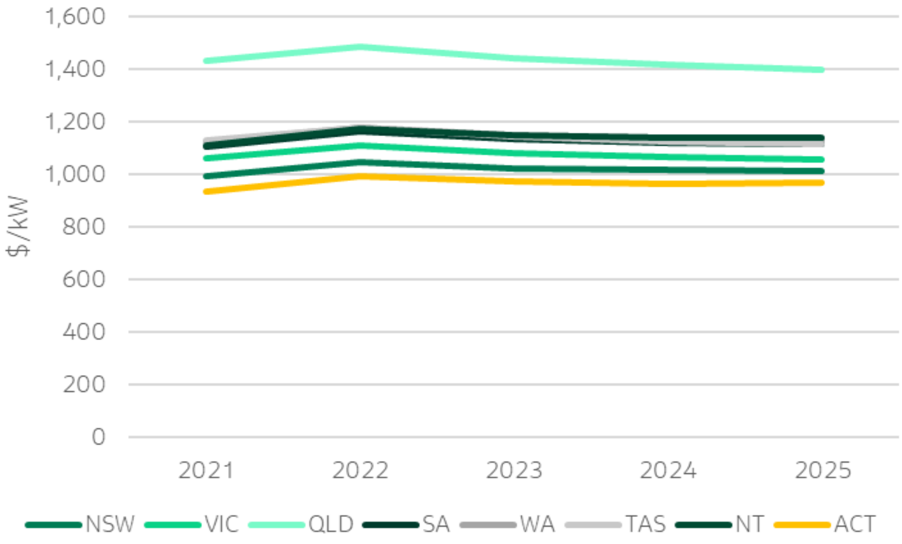


Source: Jacobs' market analysis, Solar Choice, CSIRO GenCost

A similar method was applied to costs of commercial systems, by utilising the data for systems between 10 kW and 100 kW. The average cost was plotted for all states, and the CSIRO's rate of decline was applied from 2023 to 2025.

The economies of scale were also less apparent in commercial systems, with little difference between cost per kilowatt for a 10-kW system versus a 100-kW system. Therefore, a ratio for economies of scale was not applied and the cost per unit was assumed to be constant. Figure 20 shows the historical and forecast costs assumed for commercial systems.

Figure 20: Capital costs assumed for commercial solar PV systems ($/kW 2021)



Source: Jacobs' market analysis, Solar Choice, CSIRO GenCost

5.2.3 Retail electricity tariffs

Jacobs' in-house 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 solar generation units (SGUs).

Jacobs has prepared the retail price projections using a bottom-up book build approach. This approach involves developing projections for each cost component of the retail tariff and adding up the components to formulate an overall retail price forecast. These cost components include network charges, wholesale charges, environmental scheme costs, market operator charges, and retailer charges and margins. The cost breakdown of the current retail price is used as a measure to calibrate the various components of the retail price.

Wholesale costs – The annual retail prices are built from quarterly wholesale price forecasts adjusted for seasonality based on monthly state or territory demand. The wholesale prices (real $/MWh) are based on Jacobs' most recent market forecasts. The actual historical prices are time-weighted averages over the quarter calculated from AEMO data for 2012 to 2021. The projections are from the Jacobs' forecast from FY2022 onwards extracted at hourly intervals to form a time-weighted average for each quarter.

Seasonality factors are used for annualising the pricing data, using operational demand from 2021 as a basis for this analysis. The sum of demand for each quarter is used to annualise the wholesale price[5].

In its conversion to a retail measure, the wholesale price has added to it a risk mitigation component. The wholesale price risk is taken as 20%, which is the premium for mitigating spot price risk of retailers by entering into futures agreements and hedging their position in the derivates markets.

Allowances for losses occuring across power lines in transmission and distribution are accounted for by applying transmission loss factors (TLFs) and distribution loss factors (DLFs).

Network charges – Network charges are the costs associated with transmission and distribution of electricity for retailers. These costs are set by network service providers who own the transmission infrastructure. Network charges are found on the AEMC website in their electricity prices and trends report where the 'base year' values are actuals. Network determinations are set every five years. The current network determination period with published network charges ranges from FY2019 to FY2024. After FY2024, network charges are assumed to remain constant for the duration of the forecasting period.

Large-scale renewable energy target (LRET) – The LRET provides a financial incentive to establish or expand renewable energy power stations by legislating the creation of Large-scale Generation Certificates (LGCs), where one LGC is equivalent to one MWh of eligible renewable electricity produced by an accredited power station. LGCs are sold to liable entities (mostly electricity retailers who must purchase a percentage of electricity from renewable sources each year) who must surrender them annually to the Clean Energy Regulator (CER).

LGCs were introduced as a mechanism to achieve the Federal Government's target of 33,000 GWh of electricity from eligible large-scale renewable sources in the NEM by 2020. The annual target increased each year until 2020 and is now constant at 33,000 GWh per year to 2030, when the scheme ends.

The LGC price is anticipated to decline through to 2030 because the supply of LGCs should increase as more accredited renewable energy is established in the electricity market but demand for LGCs from liable entities should remain at about the same level, in line with the steady target. However, recent LGC forward prices have retained significant value. This may be because there is increasing additional demand from voluntary

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[5] $Annual\ price = d_1q_1 + d_2q_2 + d_3q_3 + d_4q_4$, where d_i is the proportion of total demand in quarter *i* and q_i is the CPI adjusted wholesale price in quarter *i*

cancellations to meet private sector decarbonisation goals, combined with the fact that liable entities may withhold LGCs now (and pay penalties instead) if they expect strong demand and a higher price for them in the future. For these reasons LGCs are likely to continue to retain value over the next few years.

The LGC projections are adjusted using the DLF and TLF applying to the generator.

Small-scale renewable energy scheme – STCs themselves have an impact on the calculation of retail prices.

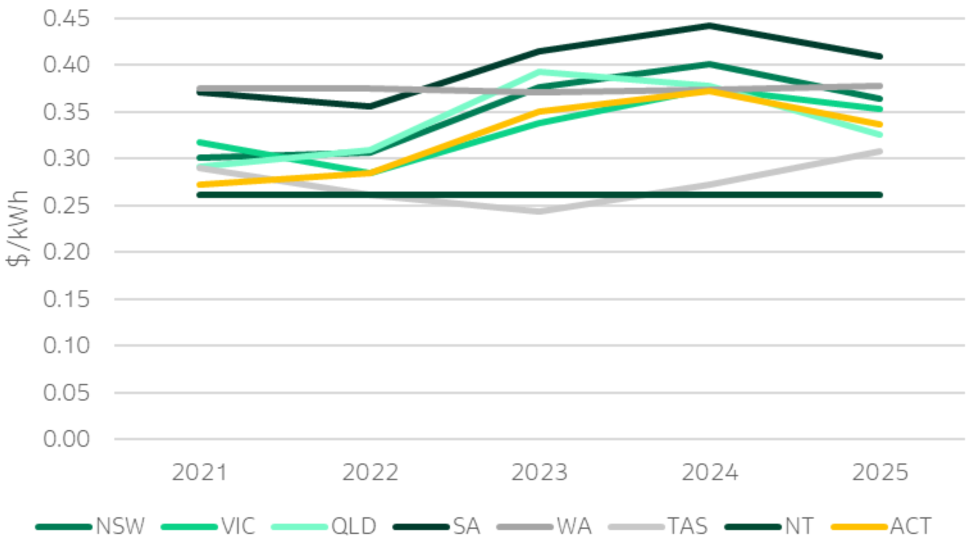
Feed-in-tariffs – This is built up by calculating the proportion of solar generation in relation to operational demand and multiplying by the relevant state or territory FiT rate.

Market charges – Market charges are extracted from the AEMO website in $/MWh which includes both NEM market operation fees.

Retailer costs/margin - The retail margin is estimated from historical data from the Australian Energy Market Commission (AEMC). The proportion of the total retail tariff that encompass retailer costs and margins is given in the AEMC electricity price trends report. This is assumed to remain constant over the forecasting period.

Figure 21 shows the retail electricity prices for each state used in the forecasts. Northern Territory prices are regulated by the state government, and it is assumed these will remain constant for the projection period.

Figure 21: Residential retail electricity tariff forecasts



Source: Jacobs' market analysis

5.2.4 Feed-in tariffs

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

Both the Northern Territory and Western Australian governments have sharply reduced their standard FiTs to reduce incentives to export rooftop solar power because of the impact of high penetration of solar on grid stability. In April 2020, the Northern Territory standard FiT was reduced from 26.05c/kWh to 8.3c/kWh, applied to all new installations.

In Western Australia, the standard FiT rate of 7.135 c/kWh was lowered to 3c/kWh for exports prior to 3pm and 10c/kWh for exports between 3-9pm. This is a move to encourage the installation of west facing solar panels and BESS to shift exports to during the evening peak period. This change is in place for all new systems installed from September 2020.

In New South Wales, the benchmarked FIT has recently been revised upwards in response to rising wholesale electricity prices. The FY2023 benchmarked FiT has increased from 4.6-5.5 c/kWh in FY2022 to 6.2-10.4 c/kWh.

5.2.5 STC prices

Figure 22 shows the monthly historical STC prices for the period January 2018 to November 2022. During this period the STC prices hovered below the target of $40, indicating that a surplus of STCs was being generated in the market. The forward curve was used, which extends to 2022, to project STC prices and have thereafter assumed the price asymptotes towards $40 per certificate by 2030. While $40 is in effect a ceiling price, and in the short-term prices may fluctuate beneath that level, it is assumed that prices converge to that level as annual targets are matched to projected levels of uptake.

Figure 22: Monthly historical STC price (nominal)

Source: Jacobs' analysis of Demand Manager data

5.2.5.1 STC zoning

The CER divides Australia into four regional zones based on the estimate of renewable energy that can be generated by a solar panel in each area, so installations in areas with high insolation[6] will create more certificates per kilowatt than rooftop installations based in areas in the south of the country. Zones are defined by postcodes. To convert the capacity of solar panels installed to the number of STCs produced, the average STC per kilowatt of installed capacity was calculated for the years 2013 to 2016 for each state and territory, which is the period when STC generation was not affected by multipliers or reduced deeming periods. Table 8 shows the effective multiplier for each state and territory used for conversion of the forecast capacity into STCs.

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[6] Insolation is the amount of solar radiation received on a given surface in a given time period.

From 2017, the deeming period reduces by an additional year every year; therefore, systems installed in 2022 will have a maximum deeming period of 9 years. As a result, the number of STCs created per kW reduces by a greater rate each year.

Table 8: Average STCs generated per kW of PV installed

Region	Pre-2017[7]	2022	2023	2024	2025
New South Wales	20.7	12.4	11.0	9.6	8.3
Victoria	17.8	10.7	9.5	8.3	7.1
Queensland	20.6	12.4	11.0	9.6	8.3
South Australia	20.5	12.3	11.0	9.6	8.2
Western Australia	20.6	12.4	11.0	9.6	8.2
Tasmania	17.6	10.6	9.4	8.2	7.1
Northern Territory	23.2	13.9	12.4	10.8	9.3
Australia Capital Territory	20.6	12.4	11.0	9.6	8.2

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[7] For a 15-year deeming period

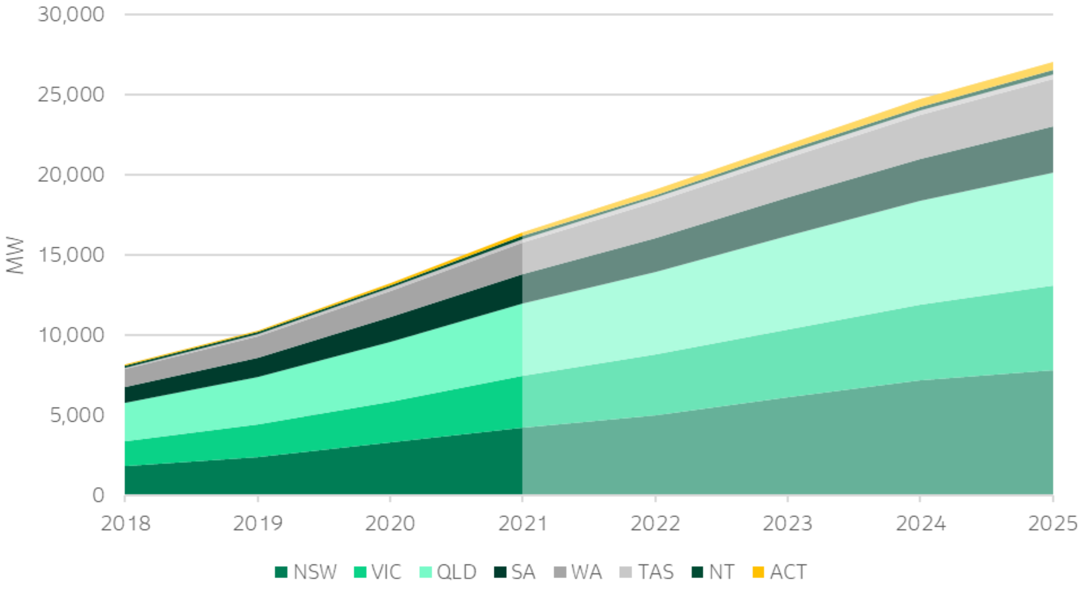
6. Results

This section presents the main projections from the agent-based and ARIMA time-series modelling undertaken by Jacobs. All results are provided in calendar years, and historical numbers from (at least) 2018 are given for context.

6.1 Rooftop PV capacity

The cumulative installed rooftop PV capacity increases over the forecast period, rising from 19,068 MW at the end of 2022, to 27,008 MW at the end of 2025, as shown in Figure 23. The significant growth in annual installed capacity that has occurred in the last few years has slowed, with 2,683 MW of newly installed capacity in 2022 compared to 3,156 MW in 2021. This is an estimated 15% reduction in expected uptake, largely realised during the first half of 2022. This reduction was likely due to the stagnant costs of solar PV systems, a continued decrease in FiT rates, shifts in household expenditure, weather impacts, recessionary impacts, and scarcity of installers and tradespeople.

Figure 23: Small-scale PV state forecasts, cumulative installed capacity

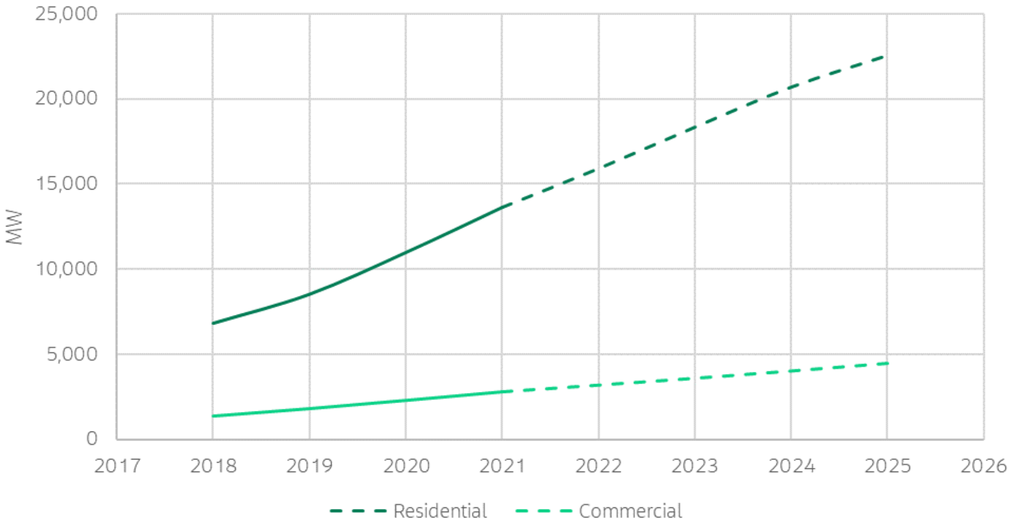


In 2023, annual uptake is anticipated to rebound to recent highs, with 2,839 MW and 2,789 MW of small-scale PV capacity expected to be installed across Australia by 2023 and 2024, respectively. This trend varies across states, but largely it is driven by an expected rise in retail electricity prices, which has a delayed correlation to wholesale electricity prices. Wholesale prices are forecast to remain at high levels due to persistently high international coal and gas prices (from sanctions imposed on Russia), paired with an increasing number of unplanned coal outages that force more expensive generation to be dispatched more often.

Annual growth is expected to reduce again in 2025 as retail electricity prices and FiTs are expected to decline, which drive this reduction in yearly growth, predominantly across the east coast of Australia. International gas prices are expected to stabilise to historical levels, and greater new entrant renewable generation (particularly utility solar farms) are forecast to impose downward pressure on wholesale and retail electricity prices and FiTs. Annual installed solar PV capacity declines from 2,789 MW in 2024 to 2,314 MW in 2025. Despite this decline, installation capacities in these years are higher than in 2019.

Figure 24 shows the forecasts of cumulative installed small-scall PV capacity, across the residential and commercial sectors.

Figure 24: Small-scale PV sector forecasts, cumulative capacity



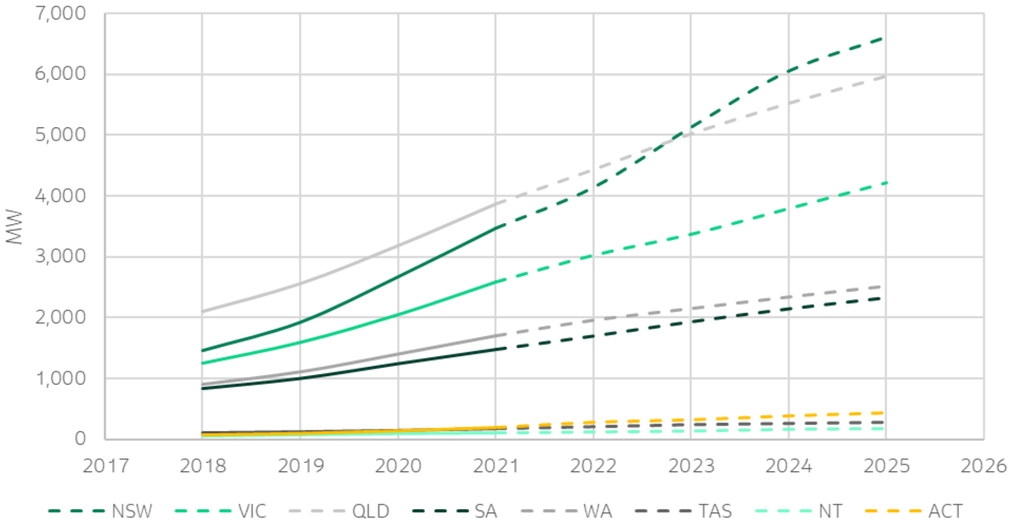
By 2021, residential cumulative capacity comprises 83.0% of total solar PV capacity in Australia, increasing slightly to 83.6% by 2025. At the end of 2022, the residential and commercial sectors have 15,884 MW and 3,183 MW of installed PV capacity, respectively. By the end of 2025, there is 22,530 MW and 4,478 MW of cumulative capacity in the residential and commercial sectors, respectively.

Throughout the forecast period, residential installations convey more volatility than commercial uptake. A reason is that residential customers are more sensitive to changing FiT rates, as they are more dependent on solar export revenue from their relatively oversized PV systems than commercial customers. Conversely, commercial PV systems tend to be sized to meet their electricity grid consumption and are less responsive to changing FiTs.

6.1.1 State residential PV projections

The cumulative residential solar PV capacity forecasts of each state are shown in Figure 25.

Figure 25: State residential small-scall PV projections, cumulative capacity



All mainland states have lower annual installed PV capacity by the end of 2022, than in 2021. As discussed in Section 6.1, annual uptake has fallen in 2022 because of a range of factors including stagnating capital costs and lower FiTs. States like South Australia and Western Australia are also starting from the position of relatively high rates of penetration of rooftop solar compared with other states.

In 2023, all regions except Western Australia are expected to see a resurgence in PV uptake, as the annual installed capacity of most states is on par with or exceeds the 2021 record levels of rooftop PV uptake. New South Wales is expected to experience the most growth in this year, largely driven by the state's higher regulated FiT. The all-day FiT benchmark in New South Wales is set to increase from 4.6-5.5 c/kWh in FY2022 to 6.2-10.4 c/kWh in FY2023 because of higher forecasted wholesale electricity prices. This is expected to drive an 47% increase in annual installed capacity, from 671 MW in 2022 to 986 MW in 2023 (23% higher than 2021).

To a lesser extent, most states follow a similar trend due to higher retail electricity prices and falling capital costs. Western Australia, which has a separate electricity grid to the eastern states, is the exception and is expected to have 191 MW of installed capacity in 2023, against 302 MW and 255 MW in 2021 and 2022, respectively. The retail electricity price in Western Australia is subject to a different regulatory process to other states and territories and is less influenced by rising wholesale electricity prices (in the state's Wholesale Electricity Market). As such, stable retail prices, falling FiTs, and increasingly stricter inverter requirements leads to a fall in installed PV capacity in Western Australia.

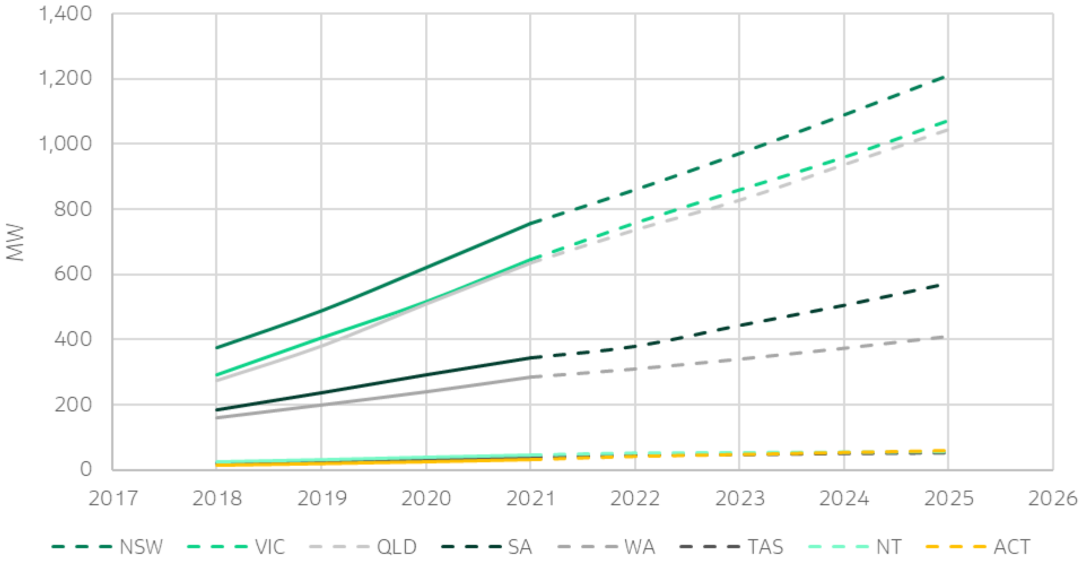
Victoria is projected to have even higher installed PV capacity in 2024, with 424 MW of rooftop PV capacity. Retail prices in Victoria are expected to peak in 2024, and Victoria's minimum FiT is forecast to increase for FY2024 in line with higher wholesale electricity prices (Victoria's FY2023 minimum FiT, which decreased from FY2022, was determined in February 2022, before international coal and gas prices soared). The remaining regions across Australia are expected to have similar uptake in 2024 compared with 2023, as their retail electricity prices also remain high. New South Wales – which has been the fastest growing region in residential rooftop PV since 2019 – overtakes Queensland to have the most installed residential rooftop PV capacity in the country.

For the remainder of the forecast period until 2025, annual uptake slumps across Australia (particularly NSW) as both FiTs and retail electricity tariffs fall. The decline in both tariffs is due to stabilising gas prices, and new entrant wind and utility solar generation applying downward pressure on wholesale electricity prices. However, solar technology costs are expected to continue reducing (albeit offset by the decreasing STC discount) and annual installed rooftop PV capacity in 2025 is expected to remain above historical 2019 levels of uptake.

6.1.2 State commercial PV projections

Figure 26 shows the cumulative installed commercial small-scale PV capacity forecasts, per state. As with the residential forecasts, all mainland states are expected to finish at the end of 2022 with lower annually installed capacity than in 2021, as capital costs remain stagnant. New South Wales, Victoria, and Queensland are projected to install 103 MW, 112 MW, and 102 MW by the end of 2022, respectively. However, unlike residential customers, commercial customers are not as reactive to changing FiTs since their systems are typically more efficiently sized to their electricity consumption and are not as reliant on solar export revenue.

Figure 26: State commercial small-scale PV projections, cumulative capacity



6.2 Water heater STCs

The ARIMA time series model forecasted the monthly STC creation of residential and commercial SWH and residential ASHP.

6.2.1 Solar water heaters

Figure 27 shows the historical actual and forecast data for the creation of STCs for SWH residential installations. The mild downtrend in uptake of these systems is projected to continue across the forecast horizon, as air-sourced heat pumps rise in popularity amongst households and gradually consume its market share.

Figure 27: Residential STCs for SWH, monthly (<= 40 STCs per installation)

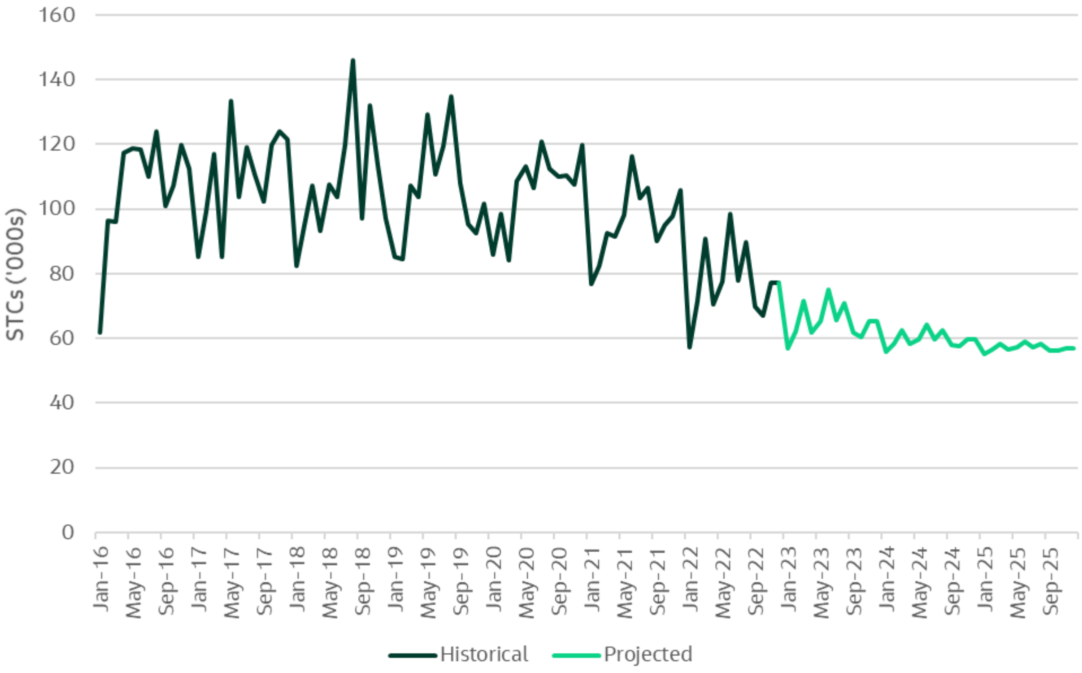
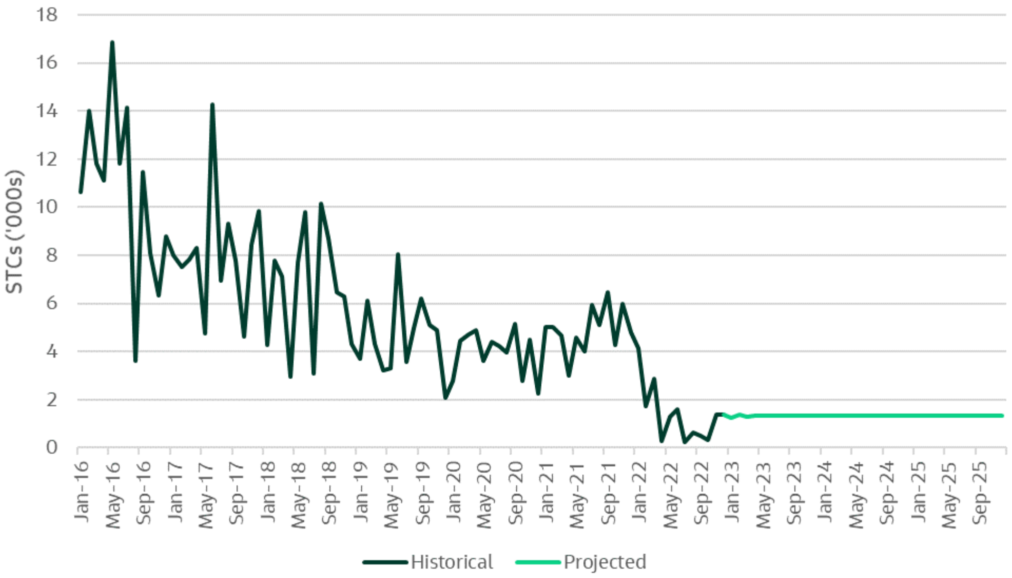


Figure 28 shows the historical actual and forecast data for the creation of STCs through SWH classified as commercial sized units. The number of installations and STCs generated for commercial SWH systems has dropped significantly in 2022, partly because business expenditure was likely brought forward to 2021, and because air-sourced heat pumps are also gaining popularity in the commercial sector. STCs generated are expected to remain stable at around 16,000 STCs per year.

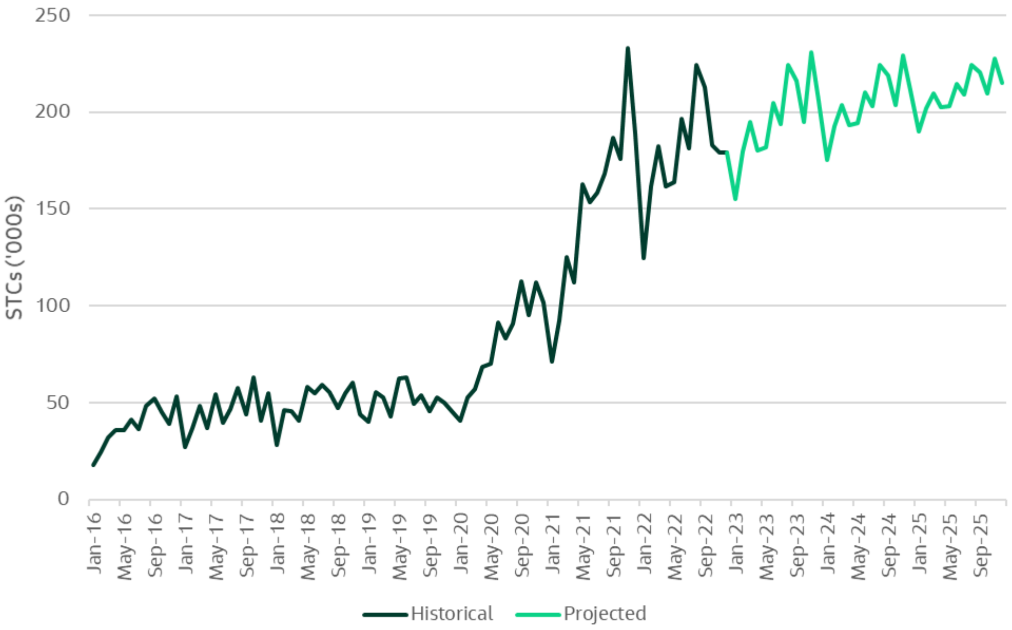
Figure 28: Commercial STCs for SWH, monthly (>40 STCs per installation)



6.2.2 Air-sourced heat pump water heaters

Figure 29 shows the historical actual and forecast data for STC creation from ASHP. Following the onset of COVID-19 there has been a boost in uptake among households and this is expected to grow throughout the forecast period. As retail electricity prices increase over the forecast period, households will turn to more energy efficient options, aided by Government subsidies in some States.

Figure 29: Residential STCs for ASHP, monthly



6.3 STC Projections

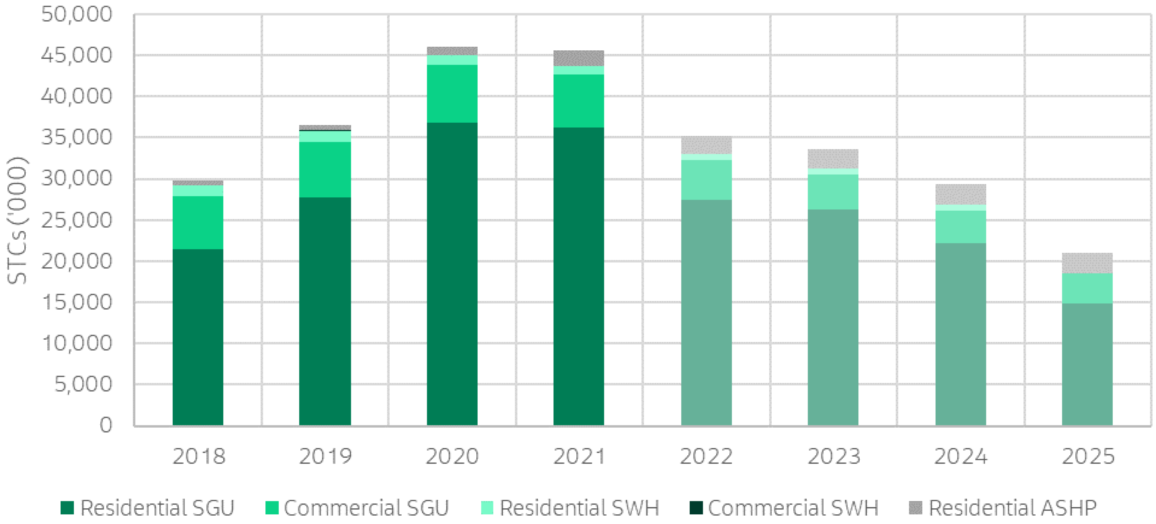
The projections for STCs created are shown in Table 9. These projections include STCs created through the installation of solar PV and hot water systems (wind and hydro STCs make up a negligible portion). In 2023, a total of 33.7 million STCs is projected to be generated; despite having an increase in SGU installations, this is 4.6% lower than 2022 due to the scheme's deeming period declining by another year, compared to the previous year.

Table 9: Small-scale technology certification (STC) creation projections ('000s)

	2022	2023	2024	2025
RESIDENTIAL				
Australian Capital Territory	1,092	455	619	415
New South Wales	8,323	10,873	8,898	4,603
Northern Territory	201	177	280	89
Queensland	6,979	6,465	4,827	3,676
South Australia	2,710	2,560	2,021	1,483
Tasmania	309	292	149	114
Victoria	4,720	3,293	3,526	3,032
Western Australia	3,153	2,100	1,827	1,452
Total Residential	**27,486**	**26,214**	**22,146**	**14,863**
COMMERCIAL				
Australian Capital Territory	117	63	59	45
New South Wales	1,281	1,227	1,139	1,004
Northern Territory	113	19	17	18
Queensland	1,260	1,006	1,052	890
South Australia	436	699	590	552
Tasmania	59	20	22	14
Victoria	1,198	966	831	802
Western Australia	310	334	324	301
Total Commercial	**4,774**	**4,334**	**4,034**	**3,626**
TOTAL SOLAR PV STCs	**32,260**	**30,549**	**26,180**	**18,489**
Residential Solar Hot Water	925	782	715	685
Commercial Solar Hot Water	16	16	16	16
Residential Air-sourced Heat Pump	2,151	2,363	2,460	2,528
ALL STCs	**35,352**	**33,709**	**29,371**	**21,718**

Figure 30 illustrates the STC creation projections by sector. Results for the projected SGU capacity can be found in Appendix A. STC trends are largely linked to residential rooftop PV installations which comprise the largest portion of STCs created. The decline in total STCs in 2022 is attributed to the fall of annual residential PV capacity, as discussed in Section 6.1.1. However, the fall in STCs between 2022 to 2024 is largely a result of fewer STCs generated per kW of small-scale solar as the deeming period continues reducing by an additional year in each subsequent year.

Figure 30: Total STC annual projections



Commercially sized SWH units are expected to maintain their relatively low level of uptake and are not expected to have considerable influence on STC creation across the forecasting period. It's expected that domestic SWH systems will continue modest negative growth, however the recent climb in uptake of ASHP systems is expected to continue for the remainder of the forecast horizon.

Appendix A: Annual small-scale PV capacity

Table 10: Annual installations of small-scale PV capacity (MW)

	2022	2023	2024	2025
RESIDENTIAL				
Australian Capital Territory	88	41	64	50
New South Wales	671	986	922	557
Northern Territory	14	14	26	10
Queensland	563	587	501	445
South Australia	220	234	211	180
Tasmania	29	31	18	16
Victoria	441	346	424	425
Western Australia	255	191	190	176
Total Residential	2,282	2,431	2,356	1,859
COMMERCIAL				
Australian Capital Territory	9	6	6	5
New South Wales	103	111	118	121
Northern Territory	8	2	2	2
Queensland	102	91	109	108
South Australia	35	64	62	67
Tasmania	6	2	3	2
Victoria	112	102	100	112
Western Australia	25	30	34	37
Total Commercial	400	408	433	455
TOTAL CAPACITY	**2,683**	**2,839**	**2,789**	**2,314**