Mid-scale Solar PV System Projections

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Executive summary

This report contains projections by Jacobs for the Clean Energy Regulator (CER) of the capacity and number of mid-scale solar photovoltaic (PV) installations for the calendar years 2022 up to and including 2027. Mid-scale PV systems are defined as having a capacity range of greater than 100 kilowatts (kW) and less than 30 MW. Large-scale Generation Certificates (LGCs) are created by the installation of these systems, which may then be sold to market participants –typically retailers who are required to surrender a determined number of LGCs to the CER. This has provided a financial incentive for the installation of mid-scale PV systems.

Historical trends

Relatively high retail electricity prices compared to the levelised cost of PV generated electricity coupled with plummeting capital costs of installation and high LGC prices saw a large growth rate in mid-scale PV installations during 2018, at two times the capacity installed in 2017. Growth steadied in 2019. However, in 2020 there was a reduction in the growth rate of installations due to factors relating to the global COVID-19 pandemic, including:

- Reduced industrial and commercial demand.
- Lower global oil and gas prices leading to perception of sustained lower electricity prices.
- Market and policy uncertainty delaying investment decisions.

In 2021 the trend reversed, and growth returned to this market segment for both behind-the-meter installations and front-of-meter systems that export all energy to the grid. For the calendar year up to September 2022, there was approximately 97 MW of new capacity in the mid-scale category compared to an historical average of 219 MW per year established since 2017 (See Figure 2 for details).

Projections

Projecting of mid-scale PV systems is inherently difficult. This study bases projections primarily on the estimated economic benefit and capability of uptake of the various market segments and an underlying assumption that there is no unanticipated constraint to additional investment in PV capacity.

Mid-scale PV systems cover a broad range of applications. The majority of these are rooftop systems to help meet the energy requirements of business enterprises and government agencies. In addition, single axis tracking systems[1] supply energy to the wholesale market.

Incentives to take up mid-scale solar PV vary. A key incentive stems from a net financial benefit by replacing grid-sourced electricity with on-site PV generated electricity. Other incentives flow from state-based programs that encourage uptake in specific sectors and communities.

With a wide range in applications and incentives, Jacobs deemed it inappropriate to utilise an all-encompassing model to project mid-scale installations. Instead, a segmentation and market sizing exercise was conducted, and a bottom-up approach was used in combination with the fitting of recent trends in installation uptake to a mathematical function.

[1] Single axis solar tracking tracks the sun on one axis only, being east to west.

The dataset supplied by the CER containing current and proposed mid-scale installations was segmented based primarily on the type of commercial organisation at which the system is installed. This enabled an estimation of the total size of the mid-scale market to be established based upon 13 segments. Of the estimated market size of more than 23,000 potential premises for mid-scale solar PV, only 1,604 premises are recorded as having a mid-scale system installed. While this suggests further room for growth, other constraints may be slowing uptake. For example, available roof space may not be suitable for PV installation, the size of net financial benefit may be too small to be attractive, and labour shortages or other supply-side factors may reduce the ability of the solar installation industry to fulfil installation requests.

Net present value (NPV) and payback periods of various cases were also calculated and factored into the projections. The payback period is expected to reduce further for the remainder of the projection period, primarily driven by a reduction in the capital cost of solar PV. This assumed cost reduction is offset by an expected decline in LGC prices from current levels, as indicated by futures contract prices[2], and a lack of new government incentives. However, on balance, the economic benefit of installing mid-scale systems is projected to continue to improve.

Key findings

The key findings of this report are as follows:

- The CER has a record of 1,604 mid-scale PV installations in Australia to date, representing a total capacity of 1,490 megawatts (MW) as of September 2022. More than 90% of installations have occurred since 2014.

- The top five sectors installing mid-scale solar PV are: commercial, electricity supply, retail, education, and industrial.

- For the period 2017 to (September) 2022, across all sectors the annual average:

    - Number of new installations was 233.

    - Installed capacity was 219 MW.

    - Installed capacity per site was 0.9 MW.

- Jacobs has projected installed capacity of mid-scale systems to increase from 1,810 MW in 2022 (full year estimate) to 2,817 MW by 2027, representing an increase in the number of systems from 1,604 to 4,187. This is driven by the economic benefits and relatively low market saturation, the practical application of energy production and consumption at the same site, utilisation of excess rooftop space, and the recent announcement of new government and utility programs.

[2] At the time of writing, LGC prices are actually increasing.

Table **1** summarises the capacity projections for the 6-year projection period for mid-scale PV systems installed across Australia from 2022 to 2027, inclusive. It divides the data into behind-the-meter systems, and front-of-meter systems of varying capacities.

Table 1: Summary of projected capacity of mid-scale PV installations 2022-2027, MW

Segment	2022	2023	2024	2025	2026	2027
Behind-the-meter systems	535	629	713	790	859	920
Aged Care	23	29	35	41	46	51
Agriculture	51	66	81	98	114	131
Airports	13	14	14	14	14	14
Commercial	111	116	119	121	122	121
Government	6	7	7	8	8	9
Hospitality	21	31	41	51	61	69
Hospitals	14	18	22	25	28	31
Logistics/Warehousing	22	23	24	25	25	25
Manufacturing	43	57	71	85	97	108
Mining	80	91	96	98	98	97
Recreation	8	10	11	13	14	15
Retail	132	155	177	198	218	236
Water Treatment	11	12	13	13	14	13
Front-of-meter systems	1,275	1,458	1,609	1,731	1,826	1,897
1-5 MW Systems	378	431	474	509	536	556
5-10 MW Systems	460	524	576	617	648	671
10-30 MW Systems	437	503	560	605	643	671
Total	1,810	2,087	2,322	2,521	2,684	2,817

Note: 2022 total is estimated, actual is 1,490 MW as of September 2022

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Acronyms and abbreviations

ABS	Australian Bureau of Statistics
AEMO	Australian Energy Market Operator
ANZSIC	Australian and New Zealand Standard Industrial Classification
CBD	Central business district
CER	Clean Energy Regulator
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DC	Direct current
ESG	Environmental and social governance
IRR	Internal rate of return
kW	Kilowatt
kWh	Kilowatt-hour
LGA	Local government authority
LGC	Large-scale Generation Certificate
LRET	Large-scale Renewable Energy Target
MLF	Marginal loss factor
MW	Megawatt
MWh	Megawatt-hour
NEM	National Electricity Market
NPV	Net present value
NSW	New South Wales
PPA	Power purchase agreement
RAES	Remote Areas Energy Supplies (Scheme)
REC	Renewable Energy Certificate
SETuP	Solar Energy Transformation Program
SME	Small-to-medium sized enterprise
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificate
WACC	Weighted average cost of capital

1. Introduction

The CER has engaged Jacobs to provide projections of the uptake of mid-scale solar PV systems across Australia for 2022 to 2027 (inclusive).

The projection of mid-scale PV uptake was based on:

- Projecting historical trends of mid-scale PV systems over the five calendar years from 2022 to 2027. These included projections for PV installations and installed capacity for commercial and industrial systems by various categories (including behind-the-meter, front-of-meter, and off-grid) and capacity bands for each state and territory in Australia. Historical data has been supplied by the CER containing detailed information on mid-scale system installations to September 2022.

- A review of the mid-scale solar PV market to identify key factors influencing the demand for and supply of mid-scale solar PV systems.

- A bottom-up analysis of known pipelines and announcements of mid-scale PV systems.

The findings presented in this report must be interpreted with an understanding of the limitations of projections that are about future market conditions. Perceptions of these parameters may change over short timeframes as wider economic, social, and technological trends evolve. Events can also occur for reasons not considered in the modelling process, such as changes to regulations affecting the use of mid-scale PVs or the development of alternative market arrangements for the output of PV systems.

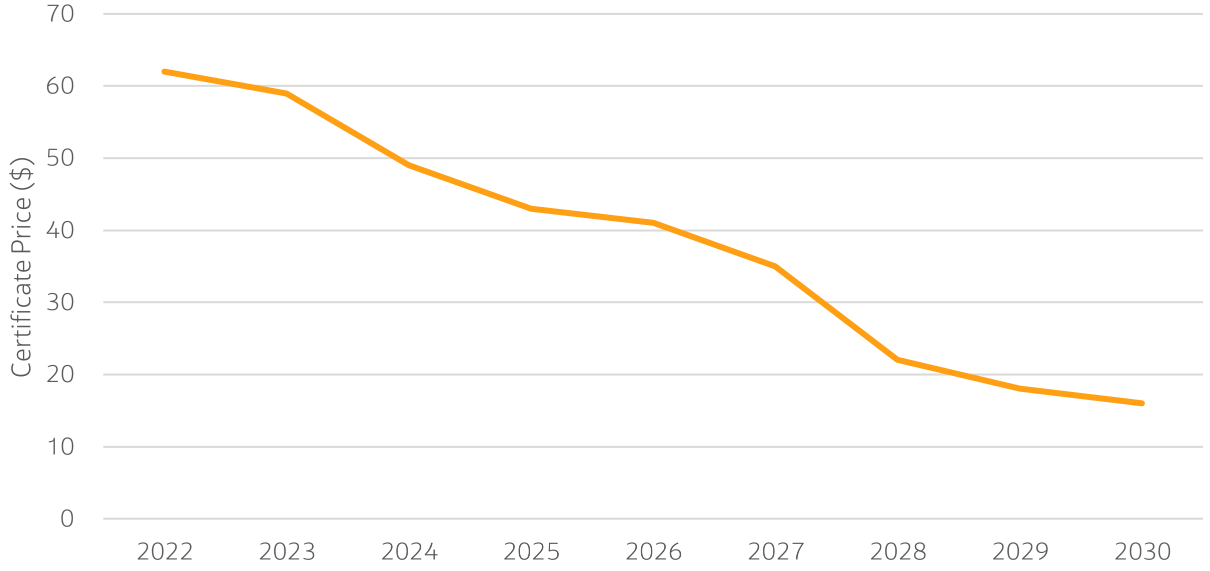
2. Federal Government incentives

The Large-scale Renewable Energy Target (LRET)[3] is designed to incentivise the development of large-scale renewable power generation in Australia through a market for the creation and sale of LGCs. Solar PV installations accredited under the LRET can create LGCs equivalent to the amount of renewable electricity they generate. One LGC is created for each megawatt-hour (MWh) deemed generated by a renewable resource. Liable entities (usually energy retailers) are required to acquire and surrender LGCs to the CER by creating them directly or purchasing them from the market.

While the LRET of 33,000 GWh of renewable energy generation has now been met, the scheme is legislated to continue until 2030 with the target remaining at that level.

Figure 1 shows the current and predicted LGC prices through to 2030[4]. The price of LGCs is expected to decline throughout the 2020s from its current (as at September-October 2022) trading range of $60 to $65 per certificate to an average price of less than $20 by 2030.

Figure 1: Current and projected LGC prices



Source: Demand Manager, Certificate Report, September 2022, Jarden

However, as evidenced from recent LGC contract prices, which appear to be retaining some value over the next two to three years, it is possible that output from renewables may be less than anticipated due to the impact of curtailment (by the Australian Energy Market Operator (AEMO) for electricity system stability reasons) and delays in the timing of construction and commissioning of projects.

Additionally, market participants and corporate entities may be purchasing (and voluntarily surrendering) LGCs as part of a push to purchase offsets to meet their decarbonisation targets and this is creating additional demand for them.

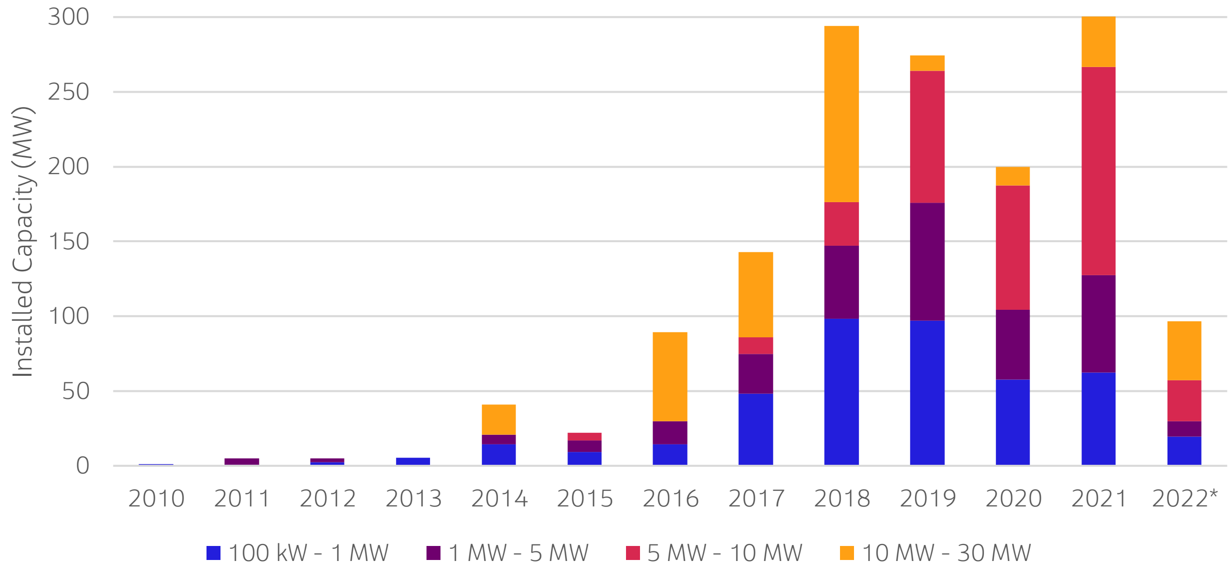
[3] See: https://www.cleanenergyregulator.gov.au/RET/About-the-Renewable-Energy-Target/How-the-scheme-works/Large-scale-Renewable-Energy-Target

[4] Predicted LGC prices are based on published forward prices.

3. Trends in uptake

Mid-scale PV installations of 100 kW to 30 MW in size have recently experienced growth in installation rates. Figure 2 highlights the trends for the installed capacity of these mid-scale systems categorised by capacity.

Figure 2: Trend in installed capacity of mid-scale PV systems, Australia, 100 kW to 30 MW systems



Source CER dataset, 2022 incomplete dataset, estimate for full-year 2022 is 320.6 MW

Across these categories:

1. Systems between 100 kW and 5 MW will predominantly include rooftop systems for behind-the-meter purposes.

2. Systems greater than 5 MW will predominantly be ground-mounted systems. With exception of large-scale industries (e.g., airports), it is likely that these systems will have a high share of their energy exported to the grid.

Table 2 shows the history indicating a trend increase across new installations and average capacity per installation.

Table 2: New installations and average capacity

Year	New installations (number)	Capacity installed (MW)	Average capacity (MW per installation)
2001	4	1	0.3
2003	1	0	0.2
2004	1	0	0.1
2005	1	0	0.2
2009	4	3	0.7
2010	5	1	0.3
2011	6	5	0.8
2012	10	5	0.5
2013	15	5	0.3
2014	50	41	0.8
2015	37	22	0.6
2016	71	90	1.3
2017	181	143	0.8
2018	352	294	0.8
2019	369	274	0.7
2020	212	200	0.9
2021	212	309	1.5
2022*	73	97	1.3
Summary	1,604	1,490	0.9
2017-2022	1,399	1,316	0.9
Average per year	233	219	

Note. 2022 is the year-to-date actual. Estimated total expected by year end is greater than the actual

4. Method

There are a range of factors affecting mid-scale PV uptake that need to be considered when doing projections.

A significant constraint in projecting PV uptake is the available land or rooftop area suitable for large commercial and industrial building sites, which will impede installation growth as uptake occurs and suitable sites decrease in number.[5] However, even if there is sufficient roof area, other factors may impede or diminish uptake such as shading from surrounding trees and buildings.

The primary incentive to uptake solar PV in the mid-scale range is a potential financial saving. The size of the financial saving depends on a range of assumptions for any prospective site.

- The magnitude of saving from partly supplying electricity on-site, resulting in avoided expenditure associated with sourcing electricity from the grid.
- The magnitude of revenue derived from creating LGC certificates.

Other motivations for installing mid-scale PV systems include:

- Behind-the-meter reductions in rates of energy use, through self-use of generated solar power.
- Export of electricity to the grid for trade in a wholesale market such as the NEM, or electricity sales through PPAs (front-of-meter systems only).
- Desire to reduce on-site greenhouse gas emissions.

The difference between commercial and industrial retail pricing is also a key factor, with industrial rates generally based on high voltage loads and baseline consumption patterns, and almost half of the rates expected by commercial and small-to-medium enterprise (SME) organisations.

For expansive ground-mounted systems within the metropolitan area, land value and other opportunity costs associated with land utilisation may outweigh the benefits of installing a mid-scale ground-mounted system.

Other factors that may affect uptake are:

- The size of the PV installation industry and its ability to meet the demand for installations. Over time, the industry is growing which yields benefits such as increasing technical proficiency, the amount of knowledge that can be shared with prospective clients, and scale benefits in sourcing supplies upstream. This dynamic engenders confidence among prospective clients, lowering the threshold to committing to install a new system.
- Alternative technologies (for example, thermal energy storage as an alternative to on-site electricity generation for space heating and cooling) and the rate of obsolescence of existing technologies.
- Property tenure. For tenant businesses, lease contracts may be too short in duration to guarantee recovery of an investment in on-site PV capacity.
- The relative simplicity of the Small-scale Renewable Energy Scheme (SRES) may dissuade companies from installing systems just above the capacity limit of SRES. The Small-scale Technology Certificate

[5] This is dependent on construction activity with new building design likely to integrate PV systems

(STC) scheme may create an incentive for companies to install systems with capacity less than the 100 kW threshold, even if they could install larger systems above the 100 kW range.

The range of factors, above, meant it was difficult to develop a single, relatively simple model that would capture all aspects in a way that provides credible projections. Instead, the preferred method was to develop projections by taking a bottom-up approach that:

- Classified each installation by industry using the Australian and New Zealand Standard Industrial Classification (ANZSIC) classification system (of the Australian Bureau of Statistics) at the four-digit level.
- Aggregated the classified installations to ANZSIC two-digit level.
- Grouped the two-digit industries to create economic segments to relate installations more clearly to news and announcements of plans for future installations.
- Developed estimates of market size by segment, with judgemental adjustment based on received information informing the likely rate of installations over the next five years.
- Fitted a mathematical function (the Gompertz function), using the established historic trend for each segment and the estimated market size likely to be achieved over the five-year horizon.

The following sub-sections outline the method used to: 1) segment and size the markets; 2) estimate the economic benefits of systems; and 3) project mid-scale PV uptake. The results of each step are presented in the Sections 5 to 8 of the report.

4.1 Segmentation and market sizing

For this study, installed PV systems were categorised into segments. Market segments were identified by matching descriptors available in the 'Power Station Name' field of the dataset provided by the CER to the ANZSIC classification descriptors. Details are provided in Appendix B.

The market size of the 13 largest segments was estimated based on relevant market information, as documented in Section 5. The 13 largest segments formed 93% of the total mid-scale capacity currently installed. These segments, listed in descending order of installed solar PV capacity, are:

1. Commercial
2. Electricity Supply
3. Retail
4. Education
5. Industrial
6. Logistics/Warehousing
7. Agriculture
8. Manufacturing
9. Services
10. Health

11. Mining

12. Water Treatment

13. Recreation

Figure 3 shows the breakdown in installed capacity across various identified segments in the 100 kW to 5 MW range and Table 3 provides information on the site count for each sector.

Figure 3: Total installed mid-scale PV capacity in identified market segments, 100 kW – 5 MW capacity

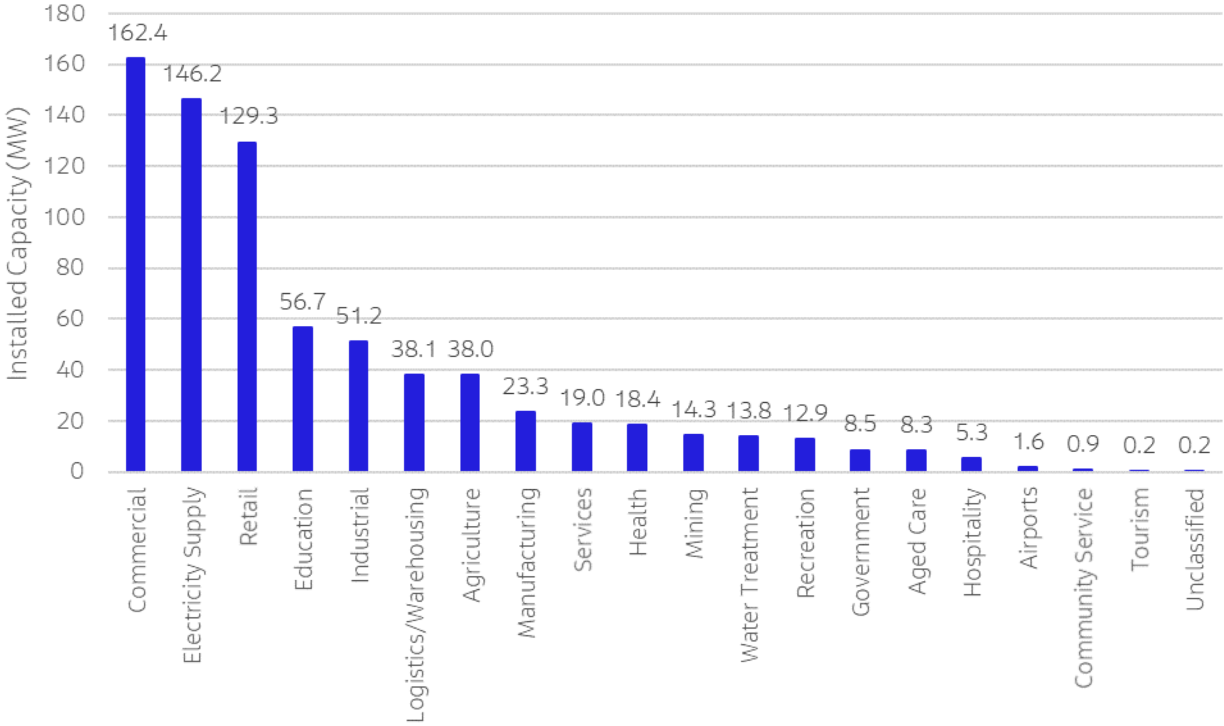


Table 3: Land classification by designated use[6]

Designated land use type	Site count
Commercial (including Retail)	15,124
Education	8,484
Hospital/Medical	1,244
Industrial	7,701
Other	5,254
Primary Production	19,429
Shipping	83
Transport	1,655
Total	58,974

Source: Australian Bureau of Statistics, Australian Statistical Geography, Edition 3. Note: data is a simple count of mesh blocks by category. Residential and Parkland categories available in the mesh block data is omitted from this table.

[6] Note that these categories are the ABS mesh block categories, not the ABS ANZSIC categories.

As can be seen in Figure 3 and Table 3, the Commercial, Electricity Supply, and Retail are the three largest segments contributing to PV installations in the mid-scale category, with a combined capacity of 438 MW accounting for 59% of total capacity. Commercial and Retail sites also have the highest site count. Education, and Industrial (predominantly manufacturing and food processing industries) are the next two biggest segments in terms of installations, with over 56 MW and 51 MW mid-scale PV capacity installed across Australia, respectively. Again, Table 3 indicates that there are many potential sites available in these segments, although fewer than for Commercial.

By casual inspection of Table 3, the apparent anomaly is Primary Production, which is the category with the greatest number of sites. However, many may have opted for small-scale PV systems.

There are many other relatively smaller industries that have embraced solar PV technology. Those with particularly high energy demands such as sports and recreation facilities that host a swimming pool, airports, water treatment plants, cool storage warehouses, and hospitals have all been quick to enter the market. In the last year, the mining industry has also shown an increase in uptake of behind-the-meter systems.

For any time-series analysis, it is important to evaluate these anecdotes with the following questions in mind:

- Is there a pattern driving these anecdotes?
- What kind of pattern is it?
- Will the pattern persist over time?

The answer to these questions is mixed. Some of these anecdotes are likely to represent once-only changes, which are often called innovations in the timeseries literature.[7]

However, there are several underlying drivers:

- Government policy favouring direct action interventions at government sites, which is being expressed in part by installing PV systems on buildings related to administration, health and recreation or other community sites.
- Energy intensive processes such as water treatment and refrigeration.
- The environmental and social governance (ESG) in mining action, which is helping to drive PV and other renewable energy installations at mine sites.

These drivers are likely to persist over several years but will reduce intensity as the number of suitable sites remaining dwindles.

These considerations are factored into the projections using a mix of quantitative and judgement-based methods.

4.2 Assessment of economic benefit

To form a view on the economic benefit over the life of a PV system, Jacobs has developed a model to project the annual cash flows that are derived from the value of expected savings of electricity not required to be purchased from the grid and/or the amount of energy exported back into the grid. When levelised, these cash flows can be used to assess the life-long benefit of a rooftop PV system or a ground-mounted grid scale PV

[7] "Innovation (Signal Processing)."

system by comparing them to the estimated upfront cost of installing the system such that comparisons can be made on the actual net benefit and the payback period.

Critical inputs and assumptions in assessing future cash flows, and thereby net benefit, and which were factored into the analysis include expected electricity cost, capital cost of the system, projected energy consumption and consumption patterns. Other important factors include the expected annual output of a PV system, considering solar insolation levels, capacity factors, and degeneration.

To determine the average net export of electricity to the grid for rooftop systems, a reference profile of daily commercial consumption published by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was utilised with 12 reference profiles of rooftop solar generation (also published by CSIRO) to represent each month of the year. The difference between the generation and consumption patterns was then taken to calculate the expected reduction in demand and thereby the expected energy savings for each of the twelve months. This figure was then annualised to represent the yearly energy savings.

4.3 Estimating uptake

The projections by segment were created by fitting a Gompertz function to the time series of installations by segment. The Gompertz function imposes an 's'-shaped curve that assumes an initial accelerating growth phase followed by a phase of decelerating growth.

A Gompertz distribution is a continuous probability distribution function using three independent parameters (a, b, c) that allow it to take various shapes as outlined below:

$$G(t) = a.\exp(-b.\exp(-ct))$$

The total market size of all segments is considered as an input to the model as the asymptote constant (the coefficient a in the Gompertz function), and the other two parameters b (halfway point or x-axis displacement) and c (growth rate or y-axis scaling) were selected based upon fitting the trend of PV installations via the sum of least squares. All mid-scale installations with exception of the education sector, airports, and front-of-meter systems were trended by month to allow the function to be fitted. The average system size for these systems was then calculated and applied to the estimated number of monthly installations to produce the capacity of mid-scale installations.

With a suite of government incentives targeting the education sector and many remote communities, the uptake of mid-scale solar PV for these segments was estimated using the bottom-up approach described in the introduction to Section 4. Similarly, the segments involving ground-mounted systems for the purpose of selling energy to the grid was also estimated with a bottom-up approach, due to the different incentives compared to the behind-the-meter categories. A search of news and announcements of intended installations was conducted to identify the current motivations, likelihood, and capabilities of businesses and industries to install such systems to arrive at estimates of future capacity.[8]

Information on developing uptake constraint assumptions is provided in Appendix C.

[8] See section 5 for details

5. Market sizing of behind-the-meter systems

To project the number of mid-scale size PV installations that will occur, an evaluation of the potential market size was conducted. This is important as it not only provides boundaries for the projections, but also allows for an indication of the saturation of the sector and any potential for growth.

This evaluation was conducted by categorising every installation on the top 13 behind-the-meter categories identified by installed capacity, which represents approximately 90% of the installed capacity within the mid-scale PV system range. Table 4 summarises the estimates of number of suitable locations for these categories, along with an indication of the current level of uptake within each segment.

Table 4: Potential market for mid-scale rooftop installations and current installations

Category	Market size, as number of sites	Number of installations
Commercial	11,419*	365
Manufacturing	5,156	55
Retail	1,786	248
Agriculture	1,387	73
Hospitality	875	19
Aged Care	776	46
Logistics/Warehousing/Transport	487	69
Recreation	322	42
Hospitals	290	37
Government	268	25
Water Treatment	129	43
Mining	157	12
Airports	20	5
Total	**23,072**	**1,039**

** Estimated from cross-matching mesh block data with other sources (see the appendix C for details). Total number of commercial sites as defined in the mesh block data equals the sum of Commercial, Retail, Hospitality, Aged Care and Government.*

5.1 Background and assumptions

This section provides the background and assumptions used in the market sizing calculations. In short, the Gompertz projection requires a market saturation level, which represents a constraint that eventually binds, forcing the growth of PV installations to decelerate. The maximum market size is typically modelled as proportional to the total number of available sites. This maximum should be considered as an imposed sensibility assumption since the number of installations cannot exceed the number of available sites.[9]

Much of the following information is qualitative and independent of the Gompertz projections. However, in constructing the projections, judgement was informed by the information provided, allowing for adjustments

[9] According to Australian Bureau of Statistics mesh block data there is a total of 58,974 potential sites for mid-scale solar. See Table 3 for a breakdown by broad type.

that deviate from a straight-line extrapolation of historical trends. It is presented here largely to assist readers' evaluation of the projections.

5.1.1 Commercial sector

This segment spans a range of economic activities such as commercial property management, parts distributors, as well as a variety of professional service providers. This sector is also one the largest potential market for non-residential behind-the-meter installations.

Given the risk of conflating commercial activities with retail activities, the distinction was based on segment allocation based on the ANZSIC coder.[10]

5.1.2 Retail sector

The Retail sector is one of the large segments of mid-scale installations. The retail industry continues to play a significant role in the uptake of rooftop PV systems, with their opening hours matching well to solar PV generation. To install a rooftop solar system greater than 100 kW, the roof space required is at least 550 m^2, which limits suitable sites in this category to retailers covering large floor spaces such as supermarkets, homemaker centres, hardware warehouses, department stores, and shopping centres.

Several such companies have begun initiatives to roll out rooftop solar PV as a part of their economic and sustainability objectives. For example, Aldi has announced a commitment to source 100% of its electricity from renewables by the end of 2021, and Woolworths and IKEA Australia have announced 100% renewable targets by 2025. By mid-2022, Aldi and Woolworths have already installed a substantial number of rooftop PV on their supermarkets across Australia.

According to the Urbis Australian Shopping Centre Industry report by Baker Consulting[11] (2018), there were 1,630 shopping centres in Australia that exceeded 1,000 square metres of gross lettable areas. These include:

- 78 regional shopping centres with at least one department store.
- 291 sub-regional centres that include at least one discount department store.
- 1,120 neighbourhood or supermarket-based shopping centres that include at least one supermarket as the major anchor.
- 96 central business district (CBD) centres.

The CBD centres were not considered to be suitable for a mid-scale PV installation since rooftops are highly constrained and there are shading issues which would materially reduce the electricity generated. Jacobs also assumed that 'shopping centres' include all suitable supermarkets and therefore additional inclusions for supermarket chains have not been made. In addition, currently there are 297 chain hardware retail outlets in Australia, with all chain hardware stores considered as having the potential to host a mid-scale PV system.

Therefore, this report has assumed the Retail segment comprises:

- Shopping centres.

[10] See this web URL for further details: https://www.abs.gov.au/statistics/classifications/australian-and-new-zealand-standard-industrial-classification-anzsic/2006-revision-2-0/how-search-works#classification-search.

[11] http://www.scca.org.au/wp-content/uploads/2020/01/AUSTR1.pdf

- Regional centres.
- Supermarket-based shopping centres.
- Chain outlets.

This gave a total of 1,786 retail premises considered suitable for the installation of a mid-scale PV system.

5.1.3 Water treatment plants

Jacobs used several sources to piece together the market share and uptake of solar PV systems at water treatment facilities in Australia. Included in this category were water treatment plants, pumping stations, and desalination plants.

The main data sources used to construct market size and projections for the water treatment sector were:

- CER mid-scale data on accredited and solar PV plants under application.
- Australian Bureau of Statistics (ABS) statistical information on the number of water treatment plants in Australia by turnover size.
- Publicly available information from Sydney Water on the number of sites and size.

The CER data includes 52 solar PV entries in the water treatment category[12]. Of the remaining 43 entries, three have commenced operation and have been accredited in the last 12 months.

SA Water has committed to 150 MW of rooftop PV across its operations as part of its Zero Cost Energy Future strategy[13]. This is a $300 million project across 33 sites for SA Water operations to reach net zero emissions. As of May 2021, 24 sites had been fully commissioned[14] and this has been cross checked with the CER data and AEMO's generation information page[15].

According to the CER data, the average size of the solar PV plants at the water treatment sites is 594 kW. Plants accredited and under application over the past year (2021) have an average size of approximately 1.39 MW, indicating that the average size of these projects is increasing. The largest of these projects are powering the water pumping stations in SA.

Market size of the water treatment sector was estimated using ABS statistical data and information available on the website of Sydney Water[16] about their water, recycled water and wastewater networks.

ABS data shows, there were a total of 635 water treatment sites across Australia, of which 116 sites (18%) had a turnover of more than $2 million. Over 50% of large water treatment sites are in NSW and Victoria. The turnover of these sites has fallen compared to 2019 turnover, which is likely to be linked to the impact of COVID-19. For this reason, Jacobs applied the 2019 turnover proportion of 20% to the 635 sites, giving 129 potential sites for PV installation.

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[12] Including water pumping and desalination

[13] https://www.sawater.com.au/education-and-community/education/the-well/Resources/Education-Fact-Sheet_Zero-cost-energy-future_Primary.pdf

[14] https://www.premier.sa.gov.au/news/media-releases/news/monday-10-may-2021-more-than-350,000-solar-panels-to-lower-costs-and-reduce-emissions

[15] https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information

[16] Although information on water treatment plant for other jurisdictions (e.g. Melbourne Water), Sydney Water provides the most detailed and comprehensive information on their website.

To substantiate the above assumptions, Jacobs used some more specific site data from Sydney Water. Sydney Water covers more than 4.3 million people in Sydney, Illawarra, and the Blue Mountains and covers a mix of urban, suburban, and regional/rural coverage that can be considered a suitable representation of Australia's water treatment activities.

According to the latest Sydney Water website data, the Sydney Water network includes nine water filtration plants, 16 wastewater treatment plants, 14 water recycling plants, and one desalination plant. Jacobs assumed that plants with a discharge of more than 10 million litres per day will be large enough to host mid-scale solar PV plants. All water filtration plants, seven recycling plants, and eight wastewater plants fall into this category. This brings the total suitable sites for Sydney Water to 25 (including the desalination plant).

The ABS data for NSW suggested a total of at least 32 plants with a turnover of more than $2 million. This provides another seven sites in regional NSW that would be large enough to host a mid-scale solar PV plant.

Therefore, the Sydney Water specific data broadly supports the ABS data. Jacobs used the assumption that 129 sites with a turnover of at least $2 million are suitable for mid-scale solar PV. The $2 million threshold was selected because the cost of a 100 kW PV system represents only about 7% of the site's annual turnover, which is likely to be small enough to be absorbed into its annual budget, especially if it is debt financed.

5.1.4 Airports

With high electricity utilisation in combination with expansive car parks and terminals, airports are prime candidates for the installation of solar panels. Furthermore, airports around the world are under increasing pressure to reduce their carbon footprint. However, many airports in Australia have already installed systems (Darwin, Alice Springs, Brisbane, and Melbourne) so this market may have fewer opportunities going forward.

5.1.5 Manufacturing, agricultural, and transport

Manufacturing has the greatest electricity usage of all industry sectors in Australia. High electricity use combined with generally large plant size (i.e., roof space), means a great potential for this industry to deploy behind-the-meter PV. The largest rooftop system installed in Australia so far is a 3.2 MW installation at a food processing plant in Queensland[17]. There are several manufacturing plants with rooftop solar installations of 2-3 MW. This highlights the potential for this sector to adopt rooftop PV technology.

Table 5 shows the number of manufacturing businesses in Australian states and territories with a turnover of greater than $5 million. Larger manufacturing businesses generally have more working capital and factory floorspace and thus more rooftop space. Therefore, Jacobs has assumed these businesses would have both the financial means and rooftop capacity to host a medium-size PV system.

Table 5: Market size assumptions for manufacturing, agricultural and transport sectors

	Number of businesses	2016-2020 survival rate	Market size assumption
Manufacturing >$5m	5,681	90.8%	5,156
Agricultural >$5m	1,549	89.6%	1,387
Transport (logistics) >$10m	556	87.5%	487

Source: ABS, Jacobs' analysis of Cat. No. 8165.0 Counts of Australian Businesses, including Entries and Exits, June 2016 to June 2020

[17] PV Magazine, Solar PV cuts the mustard for meat-processing facilities, October 7, 2019; https://www.pv-magazine-australia.com/2019/10/07/solar-pv-cuts-the-mustard-for-meat-processing-facilities/

Electricity usage by the agricultural sector is limited. However, this sector's use of petroleum products for onsite equipment (e.g., pumping installations) is significant and creates the potential for self-use of solar PV generated electricity. The largest businesses in this sector, with over $5 million turnover, are likely to have ample space for ground-mounted mid-scale solar PV systems (potentially combining self-use with exporting electricity to the grid). Therefore, it has been assumed that these agricultural businesses are most likely to host ground-mounted mid-scale PV systems. The number of suitable locations in Australia is 1,387.

The transport industry has modest usage of electricity, albeit higher than the agriculture and construction industries. Additionally, warehousing and logistics enterprises that have already elected to install solar PV are dominated by those providing cold storage and refrigerated transport. These are enterprises with large annual turnovers. For these reasons, it has been assumed that transport companies with an annual turnover of greater than $10 million would be suitable for the installation of a PV system.

5.1.6 Mining

The Australian mining sector consumes roughly 570 petajoules of energy per year, representing 10% of Australia's total energy use, and consumption has risen at 6% per annum over the last decade, driven primarily by increased mining volumes[18].

The mining sector derives most of its energy from diesel (52%), grid-supplied electricity (26%), and natural gas (20%), with the remainder supplied by a mixture of other refined fuels, coal, LPG, renewable energy, and biofuels. The percentage contribution of grid electricity has steadily increased over the last decade.

Average energy intensity is estimated at 50.5 kWh/tonne for coal, 10.7 kWh/ tonne for minerals, and 54.5 kWh/tonne for metal ores, with the majority consumed in diesel equipment and comminution operations[19]. Energy for metal ores with low on-site beneficiation, such as bauxite and iron ore, is predominately consumed as diesel for plant involved in extraction and transport. Energy for metal ores with high on-site site beneficiation, such as copper and gold, is predominantly consumed as electricity.

According to the Australian Operating Mines Map 2020[20], there are 375 operating mines in Australia, primarily for coal, bauxite, precious metals, base metals, battery/alloy metals, heavy mineral sands, lithium, and fertiliser elements.

For this study, Jacobs considered all copper and gold mines as having potential to install solar farms, bringing the number of eligible mines to 157.

5.1.7 Government buildings

Of the 31 government buildings identified in the CER dataset as having mid-scale solar PV installed, around half were council buildings. This indicates that council buildings, generally positioned in suburban or regional areas, provide an ideal platform for the installation of mid-scale solar PV.

There are 537 councils in Australia[21]. It has been assumed that all these councils will have a building suitable for the installation of solar PV.

To obtain an indication of the number of council buildings that would elect to install a mid-scale system, we investigated the current council building installations against the respective population of the local government area (LGA).

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[18] https://arena.gov.au/assets/2017/11/renewable-energy-in-the-australian-mining-sector.pdf

[19] Based on DISER (2021), *National Greenhouse Accounts Methods and Factors Workbook*

[20] https://ecat.ga.gov.au/geonetwork/srv/api/records/74c290c8-2fea-401d-bfca-9c1c0859511f

[21] Australian Local Government Association: https://alga.asn.au/facts-and-figures

To obtain an indication of the number of council buildings that would elect to install small-scale systems instead, Jacobs investigated a portfolio of installations from one of the largest commercial PV installers in Australia, Todae Solar. Upon assessment of Todae Solar's portfolio of council building installations, approximately 50% were less than 100 kW in capacity. The estimate on council buildings that would fit into the mid-scale category is therefore reduced by 50%.

The final estimate of total market size for council buildings is 268.

5.1.8 Recreation, leisure, sports, and aquatic centres

There are approximately 1,077 public swimming pools in Australia[22]. These are commonly associated with a full leisure centre that includes a gym and other sports facilities. The need for large amounts of pumped water for an aquatic centre means significant consumption of energy, and these centres are therefore considered suitable for the installation of mid-scale PV systems.

According to the ABS, there are approximately 355 sports and leisure centres with an annual turnover greater than $2m[23]. Of these, the four-year survival rate for the period of June 2016 to June 2020 is 83%. The number of facilities has decreased over the last year due to COVID-19 impacts (lower turnover), but the survival rate is similar. Jacobs has therefore assumed that the total market size for the sports and recreation sector is unchanged at 322.

5.1.9 Hospitality industry

The hospitality industry is another segment that has been identified in the CER dataset as showing an increased uptake in mid-scale PV installations. There are 30 sports, social, gambling or RSL clubs identified in the dataset that have either installed a mid-scale PV system or are under application.

The number of businesses that represent gambling, sporting, recreational, and social clubs or associations that generate income predominantly from hospitality services is estimated at 5,753.[24] The industry has shown decline in recent years and may decline even further in the foreseeable future due to overall maturity of the industry, increased competition and declining per capita alcohol consumption. Following the impact of the COVID-19, which reduced the sector's revenue by more than 22% in 2020, the sector has seen some recovery in 2022. Continuation of the post-COVID-19 normalisation process is expected to continue.

A key assumption is uptake of solar PV will be limited to businesses with a turnover of more than $5 million and an average survival rate of 89.78%.

PV installations on social clubs, just under 50%, or 19 of the 40 installations, were less than 100 kW and therefore cannot be considered in the mid-scale market.

5.1.10 Aged care industry

As of June 2022, there are 3,109 residential aged care facilities in Australia[25]. At least 46 of these already have rooftop solar panels of size greater than 100 kW. Of those remaining, it was assumed that an aged-care facility would need to house more than 100 residents to be large enough to consider a mid-scale PV system.

[22] https://www.royallifesaving.com.au/__data/assets/pdf_file/0003/21945/RLS_FactSheet_33_SWIMMING_PARTICPATION-2.pdf

[23] Australian Bureau of Statistics, Counts of Australian Businesses, including Entries and Exits; https://www.abs.gov.au/statistics/economy/business-indicators/counts-australian-businesses-including-entries-and-exits/latest-release

[24] https://www.ibisworld.com.au/industry-trends/market-research-reports/accommodation-food-services/social-clubs.html

[25] This estimate excludes Home Care https://www.gen-agedcaredata.gov.au/Resources/Access-data/2022/October/Aged-care-service-list-30-June-2022

The total number of residential aged-care facilities with more than one hundred beds is 776. This number has been taken as the total market size of aged-care facilities suitable to install a mid-scale system.

5.1.11 Hospitals

Due to the nature of services provided, hospitals are energy intensive. Hospital electricity usage is often so large that it is likely rooftop solar could only provide up to 15% of its energy needs in smaller hospitals[26]. Further, rooftop solar is more suited to smaller facilities in sunny locations. Based on this, Jacobs has assumed that a mid-scale system would power 15% of a facility's total generation requirements. For example, the minimum capacity for a mid-scale system is just over 100 kW and this is likely to produce around 200 MWh of energy across the year. Hospitals would therefore need to consume over 1,300 MWh of energy a year for mid-scale rooftop PV to meet this criterion.

Box 1: Case study of energy intensity of Victorian hospitals

To estimate likely how many Australian hospitals are good prospects for mid-scale PV system installation, it is necessary to collate indicative metrics. Although such information is rarely published, a relative recent study conducted by VicHealth[1] estimated that in the year 2016-2017, Victorian public health services consumed approximately 650 GWh of electricity. The total number of hospital beds in Victoria is 15,120. This amounts to an average of approximately 43 MWh of energy consumed per hospital bed and 11,870 MWh of electricity consumed per day per public hospital in Victoria.

Table 6: Number of Australian public hospitals by bed size and remoteness

Total Vic hospital generation (GWh)	Total hospital beds Victoria	Generation per bed (MWh)	Minimum total consumption if 15% from rooftop (MWh)	Implied minimum number of beds required
650	15,120	43	1,300	30

In 2021, Victoria announced that Government operations, including schools, hospitals, and police stations, will be powered by 100% renewable energy by 2025. Of this around 5% is targeted to be on-site renewables by 2023. Combining the results above, a criterion based on bed size can be formulated, assuming a hospital would need a minimum of 30 beds to consume enough electricity to enable installation of a mid-scale rooftop PV system. This is shown in Table 7**Error! Reference source not found.**. Given the absence of similar data for other states, these metrics a re applied across Australia to derive a national estimate of the ultimate number of prospective mid-scale solar sites at hospitals across Australia.

According to the 'Hospital resources 2018–19: Australian hospital statistics' there are 692 public and 657 private hospitals in Australia. Despite large hospitals being a significant consumer of energy, a modest 25 of the 1,350 public and private hospitals were identified from the list supplied by the CER as having mid-scale systems installed and most of these hospitals are in regional centres. Potential reasons for this limited uptake could be:

- Limited availability of suitable roof space in multi storey hospital complexes.
- Energy contracts arranged via PPA agreements.
- Access to high voltage lines and industrial retail prices reduces the value of a solar PV investment.

[26] https://www.dea.org.au/wp-content/uploads/2020/12/DEA-Net-Zero-report_v11.pdf

It is more likely that major city principal referral hospitals (of which there are 28, according to the hospital resources data) are the larger consumers of energy but have the least suitable roof space, limiting the ability of rooftop solar PV to have a substantial impact on their electricity consumption.

Therefore, Jacobs has limited the potential market size of hospital installations to the percentage of hospitals that are in regional or remote areas with greater than 30 beds. This brings the assumed market size of the public hospital sector to 22% of the total number, or 149 of the 692 potential premises, as per details provided in Table 7.

Table 7: Number of Australian public hospitals by bed size and remoteness

Public hospitals by size and remoteness	Regional	Remote	Major cities	Total
10 or fewer beds	87	57	4	**148**
More than 10 to 30 beds	181	40	25	**246**
More than 30 to 100 beds	95	14	41	**150**
More than 100 to 200 beds	20	0	38	**58**
More than 200 to 500 beds	16	1	40	**57**
More than 500 beds	3	0	30	**33**
All hospitals	**402**	**112**	**178**	**692**

Source: Hospital Resources 2018-19: Australian hospital statistics; https://www.aihw.gov.au/reports/hospitals/australias-hospitals-at-a-glance-2018-19/summary

According to Australian hospital statistics data there are a total of 657 private hospitals. However, there is no information available on the size of these hospitals. Therefore, we propose to apply the same approach to estimate the market size as we did for the public hospitals. The market size for private hospitals will then be 22% of 657 private hospitals or a total of 141 private hospitals.

The total potential market size for public and private hospitals all together in Australia used in the modelling was 290.

6. Economic benefit

Given the relatively simple Gompertz projections, it is useful to develop an independent way of assessing the likelihood of installations. This is implemented by estimating the net economic benefit and payback period of the installation of mid-scale PV systems.

In comparing the two methods, there are following logical outcomes:

- Both the Gompertz and net economic benefit estimate indicate growth or consolidation (i.e. either no growth or decelerating growth).
- The Gompertz and net economic benefit estimate indicate a contradiction with one method indicating growth and the other indicating consolidation.
    - In the case where the Gompertz projection indicates growth and the net economic benefit indicates consolidation, there may be a non-financial motivation driving uptake.
    - The reverse case might be indicating a trend change.

In evaluating the projections, it is worth bearing in mind the inherent uncertainty in projecting the future. There are typically surprise events that can occur. Some examples of surprise events are:

- An unanticipated change in government incentive or regulation.
- A shift in the LGC forward curve, possibly reflecting a market-wide shift in preference for self-creation of LGC certificates.

Due to the wide variety of segments within the market for a mid-scale solar PV system, an estimate of economic benefits was run across three different scenarios as outlined below:

- Commercial 250 kW rooftop systems (e.g., most manufacturing, retail, educational, aged care).
- Industrial 850 kW rooftop systems (e.g., large-scale manufacturing, hospitals, and large universities).
- Ground-mounted front-of-meter fixed angle 200 kW systems.

Table 8 outlines the parameters and key assumptions used for the net economic benefit calculations. It was assumed that commercial and industrial PV installations are not entitled to receive feed-in-tariffs and therefore PV installations are sized appropriately so that all electricity generated is used by the enterprise or traded in the NEM. The capacity factor of the commercial installations is assumed to be 16%, which is typical of rooftop installations in the New South Wales (NSW) region. It was assumed that the industrial sized installations would undertake an east-west configuration on the rooftop and a 17% capacity factor was allowed. In the case of ground-mounted single-axis tracking systems this figure was 23%, due to the superior ability of tracking systems to capture solar irradiation.

Net present value (NPV) calculations for rooftop systems are based upon 15 years of future cash flows, due to the potential shorter life cycle of the business hosting the system compared to the expected 25-year productive life of the PV system. For ground-mounted systems and industrial systems, the NPV is also based upon 15 years of future cash flows. Cash flows from energy savings or sale of electricity to the grid were discounted at a real rate of 7.5%[27].

[27] As used in the AEMO Final Integrated System Plan 2022 (July 2022).

Table 8: Summary of assumptions utilised for net economic benefit calculations

	Commercial	Industrial	Ground-mounted
Capacity	250 kW	850 kW	200 kW
Solar profile	NSW rooftop	NSW rooftop	NSW rooftop
Capacity factor	16%	17%	23%
Demand profile	Commercial demand	Industrial demand	N/A
Real WACC[28]	7.5	7.5	7.5
NPV time	15 years	15 years	15 years
Electricity price	Commercial	Industrial	Wholesale

Note: Weighted Average Cost of Capital (WACC) is a proxy for the required return on capital investment and is used as the discount rate in this financial evaluation.

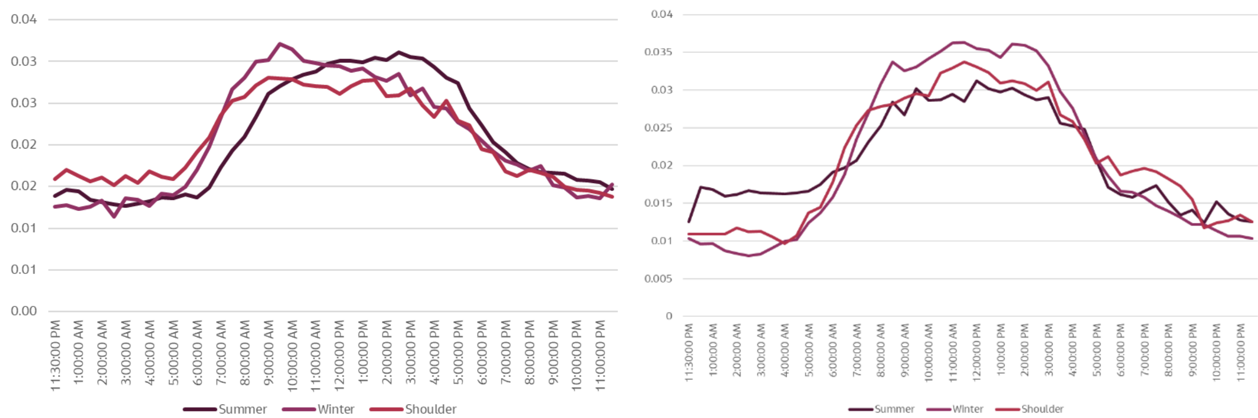
6.1 Assumptions

This section presents further assumptions used in the process of assessing economic benefit that relate to electricity consumption, electricity prices, and government schemes.

6.1.1 Electricity consumption

Industrial and commercial electricity consumption (load) shapes were obtained from a study conducted by CSIRO and are illustrated in Figure 4. These were measured and normalised over different periods of the year including summer, winter, and shoulder periods.

Figure 4: Normalised average daily load profiles for commercial customers (LHS), industrial customers (RHS), kWh/kW$_p$



Source: CSIRO technical report: Load and solar modelling for the NFTS feeders, 2015

The CSIRO study was used for this analysis as it is the only public source of information of this type known to Jacobs. Further, this analysis seeks to quantify the benefits to commercial and industrial users of PV systems and the underlying load shape of such users not already possessing PV systems is unlikely to have changed materially from 2015.

The load shapes were not adjusted for any COVID-19 impact for the following reasons:

[2828] Weighted average cost of capital

- It appears that COVID-19 has not had a material impact on industrial demand.
- In the commercial sector, COVID-19 is understood to have had an impact on the load shape for office buildings. However, this represents only a small proportion of the commercial sector, which includes a diverse range of businesses.

It was assumed for both the commercial and industrial cases, that the PV system size is optimised so that all solar generation output is consumed, and that no generation is exported.

6.1.2 Retail electricity prices

Grid (retail) electricity prices are likely to influence consideration of installing PV systems. Enterprises would likely form an expectation about future price trends, and if electricity prices are expected to increase in real terms then electricity expenditure could be reduced by installing a PV system.

Commercial prices are used for most enterprises including the retail, agricultural, and manufacturing sectors. Industrial prices are only considered applicable to major energy consumers connected to a high voltage line such as large hospitals, large manufacturing plants, and major university campuses.

The electricity price assumptions underpinning the analysis in this report are held constant in real terms. This reflects the balance between two conflicting influences: 1) The likelihood that the wholesale price of electricity is likely to decrease over the period to 2030 as more renewable generation is added to the total stock of electricity generation capacity under state government programs; and 2) The likelihood that there will be upward pressure on prices from increased expenditure on network augmentation, retail margins, and electricity storage costs.

6.1.3 LGC and STC schemes

Table 9 shows the averaged LGC price per calendar year used by Jacobs to estimate the annual benefits provided to mid-scale systems from the generation of renewable energy.

Table 9: Historical and projected annual LGC prices

Year	LGC price
2015	58.6
2016	89.6
2017	88.3
2018	78.9
2019	42.8
2020	38.2
2021	34.0
2022	50.0
2023	48.0
2024	43.0
2025	35.0

Source: LGC prices obtained from Clean Energy Regulator, Quarterly Carbon Market Report – June Quarter 2022, Figure 2; June spot and forward contracts.

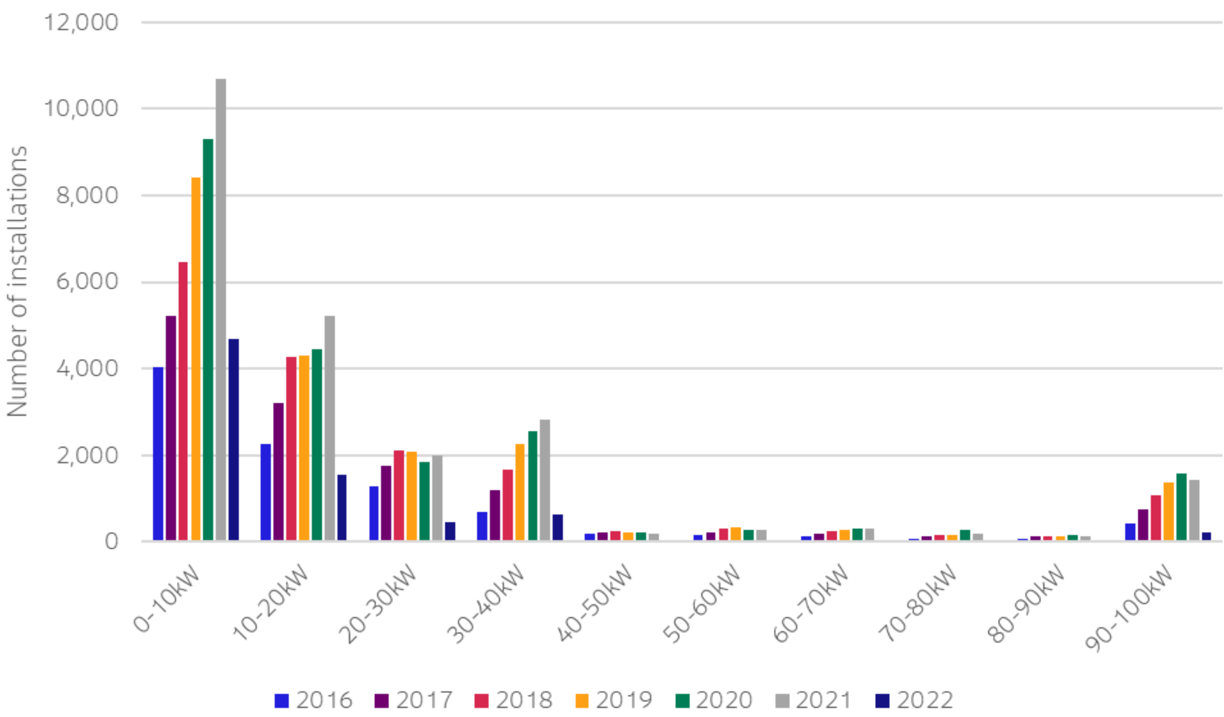
To calculate the benefits of mid-scale system, the marginal loss factor (MLF) for commercial and industrial mid-scale systems was assumed to be 1 (one).

Annual benefits for mid-scale systems were calculated by the following equation:

Annual benefits = capacity of system x capacity factor x 24 hours/day x 365 days/year x LGC price

Figure 5 shows the number of commercial small-scale PV installations by size bracket. In both 2020 and 2021 there were more than 1,500 behind-the-meter installations in the 90-100 kW bracket, which is more than the entire number of behind-the-meter mid-scale (100 kW to 30 MW) PV systems recorded in the 2016 to 2019 period.

Figure 5: Number of commercial small-scale installations by capacity bracket, 2016 to 2022



Source: Jacobs' analysis of CER data. 2022 data is incomplete.

It is also possible for these companies to undertake a second installation later, to optimise a system size for their energy requirements, while still obtaining the once-off STC rebate. The implication of this is that it may be attractive for some firms who wish to install systems larger than 100 kW to install two smaller systems consecutively. To explore this, Jacobs compared the financial impact of the two schemes by levelising higher future LGC payments against the upfront lump sum STC payment.

From this comparison Jacobs observed that:

- The STC rebates have a clear economic advantage for a 100 kW system over the LGC certificates.
- The difference between these benefits is relatively consistent across reference cases (i.e. commercial, industrial systems less than 100 kW).

Despite the projected decline in the deemed creation of STCs, the benefits from STCs are expected to be greater than those from LGCs over the projection period (as LGC prices are expected to decline). Therefore, Jacobs has assumed that companies will continue to install systems just shy of 100 kW at the current increasing trend (estimated in Jacobs' Small-scale Technology Certificate Projections report), and that the effect of LGC price decreases will not have a substantial impact on mid-scale PV uptake.[29]

6.2 Economic benefit estimates

To estimate the economic benefits of mid-scale solar PV installation, the NPV is calculated as:

NPV = capital cost – 1st year LGC payment + 1st year energy savings cash flow + NPV (9 years cash flows)

The payback period is calculated as:

Payback Period = (capital cost x real WACC) / (average annual energy savings + average annual LGC payment)

The economic benefits of PV installations where the PV generation matches well with typical daily demand results in a continuing high uptake rate for mid-scale PV for such enterprises. The results for commercial and industrial systems are presented in the following sub-sections.

6.2.1 Commercial 250 kW behind-the-meter system

Commercial rooftop systems (250-850 kW) are assumed to operate at a capacity factor of 16%. For a 250 kW system, this would lead to output of approximately 350 MWh per year.

Based on the assumed parameters, the payback period for a commercial 250 kW rooftop system is outlined in Table 10. Payback periods have dropped steadily since 2012, driven by a continual drop in capital cost and high LGC prices. The payback period is projected to continue to decline for the remainder of the projection period despite a reduction in LGC.

Table 10: Payback period of 250 kW commercial PV systems

Year	Capital cost ($)	1st year cash flows ($)	Payback (years)	IRR (%)
2023	340,750	30,945	11	3
2024	327,250	30,783	11	4
2025	314,750	30,544	10	4
2026	302,500	30,162	10	5
2027	291,250	29,653	10	5

Note: Cashflow captures LGC payments plus reduced grid electricity cost. Average demand is 200 kW, capacity factor = 0.16, discount rate is 7.5%

6.2.2 Industrial 850 kW behind-the-meter system

The key differentiator for the economic analysis of industrial PV systems (850 kW to 30 MW) compared with commercial systems is based on the retail price assumption. The electricity retail price for large industrial customers is generally less than for commercial businesses.

The results of the analysis for industrial PV systems are presented in Table 11. Key assumptions driving the results are:

[29] Note that this is subject to periodic reviews conducted by the Climate Change Authority

- Average demand of 850 kW.
- A flat retail tariff of 15 cents per kWh.
- No feed-in-tariff (for exports of excess electricity generation).
- Decreasing LGC prices.

Table 11: Payback period of 850 kW industrial high voltage PV systems

Year	Capital cost ($)	1st year cash flows ($)	Payback (years)	IRR (%)
2023	1,158,550	43,574	27	-9
2024	1,112,650	42,870	26	-8
2025	1,070,150	41,592	26	-8
2026	1,028,500	40,184	26	-8
2027	990,250	37,980	26	-8

Note: Assumed average demand is 850 kW and constant throughout the year with no seasonal variation, discount rate of 7.5%

6.2.3 Fixed angle ground-mounted front-of-meter systems

The assumptions for assessing the uptake of ground-mounted systems were that a 200 kW ground-mounted system is set with fixed tilt at a 19% capacity factor in New South Wales, and average annual wholesale solar dispatch-weighted prices reflect those of New South Wales.

An extended period of cash flows of 15 years was considered for ground-mounted systems, under the assumption that these assets are considered a long-term investment and are less dependent on the life of a host business. The NPV was calculated as the present value of 15 years of energy sales plus LGC payments at a real discount factor of 7.5%.

The results of the NPV and payback period are outlined in Table 12. Key assumptions include:

- Export-only, so no saving by reducing grid demand.
- A daily fixed charge for grid connection converted to a per kWh charge.
- A PPA averaging $60 per MWh.

Table 12: NPV and payback estimates of a 200 kW, fixed angle ground-mounted system

Year	Capital cost ($)	1st year cash flows ($)	Payback (years)	IRR (%)
2023	272,600	40,749	7	7
2024	261,800	39,566	7	7
2025	251,800	37,328	7	7
2026	242,000	35,051	7	7
2027	233,000	31,347	7	6

The results indicate that these systems are not a good investment if cash flows are only dependent upon LGC payments and wholesale energy sales to the market. This indicates that for mid-scale ground-mounted fixed tilt PV arrays to be a reasonable investment, either expected energy prices must be higher or they must be installed in behind-the-meter applications and/or have a reasonable PPA arrangement. The other case where front-of-the-meter fixed tilt systems would be financially beneficial is in the case of remote communities where the solar generation displaces the cost of diesel generators, or in fringe of grid applications where solar generation would replace higher energy costs (due to the high losses incurred in transmitting energy).

7. Projections of uptake

This section presents the results for the uptake of mid-scale PV systems, based on the modelling and analysis described in Sections 4-6.

7.1 Behind the meter systems

Figure 6 shows a stacked column chart of new installations by category since 2001 and the projections to 2027. Retail has featured prominently since 2018 and this continues over the projection period. The education sector has been the most consistent contributor over the years, and a flat rate of uptake is projected. Figure 7 indicates that the Commercial category account for the largest new capacity by year.

Figure 6: Uptake of PV systems by segment, 100 kW - 1 MW

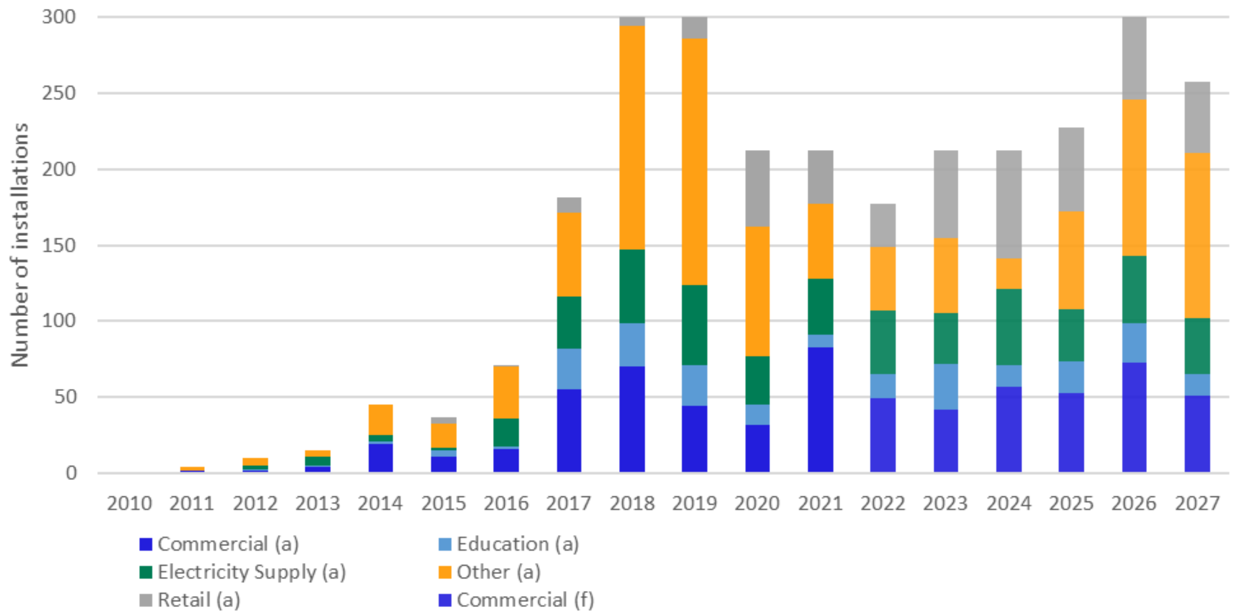
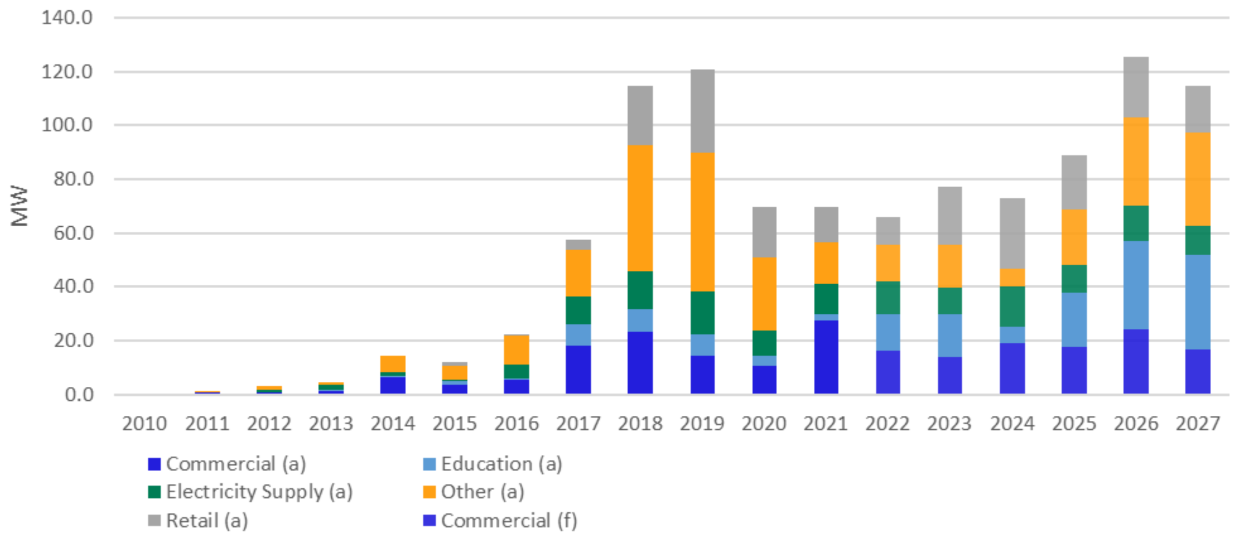


Figure 7: New PV system capacity installed by segment, 100 kW - 1 MW



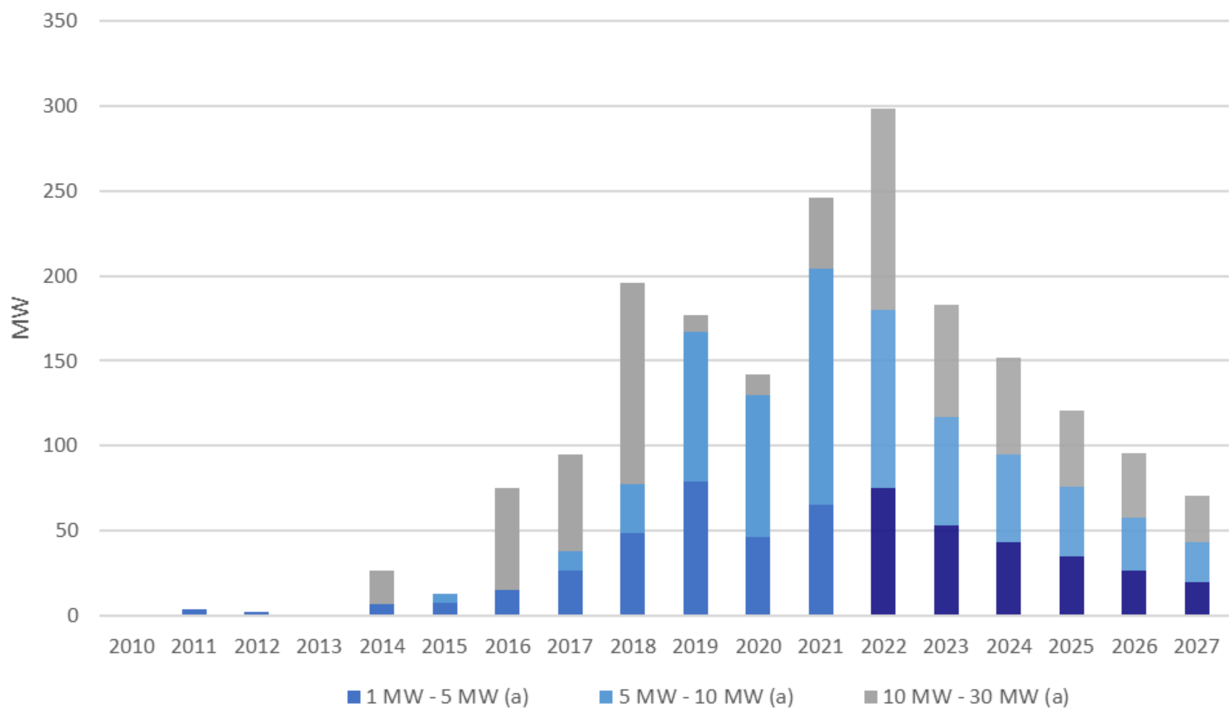
The charts indicate two phases: an initial exponential growth phase up to 2018, followed by a subsequent consolidation phase (i.e. decelerating growth).

The pre-2019 phase likely reflects a combination of favourable financial incentives and a rich choice of relatively easy site amenable to PV installation. The 2019 -2022 phase reflects a more difficult environment, but still favourable enough to justify PV installations.

7.2 Front of meter systems

Figure 8 shows the history and forecast of the front of meter system capacity by year. There is a clear deceleration in growth forecast, reflecting the analysis contained in this report.

Figure 8: New front of meter system capacity by capacity band



7.2.1 Systems of 1-5 megawatts

There are two main categories identified that fall within this front-of-meter capacity segment:

- Solar farms in remote communities to offset diesel consumption.
- Mid-scale solar farms designed to trade electricity in the wholesale market.

The establishment of mid-scale solar farms designed to trade in the NEM is considered to have different economic incentives to commercial behind-the-meter systems.

A bottom-up approach was also adopted to project uptake for both these categories of mid-scale solar PV. This section outlines the assumptions surrounding Jacobs' estimates of these front-of-meter system projections of less than 5 MW capacity.

Table 13 shows the historical uptake of the front-of-meter sub 5 MW installations. It is difficult to spot a reliable trend by category. The most reliable trend indication is provided by the 'Total' row.

Table 13: Summary of front-of-meter 1 MW-5 MW installation of PV system capacity by year

Category	2009	2011	2012	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Agriculture							3	4	3	5			15
Commercial				4	1	2		13	6	5	21	1	54
Education			2				12	3	4	5			26
Electricity supply		4			2	10	8	7	20	7	34	6	99
Government								2	1				3
Health											1	2	3
Industrial								1	10	5			16
Logistics/ warehousing	1						2	2	1	11	2		20
Manufacturing						1	1		5				7
Mining							1	4	2	6			13
Recreation	1												1
Retail				3				11	24	4	6		48
Services					5	2					1		8
Water treatment									2				2
Total	**2**	**4**	**2**	**7**	**8**	**16**	**27**	**49**	**79**	**47**	**65**	**10**	**315**

As shown in Table 14, there is an expectation that this category will continue to grow steadily through to 2027.

Table 14: Projections of cumulative capacity by year, 1-5 MW systems

	2022	2023	2024	2025	2026	2027
1-<5 MW systems	377.9	429.1	469.7	500.6	523.1	538.2

7.2.2 Ground-mounted community installations

An increase in mid-scale community based solar systems has been observed over the past few years. The incentive for establishing such units is not only to supply renewable energy to remote communities, but also to offset diesel consumption. Some of the programs that have promoted installations are outlined below.

7.2.2.1 Norther Territory: Solar Energy Transformation Program

The Solar Energy Transformation Program (SETuP) was an initiative by the Northern Territory Government to integrate 10 MW of solar PV into 25 remote locations with existing diesel power stations[30]. The majority of these were expected to achieve 15% of diesel fuel displacement. The $59 million project was designed to create a platform for greater use of renewable energy in communities. Construction began mid-2014 and has

[30] https://arena.gov.au/projects/northern-territory-solar-energy-transformation-program/

recently been completed. It is therefore assumed that no further major PV projects will occur in Northern Territory remote communities for the remainder of the projection period.

7.2.2.2 Queensland: Decarbonising Remote Communities program

The $3.6 million Decarbonising Remote Communities program formed part of a broader scheme for investment in renewable energy generation established by the Queensland government during the 2017 state elections[31]. Four Indigenous communities in Queensland's far north (Doomadgee, Mapoon, Pormpuraaw and the Northern Peninsula area) have been selected as part of this program to have renewable energy systems installed to reduce the use of diesel power.

Solar PV installations at Doomadgee and Mapoon have already begun, and the 304 kW system at Doomadgee is assumed to contribute to the mid-scale solar installations completed in 2019. The intention at Mapoon however, had a total of 104 kW solar PV installed across the rooftop of 4 separate buildings[32]. These are not mid-scale solar installations. Similarly, a further 550 kW of rooftop solar was installed on 21 buildings in the Pormpuraaw and Northern Peninsula regions during 2020, but again these were small-scale installations.

There have been no further announcements for additional projects under this program. However, Ergon Energy owns and operates 33 standalone power stations in Queensland that supply 38 remote communities, typically operated by diesel generators[33]. This opens the opportunity for further solar PV installations to partially offset diesel generation at these communities, although it is assumed in this study that any PV installations at these sites would be small-scale (less than 100 kW).

7.2.2.3 South Australia: remote mid-scale solar

Electricity is supplied to around 2,400 customers in 13 remote towns through the Remote Areas Energy Supplies (RAES) scheme and to a further 1,000 customers living in remote Aboriginal communities via the RAES Aboriginal Communities scheme.

The Central Powerhouse is the primary electricity generation facility that supplies eight aboriginal communities, and a further four power stations are in other aboriginal communities.

Stand-alone diesel and gas generators supply electricity at most RAES sites. These sites are being evaluated for cost effectiveness of implementing renewable energy solutions such as solar or wind.

With low population densities at each of these towns, it is assumed that any systems installed would fit into the small-scale classification and will not contribute to capacity in the mid-scale segment.

7.2.2.4 Western Australia: remote communities solar project

As a part of its commitment to clean energy, the Western Australian Government announced plans to invest $11.6 million for the construction of solar farms in remote Kimberley Aboriginal communities[34]. Six remote community towns have been identified as part of the program that will involve up to 4 MW of solar PV installed at around 400 kW to 600 kW per site. Planning is underway for projects to be completed in the east Kimberly remote communities of Warmun and Kalumburu. It is assumed that 500 kW will be installed at each of these sites.

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[31] https://www.dnrme.qld.gov.au/energy/initiatives/solar-remote-communities

[32] https://arena.gov.au/projects/doomadgee-solar-project/

[33] https://www.ergon.com.au/network/network-management/network-infrastructure/isolated-and-remote-power-stations

[34] https://onestepoffthegrid.com.au/w-a-to-fund-solar-farms-in-six-remote-indigenous-communities/https://horizonpower.com.au/our-community/projects/remote-communities-centralised-solar-project/

Construction was scheduled for solar farms in the west Kimberley communities of Ardyaloon, Beagle Bay, Djarindjin-Lombadina and Bidyadanga in 2021. However, only some of the solar projects in these Kimberley communities have appeared in the CER's mid-scale database. Jacobs has assumed that program will be completed in the 2022 and 2023 years.

7.2.2.5 Western Australia: Recovery Plan

In July 2020, the Western Australian Government announced plans to invest $66.3 million in renewable energy, most of which would be spent on solar and battery projects. This formed a part of its $5.5 billion 'Recovery Plan' to combat the economic impacts of COVID-19. Among other things, the stimulus package has allocated funds to an additional 50 standalone power systems, largely aimed at regional communities and remote indigenous communities. For the purposes of this study, it is assumed that these systems will be >100-150 kW each installed over a five-year period beginning in 2022.

7.2.3 Systems greater than five megawatts

This section includes a discussion of the mid-scale solar PV projections for systems greater than 5 MW capacity, with references to smaller systems of 1-5 MW. These solar PV plants are considered utility scale or community projects, ground-mounted and, in most cases, directly connected to a high-voltage distribution or sub-transmission network.

For PV systems with capacity less than 5 MW, the connection process to the grid is less time-consuming and less costly. Systems of this size can submit a network connection application as an embedded generator under Chapter 5, Part A of the National Electricity Rules. These embedded generators then negotiate a connection agreement with the applicable Network Service Provider, who generally imposes less stringent requirements than for larger systems.

To a lesser degree there are also less strict requirements for the connection application of generators applying under Chapter 5, Part B of the NER for systems with a nameplate capacity larger than 5 MW but not more than 30 MW. These systems are typically considered non-scheduled generating units. Classification of generator size by AEMO is summarised in Table 15.

Table 15: AEMO classification of generators

AEMO classification	Exempt	Non-scheduled	Semi-scheduled	Scheduled
Nameplate capacity	Up to 5 MW	5-30 MW	>30 MW	>30 MW
Note	Free to generate; not curtailed.	Does not participate in central dispatch but can be curtailed.	Participates in central dispatch in specified circumstances.	Participates in central dispatch.

Source: AEMO

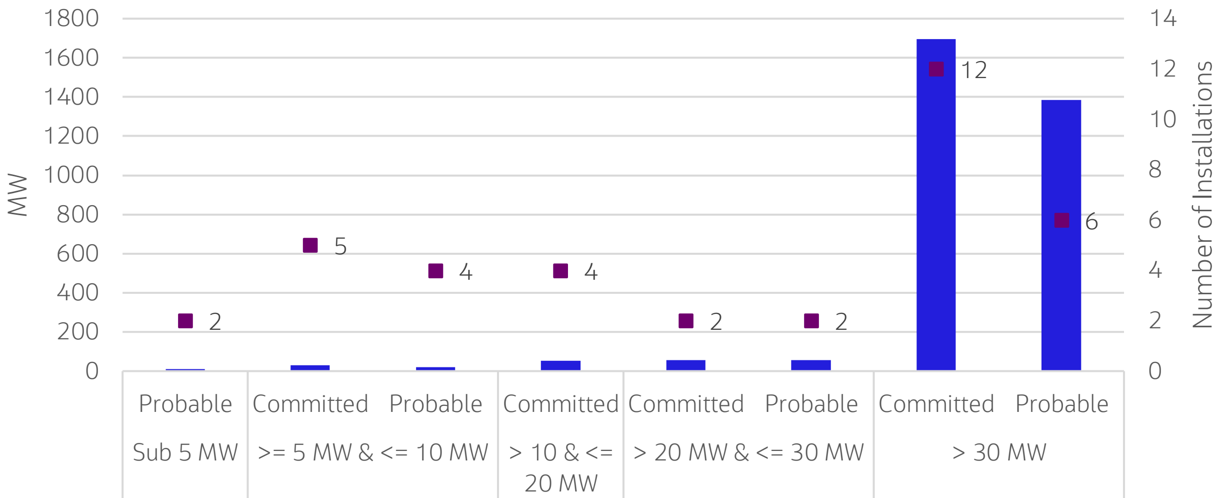
As observed over the past few years through anecdotal evidence, there is a tendency for proponents to avoid the interaction with AEMO by developing multiple embedded solar farms of 5 MW rather than larger non-scheduled systems up to 30 MW.[35] This may be due to the strict requirements for obtaining connection approvals, combined with delays in processing connection applications by AEMO.

The CER lists 17 PV system projects between 5-30 MW under development in Australia as at September 2022, which are listed in Appendix A. Compared to previous years, it appears that there are more projects

[35] This is supported by several recent publications, including:
https://reneweconomy.com.au/solar-developers-downsize-to-dodge-complex-and-costly-connection-rules-39495/
https://www.pv-magazine-australia.com/2020/02/28/small-scale-utility-solar-thriving-on-path-of-least-resistance/

with capacity of more than 30 MW. Widespread media coverage indicates that a growing number of Australian large energy consumers are actively implementing decarbonisation strategies.[36] The project pipeline of those 17 ground-mounted solar PV systems underway totals almost 216 MW of capacity, representing an average of 12.7 MW per project). Figure 9 shows the total capacity and number of projects for each of the mid-scale categories.

Figure 9: Overview of mid-scale project pipeline, ground-mounted systems



Source: Multiple sources, see Appendix A for details

7.3 Summary of PV projections

This section presents a summary of the results (in calendar years) of all the mid-scale PV projections. Table 16 summarises Jacobs' projected installed capacity of mid-scale systems over the 5-year period by segment.

There is still substantial room for growth in uptake in the mid-scale PV behind-the-meter sector. Projected installations are dominated by systems for commercial use, which is consistent with the large potential market size and economic benefits that these systems bring. The production of energy at the site of consumption and opportunistic utilisation of otherwise unutilised rooftop can be both economic and practical.

Industrial behind-the-meter systems represent a relatively small proportion, accounting for 8% of total installed systems. Out of the 114 behind-the-meter systems categorised as industrial, 105 were installed in the years 2018 to 2020 (inclusive) with only four PV systems installed in 2021 and 2022. Given this and the less than compelling financial assessment, it is likely that there will only be a few installed in the projection horizon.

With respect to front-of-meter systems, the number across segments are too small to provide segment specific projections. Within the 10 MW to 20 MW capacity band, 13 installed systems (out of a total of 19) correspond to the Electricity Supply segment. The remainder are spread across Agriculture, Commercial, Manufacturing, and Services. Across these segments, there is a reasonable prospect of seeing a similar number over the projection horizon. The motivation likely to be split across financial and non-financial drivers.

Table 16: Summary of projected capacity mid-scale PV installations 2022-2027, MW

[36] For example, see this article published by the Australian Energy Council: https://www.energycouncil.com.au/analysis/four-pathways-to-decarbonisation/

Mid-scale Solar PV System Projections

Segment	2022	2023	2024	2025	2026	2027
Behind-the-meter systems	535	629	713	790	859	920
Aged Care	23	29	35	41	46	51
Agriculture	51	66	81	98	114	131
Airports	13	14	14	14	14	14
Commercial	111	116	119	121	122	121
Government	6	7	7	8	8	9
Hospitality	21	31	41	51	61	69
Hospitals	14	18	22	25	28	31
Logistics/Warehousing	22	23	24	25	25	25
Manufacturing	43	57	71	85	97	108
Mining	80	91	96	98	98	97
Recreation	8	10	11	13	14	15
Retail	132	155	177	198	218	236
Water Treatment	11	12	13	13	14	13
Front-of-meter systems	1,275	1,458	1,609	1,731	1,826	1,897
1-5 MW Systems	378	431	474	509	536	556
5-10 MW Systems	460	524	576	617	648	671
10-30 MW Systems	437	503	560	605	643	671
Total	1,810	2,087	2,322	2,521	2,684	2,817

The 20 MW to 30 MW systems are all most likely to be installed in the Electricity Supply segment, since all four systems installed correspond to Electricity Supply.

Compared to previous years, it appears that the impetus to decarbonise the Australian economy will spur continued growth for mid-scale PV systems.

Appendix A. Ground-mounted front-of-meter projects by status

Table 17: Ground-mounted solar projects by status (less than 30 MW)

Project Name	Status	State	MW capacity	Capacity category
BHP's Leinster Solar project	Committed	WA	10.7	> 10 & <= 20 MW
BHP's Mt Keith Solar project	Committed	WA	27.4	> 20 MW & <= 30 MW
Cosgrove solar farm	Committed	VIC	5	>= 5 MW & <= 10 MW
Greenough Solar Farm Stage 2	Committed	WA	30	> 20 MW & <= 30 MW
Happy Valley Reservoir - Solar	Committed	SA	12	> 10 & <= 20 MW
Mangalore Renewable Energy Project	Committed	VIC	5	>= 5 MW & <= 10 MW
McCain Ballarat Solar Plant	Committed	VIC	7	>= 5 MW & <= 10 MW
Melbourne Water ETP Solar	Committed	VIC	19	> 10 & <= 20 MW
Narromine Renewable Energy Project	Committed	NSW	5	>= 5 MW & <= 10 MW
Tullamarine Airport Solar Farm	Committed	VIC	12.4	> 10 & <= 20 MW
Waurn Ponds Smart Energy Project	Committed	VIC	7.25	>= 5 MW & <= 10 MW
Byford Solar Project	Probable	WA	30	> 20 MW & <= 30 MW
Byron Bay Solar Farm	Probable	NSW	4.99	Sub 5 MW
Kalbarri Microgrid Project	Probable	WA	5	>= 5 MW & <= 10 MW
Manilla Community Solar	Probable	NSW	4.5	Sub 5 MW
Orange Community Renewable Energy Park	Probable	NSW	5	>= 5 MW & <= 10 MW
Planet Ark Power - Schneider Electricity PV and Battery Project	Probable	SA	5.7	>= 5 MW & <= 10 MW
SA Water floating PV	Probable	SA	5	>= 5 MW & <= 10 MW
Walgett Solar Farm	Probable	NSW	25	> 20 MW & <= 30 MW

Source: Clean Energy Regulator, 2022

Appendix B. Segment to 2-digit ANZSIC grouping

Table 18 lists the allocation of power stations to Jacobs segments. Ensuring consistency of allocation can be challenging, so an intermediate step is to use the ABS ANZSIC classification system[37]. In some cases, the same 2-digit code appears in more than one segment. These clashes were resolved by searching for additional information and using a 3-digit (or longer code) to determine the allocation. For example, there is ambiguity with respect to distinguishing between Hospitality and Tourism[38].

Table 18: Segmentation breakdown

Segment	2-digit ANZSIC code	ANZSIC Title
Aged Care	86	Residential Care Services
Agriculture	01	Agriculture
Agriculture	05	Agriculture, Forestry and Fishing Support Services
Airports	52	Transport Support Services
Commercial	33	Basic Material Wholesaling
Commercial	35	Motor Vehicle and Motor Vehicle Parts Wholesaling
Commercial	36	Grocery, Liquor and Tobacco Product Wholesaling
Commercial	67	Property Operators and Real Estate Services
Community Service	95	Personal and Other Services
Education	80	Preschool and School Education
Education	81	Tertiary Education
Electricity Supply	26	Electricity Supply
Government	75	Public Administration
Health	85	Medical and Other Health Care Services
Hospitality	45	Food and Beverage Services
Industrial	15	Pulp, Paper and Converted Paper Product Manufacturing
Industrial	19	Polymer Product and Rubber Product Manufacturing
Industrial	21	Primary Metal and Metal Product Manufacturing
Industrial	24	Machinery and Equipment Manufacturing
Industrial	25	Furniture and Other Manufacturing
Industrial	29	Waste Collection, Treatment and Disposal Services
Industrial	31	Heavy and Civil Engineering Construction
Industrial	33	Basic Material Wholesaling

[37] for details, see: https://www.abs.gov.au/ausstats/abs@.nsf/0/20C5B5A4F46DF95BCA25711F00146D75

[38] For details, see: https://www.abs.gov.au/methodologies/australian-national-accounts-tourism-satellite-account-methodology/2020-21

Industrial	36	Grocery, Liquor and Tobacco Product Wholesaling
Industrial	37	Other Goods Wholesaling
Logistics/Warehousing	53	Warehousing and Storage Services
Manufacturing	11	Food Product Manufacturing
Manufacturing	12	Beverage and Tobacco Product Manufacturing
Manufacturing	13	Textile, Leather, Clothing and Footwear Manufacturing
Manufacturing	14	Wood Product Manufacturing
Manufacturing	19	Polymer Product and Rubber Product Manufacturing
Manufacturing	20	Non-Metallic Mineral Product Manufacturing
Manufacturing	21	Primary Metal and Metal Product Manufacturing
Manufacturing	22	Fabricated Metal Product Manufacturing
Manufacturing	24	Machinery and Equipment Manufacturing
Mining	09	Non-Metallic Mineral Mining and Quarrying
Recreation	44	Accommodation
Recreation	89	Heritage Activities
Recreation	91	Sport and Recreation Activities
Retail	41	Food Retailing
Retail	42	Other Store-Based Retailing
Services	59	Internet Service Providers, Web Search Portals and Data Processing Services
Services	60	Library and Other Information Services
Services	69	Professional, Scientific and Technical Services (Except Computer System Design and Related Services)
Services	95	Personal and Other Services
Tourism	44	Accommodation
Tourism	45	Food and Beverage Services
Water Treatment	28	Water Supply, Sewerage and Drainage Services

Appendix C. Developing uptake constraint assumptions

The uptake of solar PV systems is not an instantaneous decision and action. A variety of constraints can impede uptake, such as:

- Available land or roof space
    - Size of land area required to achieve a level of desired output
    - Site difficulty due to the height of buildings or other accessibility issues
    - Land tenure and whether the landowner or tenant has the incentive or right to install a system
    - The number of available sites
- Installing industry capacity to install systems, which may act as an upper limit.
    - For example, the technical capacity to evaluate, design and install systems is relatively scarce.
    - The proximity of prospective sites to installers
    - The extent of marketing and searching required for business development
- Financial benefit, both current and future.
    - Extent of familiarity with photovoltaic technology in the context of realising an ongoing business benefit. For example, word of mouth among fellow business owners or between technical salespeople and prospective buyers.
    - Forward expectations about future return, the immediacy and materiality of the returns.
        - Fluctuating subsidies, rebates, feed-in-tariff and system installation costs complicate the assessment
        - Outlook for the price of electricity tariffs. On-site generation can offer a degree of insurance against future periods of rapid price escalation.
        - The degree of match between business use of electricity and the availability of photovoltaic electricity generation.
    - The primary business operating state (i.e., growth or consolidation). Considerations of photovoltaic installations may be more urgent during periods of consolidation when revenue is slowing or shrinking.

Constraint assumptions reflected in the Gompertz model

For this report, the above considerations have been split into physical and financial constraints. The physical constraints are reflected in the Gompertz model, which implicitly recognises the past rate of installations as reflecting some of the short-term constraints related to installation and the physical constraints associated with the sales and installation cycle. The Gompertz model also reflects the medium-term relaxation of these constraints as well as the ultimate physical constraint of site availability and suitability.

Assumptions about the availability of suitable sites

There are several underlying assumptions in determining site availability in the following order:

- The number of business sites
- The land area occupied by business
- The proportion of business sites already installed (evaluated across both small and midscale systems)
- The density of installed sites and prospective sites

Number of business sites

The Australian Bureau of Statistics periodically publishes business count data.[39] The most recent data indicates more than 2 million business operating in Australia. Many of these businesses are sharing buildings, which likely substantially limits the number of businesses that could practically consider installation.

Land area occupied by business

Given the many-to-one relationship between business counts and buildings, it is reasonable to examine land parcel data. The Australian Bureau of Statistics publishes geospatial mesh block data containing the categorisation of land by type of use.[40]

The mesh block contains two relevant categories: Commercial; Industrial. These mesh blocks contain both a measurement of area and the location.

Proportion and density of sites already installed compared to potentially available sites

The Clean Energy Regulator provides data about the number of small-scale photovoltaic installations by post code.[41] Unfortunately, the data does not separate commercial from residential installations. By assuming a given propensity for various industries to install solar systems, the split between commercial, school and residential sites can be estimated.

This split recognises that retail outlets and warehouses have a higher propensity to install systems, the relative land area available between commercial and residential can be estimated from the mesh block data.

Once the number of small-scale commercial sites is estimated for a given post code, the midscale installation location data is added. The remainder is the land area still potentially available for installing photovoltaic systems is calculated. The remaining area also needs to be split between small and midscale, which is based on the estimated ratio of past small to midscale systems.

[39] "8165.0 Counts of Australian Businesses, Including Entries and Exits, June 2017 to June 2021."

[40] "Mesh Blocks | Australian Bureau of Statistics."

[41] "Postcode Data for Small-Scale Installations."

Constraint assumptions reflected in the financial model

Applying a financial evaluation implicitly captures a range of constraints that directly impact the size of any benefit that might accrue. The key assumptions in this report are:

- Installation cost, both now and in the future
- Large-scale Generation Certificate prices, which can offset the installation cost over time
- The size of likely saving, which is based on the degree of similarity between the load profile and the photovoltaic output profile.
- The electricity tariff, both current and future.