Mid-scale Solar PV System Projections

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Jacobs Group (Australia) Pty Ltd

Floor 13, 452 Flinders Street
Melbourne, VIC 3000
PO Box 312, Flinders Lane
Melbourne, VIC 8009
Australia

T +61 3 8668 3000
F +61 3 8668 3001
www.jacobs.com

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 2024 up to and including 2030. Mid-scale PV systems are defined as having a capacity range of greater than 100 kilowatts (kW) and less than or equal to 30 MW. Large-scale Generation Certificates (LGCs) may be created by 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, although there has been an increasing trend of voluntary surrender of certificates, typically by corporations, to meet their emission reduction pledges. This has provided a financial incentive for the installation of these systems.

Historical trends

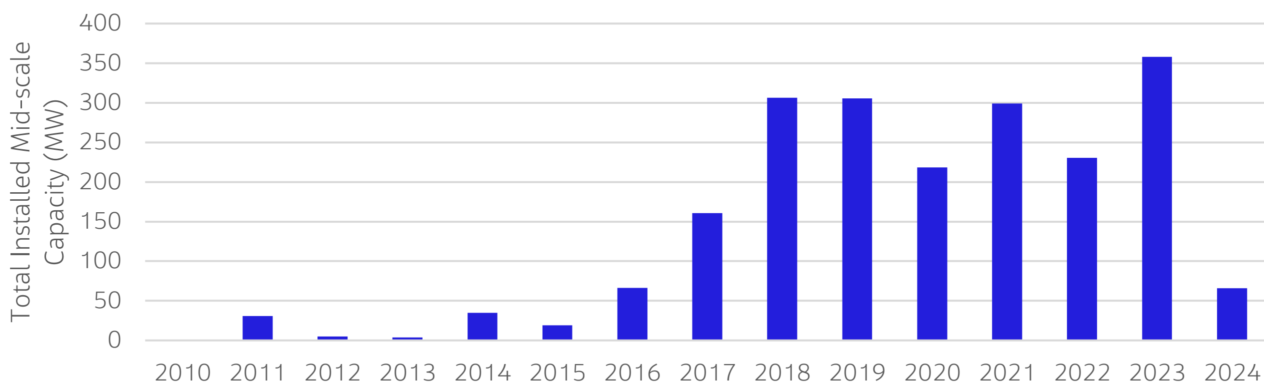
Figure 1 shows the total installed mid-scale capacity up to April 2024. Installation dates correspond to the date of first generation, unless this value was denoted as not applicable for a particular plant, in which case the initial application date was used. Relatively high retail electricity prices 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 for both behind-the-meter installations and front-of-meter systems that export all energy to the grid. Uptake of mid-scale PV systems softened again in 2022 with lower installations of front-of-meter systems. However, record electricity prices brought about by a spike in the cost of fuel in mid-2022 caused by the war in Ukraine, sparked another surge in mid-scale uptake in 2023 with the largest gains in the front-of-meter segment of the market. As a result, 2023 was a record year for mid-scale uptake and for front-of-meter uptake with 358 MW of capacity installed in total.

The decline of electricity prices since then seems to have prompted a decline in activity in the mid-scale sector. There have been 66 MW of mid-scale installations until April 2024, although we expect this is somewhat muted by registration lag. Indications are that capacity installed in 2024 will reduce back to levels like 2020 and 2022.

Figure 1: Trend in installations of mid-scale PV systems, Australia, 100 kW to 30 MW systems



Projections

Projecting of mid-scale PV systems is inherently difficult. This study bases projections primarily on the estimated economic benefit and capability of uptake in 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.

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. Mesh blocks data from the Australian Bureau of Statistics (ABS) was used to estimate the potential market size: of the estimated market size of more than 37,000 potential premises for mid-scale solar PV, only 2,175 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 for behind-the-meter installations is expected to reduce further for the remainder of the projection period, primarily driven by a reduction in the capital cost of solar PV and the

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

increasing cost of retail electricity over the medium to long term. This assumed cost reduction is partially offset by an expected decline in LGC prices from current levels, as indicated by futures prices and a lack of new government incentives. However, on balance, the economic benefit of installing mid-scale systems for behind-the-meter applications continues to improve.

The case for front-of-meter systems is not as clear. The Federal Government's expansion to the Capacity Investment Scheme, which seeks to install 23 GW of new renewable capacity across Australia by 2030, is expected to put downward pressure on the dispatch-weighted pool price for a solar generator in the medium term. This, coupled with the continuing pace of small-scale PV uptake by families and businesses makes investing in mid-scale front-of-meter systems less attractive.

Key findings

The key findings of this report are as follows:

- The CER has 2,137 mid-scale PV installations in Australia to date, representing a total capacity of 2,108 megawatts (MW) as of April 2024. These figures include installations with applications for accreditation which are currently under assessment, but Jacobs have assumed that all of these applications will be approved. More than 90% of installations have occurred since 2014.

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

- For the period 2019 to (April) 2024, across all sectors the annual average:

    - Number of new installations was 236.

    - Installed capacity was 243 MW.

    - Installed capacity per site was 1.0 MW.

- Jacobs has projected installed capacity of mid-scale systems to increase by 223 MW in 2024 (full year estimate) ranging up to an increase of 254 MW in 2030. This is driven by the economic benefits, particularly for behind-the-meter systems, relatively low market saturation, the practical application of energy production and consumption at the same site, utilisation of excess rooftop space and recent announcements of new government programs.

Table 1 summarises the annual installations of capacity projected for mid-scale PV systems across Australia from 2024 to 2030, inclusive. It divides the data into behind-the-meter systems, and front-of-meter systems of varying capacities.

Table 1: Summary of incremental projected capacity of mid-scale PV installations 2024-2030, MW

Segment	2024	2025	2026	2027	2028	2029	**2030**
Behind-the-meter systems	142	157	170	185	203	213	226
Aged Care	3	3	4	4	3	3	4
Agriculture	5	5	5	5	5	4	5
Airports	0	1	0	0.5	5	1	0
Commercial	37	41	44	44	45	44	49
Education	5	5	5	5	5	5	4
Government	2	2	2	2	2	2	2
Hospitality	0	0	0	0	0	0	0
Hospitals	3	3	4	4	4	5	7
Logistics/Warehousing	8	10	13	17	20	25	30
Manufacturing	27	27	27	27	25	23	24
Mining	1	2	2	2	2	2	3
Recreation	2	3	3	3	3	4	5
Retail	24	32	41	53	67	79	78
Water Treatment	8	5	3	2	1	1	1
Other	17	18	18	17	15	14	15
Front-of-meter systems	81	32	36	28	28	29	28
0.1-5 MW Systems	2	9	2	1	1	2	1
5-10 MW Systems	32	7	5	6	6	6	6
10-30 MW Systems	47	16	29	21	21	21	21
Total	223	189	206	213	231	242	253

Note: 2024 total is estimated, actual is 66 MW as of April 2024

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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 2024 to 2030 (inclusive).

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

- Projecting historical trends of mid-scale PV systems over the six calendar years from 2024 to 2030. 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 April 2024.

- 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.

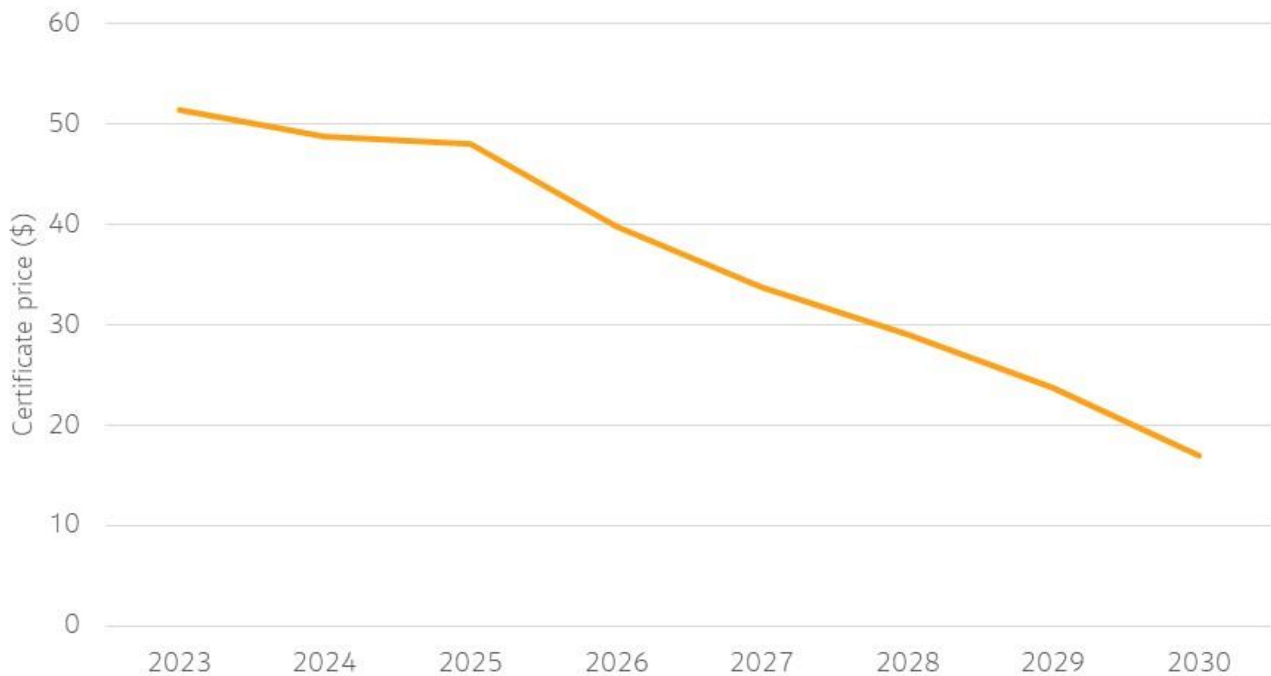
2. Federal Government incentives

The Large-scale Renewable Energy Target (LRET)[2] 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 2 shows the current and predicted LGC prices through to 2030[3]. The price of LGCs is expected to decline throughout the 2020s from its current (as at May 2024) trading range of $45 to $50 per certificate to an average price of less than $20 by 2030.

Figure 2: Current and projected LGC prices



Source: Jacobs analysis

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.

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

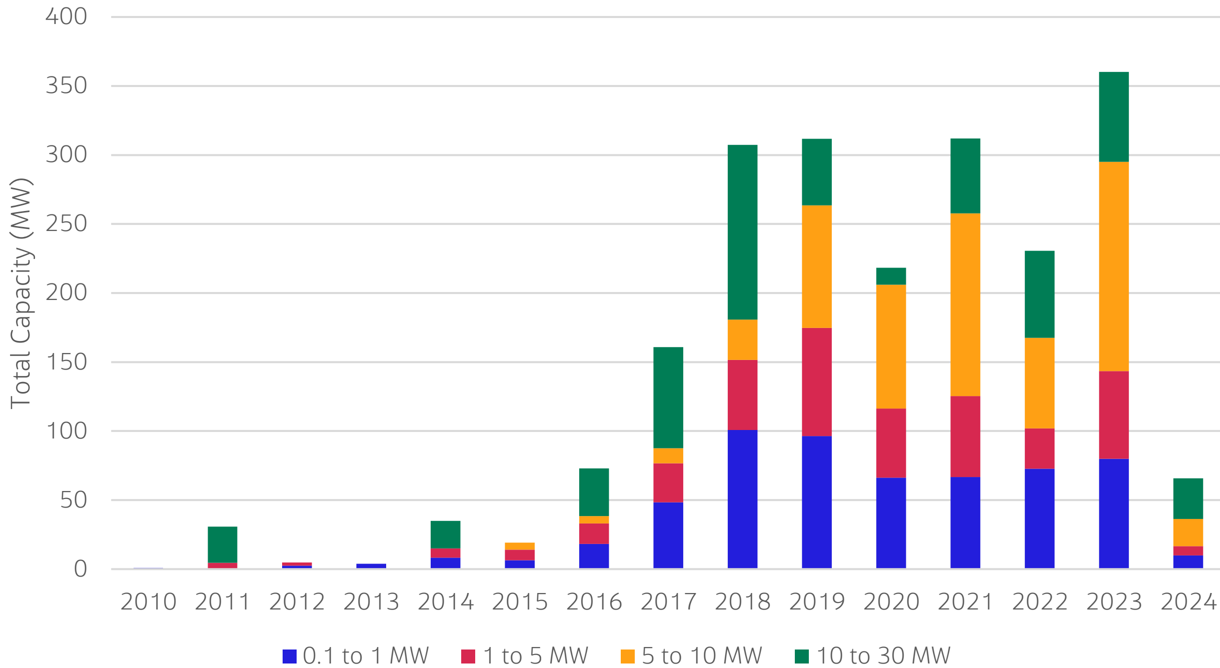
[3] Predicted LGC prices are based on published forward prices.

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. Trends in uptake

Mid-scale PV installations of 100 kW to 30 MW in size have recently experienced growth in installation rates. Figure 3 highlights the trends for the installed capacity of these mid-scale systems categorised by capacity.

Figure 3: Trend in installed capacity of mid-scale PV systems, Australia, 100 kW to 30 MW systems



Source CER dataset, 2024 incomplete dataset, estimate for full-year 2024 is 229 MW

The years indicate primarily first generation date of the plants installed, but if first generation date for a plant was denoted as not applicable, then the initial application date was used. For entries with an "not applicable" generation date their application dates fall almost exclusively between 2015-2018, so it was assumed there was an issue with generation date data capture for these sites.

Projects that are "under assessment" are included, but they are all assumed to be already generating and their application capacity are assumed to be relatively accurate.

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)
2004	1	0.1	0.1
2009	4	3	0.7
2010	4	1	0.2
2011	5	31	6.2
2012	10	5	0.5
2013	11	4	0.4
2014	35	35	1.0
2015	26	19	0.7
2016	81	73	0.8
2017	186	161	0.9
2018	357	307	0.9
2019	362	312	0.8
2020	235	218	0.9
2021	247	312	1.2
2022	242	231	1.0
2023	303	360	1.2
2024*	37	66	1.8
Summary	2,137	2,142	1.0
2019-2024	1,426	1,499	1.1
Average per year	238	250	

Note. 2024 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 grow as suitable sites decrease in number.[4] 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.

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

- 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 (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 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) as a guide, including:
    - classifying installations using the ANZSIC four-, three- or two-digit levels; and
    - grouping the classified 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 generalised Gompertz function), using the established historic trend for each segment and the estimated market size likely to be achieved over the five-year horizon.

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 A.

The market size of the 10 largest segments was estimated based on relevant market information, as documented in Section 5. The 10 largest segments formed 90% of the total mid-scale capacity currently installed. These segments, listed in descending order of installed solar PV capacity, are:

1. Electricity Supply
2. Commercial
3. Retail
4. Mining
5. Water Treatment
6. Logistics/Warehousing
7. Education
8. Industrial
9. Agriculture

10. Services

Table 3 and Figure 4 show the breakdown in installed capacity across various identified segments in the 100 kW to 5 MW range. Table 4 provides information on the potential site count for all mid-scale PV for each sector, as counted from the mesh blocks data from the Australian Bureau of Statistics.

Table 3: Installed capacity between 100 kW and 5 MW per category

Category	Installed capacity, in MW (100 kW to 5 MW installations)
Retail	188
Commercial	181
Electricity Supply	161
Logistics/Warehousing	85
Education	68
Industrial	65
Agriculture	45
Manufacturing	40
Airports	35
Mining	27
Health	23
Water Treatment	23
Services	18
Recreation	18
Government	14
Aged Care	11
Hospitality	7
Other	2
Tourism	1
Community Service	1
Unclassified	0
Total	1,014

Figure 4: Total installed mid-scale PV capacity in identified market segments, 100 kW – 5 MW capacity

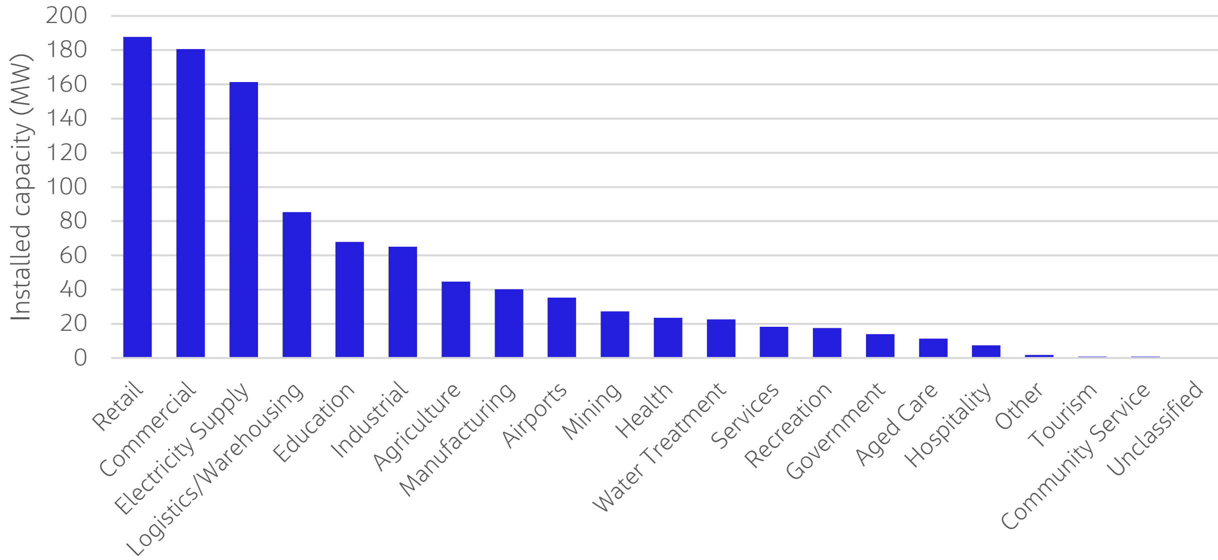


Table 4: Land classification by designated use[5]

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.

As can be seen in Figure 4 and Table 4, 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 530 MW accounting for 54% of total capacity. Commercial and Retail sites also have the highest site count. Logistics and Warehousing and Education are the next two biggest segments in terms of installations, with over 85 MW and 68 MW mid-scale PV capacity installed across Australia, respectively. For Education, the data indicates that there are many potential sites available, although fewer than for Commercial. Logistics and Warehousing is not as well-defined in the statistical geography data, so the numbers for Industrial, Shipping and Other classifications could include Logistics & Warehousing usage.

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

By inspection of Table 4, the apparent anomaly is Primary Production, which is the category with the greatest number of sites. However, larger power stations (>100 MW) tend to be situated on agricultural land, which is counted in this mesh blocks category. Additionally, many sites in this category may have opted for small-scale PV (<100 kW) 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 entered the market. Over the last two years, the mining, and manufacturing industries have also shown an increase in uptake of behind-the-meter systems.

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

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

There are several underlying drivers impacting installations:

- 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 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, and degradation.

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

A generalised 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:

$$G(t) = A.c.exp(-ct - b.exp(-ct)).[1+b.(1-exp(-ct))]$$

The total market size of all segments is considered as an input to the model as the asymptote constant (the coefficient *A* in the generalised Gompertz function), and the other two parameters *b* (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.

The optimised sum of least squares solution for the generalised Gompertz distribution is as follows:

A = 37,463[6]

b = 7.048

c = 40.885

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

[6] As per the total in Table 5

[7] 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.

To conduct this evaluation, every installation in the top 10 behind-the-meter categories by installed capacity was matched to a mesh block category, whereas all remaining installations were grouped in the "other" category. The installations contained in these top 10 behind-the-meter categories represent approximately 91% of the installed behind-the-meter capacity within the mid-scale PV system range. Table 5 summarises the estimates of number of suitable locations for these mesh block categories (where the Services category is included in Commercial), along with an indication of the current level of uptake within each segment.

Table 5: Potential market for mid-scale rooftop installations and current installations

Category	Market size, as number of sites	Number of installations
Commercial (including Services)	11,419*	455
Education	8,484	154
Industrial	7,701	166
Manufacturing	5,480	100
Retail	1,786	397
Agriculture	1,671	90
Logistics/Warehousing/Transport	641	137
Water Treatment	119	60
Mining	162	27
Total	**37,463**	**1,596**

** Estimated from cross-matching mesh block data with other sources. Total number of commercial sites as defined in the mesh block data equals the sum of Commercial, Retail, Hospitality, Services, 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.[8]

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

[8] According to Australian Bureau of Statistics mesh block data there is a total of 58,974 potential sites for mid-scale solar. See Table 4 for a breakdown by broad type.

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.[9]

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[10] (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.

[9] 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.

[10] 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[11]. Of the remaining 43 entries, three have commenced operation and have been accredited in the last 12 months.

SA Water's 150 MW Zero Cost Energy Future strategy[12] was a $300 million project across 33 sites for SA Water operations to reach net zero emissions. It was completed in 2022 and we have identified all 33 sites in the CER dataset. We have identified several future mid-scale solar PV projects announced by various water authorities, which we have also cross-checked with the CER dataset, but no other systematic plan akin to that of SA Water.

According to the CER data, the average size of the solar PV plants at the water treatment sites is 1.65 MW, although this is skewed by the two largest plants. Excluding these reduces the average size to 989 kW. Plants accredited and under application over the past year (2023) (excluding the largest) have an average size of approximately 1.02 MW, indicating that the average size of these projects has stabilised, although it is much larger than the study from 2 years ago[13] when the average size was 594 kW. The largest of these projects are powering the water pumping stations in SA and the SA desalination plant.

Market size of the water treatment sector was estimated using ABS statistical data and information available on the website of Sydney Water[14] about their water, recycled water and wastewater networks.

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[11] Including water pumping and desalination

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

[13] https://cer.gov.au/document/mid-scale-solar-pv-modelling-report-jacobs-july-2021

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

ABS data shows, there were a total of 615 water treatment sites across Australia, of which 119 sites (19%) had a turnover of more than $2 million. We assume this sets the size of the water treatment market. Over 50% of large water treatment sites are in NSW and Victoria.

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 26 plants with a turnover of more than $2 million, which is consistent with the Sydney Water data. Therefore, the Sydney Water specific data broadly supports the ABS data. Jacobs used the assumption that 119 sites across all of Australia 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

Appendix B lists the twenty busiest airports in Australia during 2023-2024 and the capacity of solar currently installed at these airports. With over 400,000 passengers per year, we assume these are all potential candidates for mid-scale PV installations. Due to the limited number of premises and high penetration rate, a bottom-up approach to projections will be applied to this segment.

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.

Gold Coast airport has highlighted plans for "procurement of renewable energy and onsite solar" to be implemented by 2028. This has been estimated to be 500 kW for the purposes of this assessment and we assume it is commissioned in 2027.

Sunshine Coast airport has outlined plans for solar facilities to be installed in the "first-stage" between 2025 and 2030, and to be completed between 2031 to 2040. The first stage of installations is estimated at 1 MW for the purposes of this assessment, and we assume it is commissioned in 2029.

Launceston airport has announced plans to install a ground-mounted solar array as part of a Renewable Hydrogen Project with developer Countrywide Hydrogen. Initial works were due to start in 2022. This has been estimated to be 5 MW capacity for the purposes of this assessment. We have assumed the plant is commissioned in 2028.

Rockhampton airport has received funding from the Rockhampton Regional Council, via the Federal Government's Reef Guardian Councils program, to install a 976kW solar PV system. This system is currently under construction and is anticipated to be online in 2025.

5.1.5 Manufacturing, agriculture and logistics

The Australia Energy Statistics 2020 indicated that manufacturing consumes in total 19.6% of total energy from primary energy production[15]. Manufacturing is the second largest electricity usage of all industry sectors in Australia, behind commercial sector. This sector has the potential to adopt more rooftop PV technology given its available roof-space and its commercial drive to reduce energy cost, particularly that 73% of the manufacturing businesses indicated that the cost of doing business has significantly increase[16].

Jacobs has also analysed another subset of manufacturing sector, which is industrial businesses that produce goods at wholesale level but operating differently to the traditional manufacturing. From the registry provided by CER, there is 342 businesses that registered and approved under the same sector. The businesses range from seafood processing, printing, fabricating to sawmilling. By analysing this subset, the forecast is capturing a more robust representation of the manufacturing segment based on the categorisation implemented for this analysis. Jacobs note that the contribution by this subsection is relatively small given the total size of the manufacturing segment.

Table 6 shows the number of industrial and manufacturing businesses in Australian states and territories with a turnover of greater than $5 million. Larger 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 6: Market size assumptions for the manufacturing, agriculture and logistics sectors

	Number of businesses	2019 - 2023 survival rate	Market size assumption
Manufacturing >$5m	5,931	92.4%	5,480
Agricultural >$5m	1,797	93.0%	1,671
Transport (logistics) >$10m	692	92.7%	641

Source: ABS, Jacobs' analysis of Cat. No. 8165.0 Counts of Australian Businesses, including Entries and Exits, June 2019 to June 2023

The agricultural sector uses significant amounts of energy, but the usage of electricity is limited. A large portion is oil and LPG[17], which are mainly use for onsite equipment. Farmers are driven to reduce their energy expenses while retaining sustainability of their practices, which creates the potential to install solar PV for self-use. The data for largest businesses in this sector (with $5 million and above turnover) are assumed to have the space for ground-mounted mid-scale solar PV systems. 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 1,671.

The transport industry energy usage is the highest in Australia when looking at primary energy production[18] consumption, however a large section of this is non-electricity. The logistics sector is assumed to comprise a

[15] Australian Energy Flows accessed here: https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Flows%202018-19.pdf

[16] Australian Business Statistics, Business Conditions Sentiments April 2022: https://www.abs.gov.au/statistics/economy/business-indicators/business-conditions-and-sentiments/apr-2022

[17] Extracted from the energy government website: https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Flows%202018-19.pdf

[18] Department of Industry, Science, Energy and Resources primary energy production Sankey diagram: https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Flows%202018-19.pdf

smaller section of that electricity consumption and is highly cost competitive. The warehousing and logistics enterprises that have already elected to install solar PV are dominated by those providing cold storage and refrigerated transport, which also have 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

Mining consumes approximately 861 petajoules per annum[19], third largest in Australia behind transport and manufacturing on primary energy consumption basis. Most of the energy in this sector is mainly from gas, followed by oil and LPG then electricity (approximately 18%). The percentage contribution of grid electricity has steadily increased, consistent with the rise of at 6% per annum of total energy consumption over the last decade driven primarily by increased mining volumes[20]. There is an increase interest in replacing the electricity generation with renewable sources[21], however a significant number of these mines are highly organised underground mechanised operations[22], therefore limiting their ability to install solar PV on site. Some mines are directly connected to smelters that has their own electricity connections points, which again limit their commercial drive to have solar PV on sites.

The 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[23]. Energy for metal ores with low on-site beneficiation[24], 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 beneficiation, such as copper and gold, is predominantly consumed as electricity.

Lithium, given its rise in importance in recent years, together with Australia's role as largest producer[25] has been included in this analysis. The energy intensity of producing lithium varies greatly in the industry with the ones produced in Australia is more energy intensive than other competitor countries[26]. It is assumed that given its locations (WA and Northern Territory), there will be a significant commercial drive to install solar PV onsite for these mines.

According to the Australian Operating Mines Map 2022[27], there are 473 operating mines in Australia, primarily for coal, bauxite, precious metals, base metals, battery/alloy metals, heavy mineral sands, lithium, and fertiliser elements.

[19] Australia energy flow: https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Flows%202018-19.pdf

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

[21] ARENA's facts on off-grid renewable interest: https://arena.gov.au/renewable-energy/off-grid/

[22] Jacobs analysis of production of important minerals to Australia such as mineral sands, lead and silver, and the feasibility of the mines installing solar PV: https://www.ga.gov.au/scientific-topics/minerals/mineral-resources-and-advice/australian-resource-reviews/minerals-sands ; https://www.ga.gov.au/education/minerals-energy/australian-mineral-facts/lead ; https://www.ga.gov.au/education/minerals-energy/australian-mineral-facts/silver

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

[24] Beneficiation in metal ore mining refers to a process which removes gangue minerals, resulting in higher grade ore concentrate and tailings byproducts.

[25] Australia's rank in lithium production: https://www.ga.gov.au/scientific-topics/minerals/mineral-resources-and-advice/australian-resource-reviews/lithium

[26] Lithium mining data scarcity flagged in Grattan's recent review: https://grattan.edu.au/wp-content/uploads/2023/02/Critical-minerals-delivering-Australias-opportunity.pdf

[27] https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/147694

For this study, Jacobs considered all copper, gold and lithium mines as having potential to install solar farms, bringing the number of eligible mines to 172.

5.1.7 Government buildings

In the latest CER dataset, there are 46 government buildings identified with 40 approved for having mid-scale solar PV installed. Going forward, PV installation is expected to take place as council buildings are generally positioned in suburban or regional areas which is ideal for mid-scale solar PV installation.

There are 537 councils in Australia[28]. 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). We then cross check it with the Local Government Climate Review data from 2021 to indicate if the portion of councils that have implemented emissions reduction targets[29] which is 58%.

From this group, it is assumed that the councils would elect to install systems that are greater than 100 kW as indicated by the most recent data provided by the Australian PV Institute[30]. Jacobs also investigated a portfolio of installations from one of the largest commercial PV installers in Australia, Todae Solar for 2021 and found that approximately 50% council building installations were less than 100 kW in capacity.

The final estimate of total market size for council buildings is 311, taking 58% as the percentage of council buildings that are available to install mid-scale rooftop PV.

5.1.8 Recreation, leisure, sports, and aquatic centres

There are approximately 1,306 public swimming pools in Australia[31]. 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 431 sports and leisure centres with an annual turnover greater than $2m[32]. Of these, the four-year survival rate for the period of June 2020 to June 2023 is 86%, which we have applied to the existing facilities. Jacobs has therefore assumed that the total market size for the sports and recreation sector is 371.

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

[29] Australian Local Government Association Climate Review 2021, pg 34: https://ironbarksustainability.app.box.com/s/p6ylewyv92c6rkfh2k44vwjr9b6r9ltc

[30] Australian PV Institute (APVI) Solar Map, funded by the Australian Renewable Energy Agency, accessed from pv-map.apvi.org.au on 1 June 2024

[31] RLS_AquaticInfrastructure2022_placemat.pdf (royallifesaving.com.au)

[32] 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#data-downloads

5.1.9 Hospitality industry

The hospitality industry is one of the most rapidly declining sectors in Australia. The downward trend continues post Covid-19, as alcohol consumption per capita and gambling[33] declines. It is expected that with rising cost of living, further spend on these sectors will be curtailed together with other discretionary spending per household.

There are currently 3,483 business that represent gambling, sporting, recreational and social clubs[34]. 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 87.7%.

There are only two recent installations on social clubs that are above 100 kW, therefore it is assumed that the sector cannot be considered in the mid-scale market.

5.1.10 Aged care industry

As of June 2023, there are 2,640 residential aged care facilities in Australia[35]. At least 71 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. The total number of residential aged-care facilities with more than one hundred beds is 901. 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

Hospitals is one of the most energy intensive infrastructure due to the nature of operation and services they provide. A total of 7% of Australia's carbon emissions is estimated to come from the healthcare sector[36], and it has pledged to continue its aspiration to achieve net zero by 2040. While the energy consumption for the sector is significant, not all of it can be satisfied using the rooftop solar PV generation.

Jacobs has assumed that a mid-scale system would power 15% of a facility's total generation requirements, as rooftop solar is not large enough to satisfy the total energy needs[37].

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[33] The Australian Institute of Health and Welfare, statistics on gambling: https://www.aihw.gov.au/reports/australias-welfare/gambling

[34] Social Clubs in Australia - Market Size, Industry Analysis, Trends and Forecasts (2024-2029)| IBISWorld

[35] This estimate excludes Home Care Aged care service list: 30 June 2023 - AIHW Gen (gen-agedcaredata.gov.au)

[36] Doctors for the Environment Australia, Net Zero Carbon Emission report December 2020: https://assets.nationbuilder.com/docsenvaus/pages/390/attachments/original/1709002062/Net_zero_carbon_emissions_responsibilities_pathways_and_opportunities_for_Australias_healthcare_secto.pdf?1709002062

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

Box 1: Case study of energy intensity of Australian Hospital

To estimate likely how many Australian hospitals are good prospects for mid-scale PV system installation, it is necessary to collate indicative metrics. Using the most recent data by Medical Journal Australia, a study conducted in 2021 indicated that Australian public hospitals used on average 4.15 TWh of energy per annum between 2016 and 2019. The total number of public hospital beds in Australia on average between the same period was 62,660. This amounts to an average of approximately 66 MWh of energy consumed per hospital bed and 6,019 MWh of electricity consumed per annum per public hospital in Australia.

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

Total hospital energy consumed	Total hospital beds	Consumption per bed (MWh) per annum	Minimum total consumption if 15% from rooftop (MWh)	Implied minimum number of
4.15	62,660	66	1,300	20

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 20 beds to consume enough electricity to enable installation of a mid-scale rooftop PV system. Given the absence of similar data for other states, these metrics are applied across Australia to derive a national estimate of the ultimate number of prospective mid-scale solar sites at hospitals across Australia.

Analysis by Jacobs using data by Australian Medical Journal[38] and Australian Government Productivity Commission[39].

According to the Australian Productivity Commission's Report on Government Services 2024, there are 697 public and 657 private hospitals in Australia. Despite large hospitals being a significant consumer of energy, only 56 of the 1,354 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 utilising multiple locations some hospitals might have, for example Mercy Health[40] have a portfolio of hospitals, palliative care and residential aged care that are spread across Victoria. Barwon Health is another example of a health provider participating in a PPA with a local renewable generator[41].
- Access to high voltage lines and industrial retail prices reduces the value of a solar PV investment.

The largest consumers of energy for hospitals are probably the ones located in major cities, of which there are 185 as indicated by the most recent hospital resource data. However, these hospitals will most likely have unsuitable roof space for rooftop solar PV.

[38] Australia Medical Journal, Renewable Energy Use in Australian Public Hospitals accessed 2 June 2024: https://www.mja.com.au/journal/2021/renewable-energy-use-australian-public-hospitals

[39] Productivity Commission Report on Government Services 2024: https://www.pc.gov.au/ongoing/report-on-government-services/2024/health/public-hospitals#:~:text=In%202021%2D22%2C%20there%20were,3).

[40] MercyHealth portfolio: https://www.mercyhealth.com.au/

[41] Barwon Renewable Energy Partnership secures wind power agreement - Barwon Water

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 20 beds. There are 74% of public hospitals located in the remote and regional areas. Out of this, 98.4% have greater than 10 beds (by approximation of published data) but only 33% of the total available beds are in the same area. This brings the assumed market size of the public hospital sector to 24% of the total number, or 168 of the 697 premises. Similar information is not available for the other 657 private hospitals. Therefore, we used the same approach to estimate the market size as we did for the public hospitals. The market size for private hospitals will then be 24% of 657 private hospitals or a total of 158 private hospitals.

The total potential market size for public and private hospitals all together in Australia used in the modelling was 326.

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 1,000 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 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 10 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 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%[42].

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

	Commercial	Industrial	Ground-mounted
Capacity	250 kW	850 kW	1,000 kW
Solar profile	NSW rooftop	NSW rooftop	NSW rooftop
Capacity factor	16%	17%	23%
Demand profile	Commercial demand	Industrial demand	N/A
Real WACC[43]	7.5	7.5	7.5
NPV time	10 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.

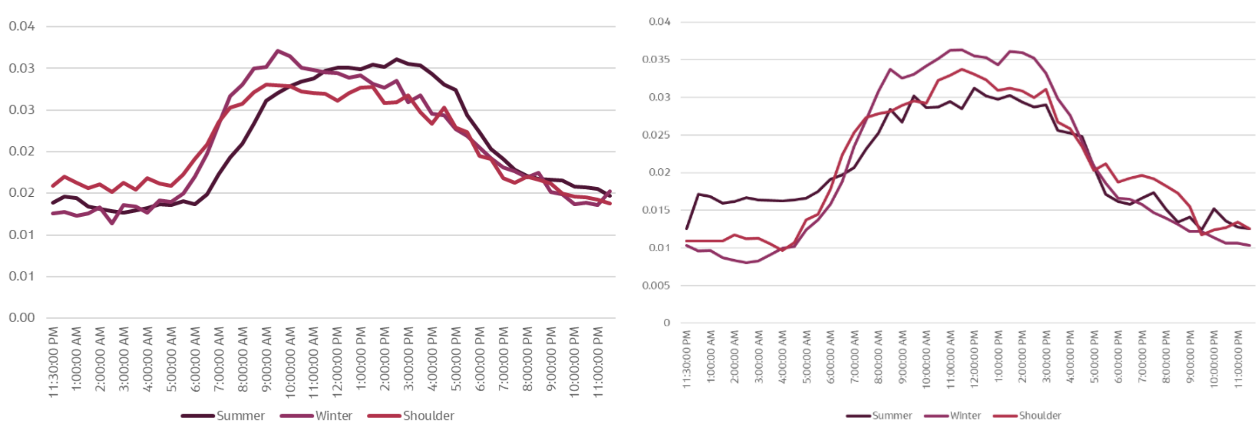
6.1 Assumptions

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 5. These were measured and normalised over different periods of the year including summer, winter, and shoulder periods.

Figure 5: 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

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

[43] Weighted average cost of capital

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.

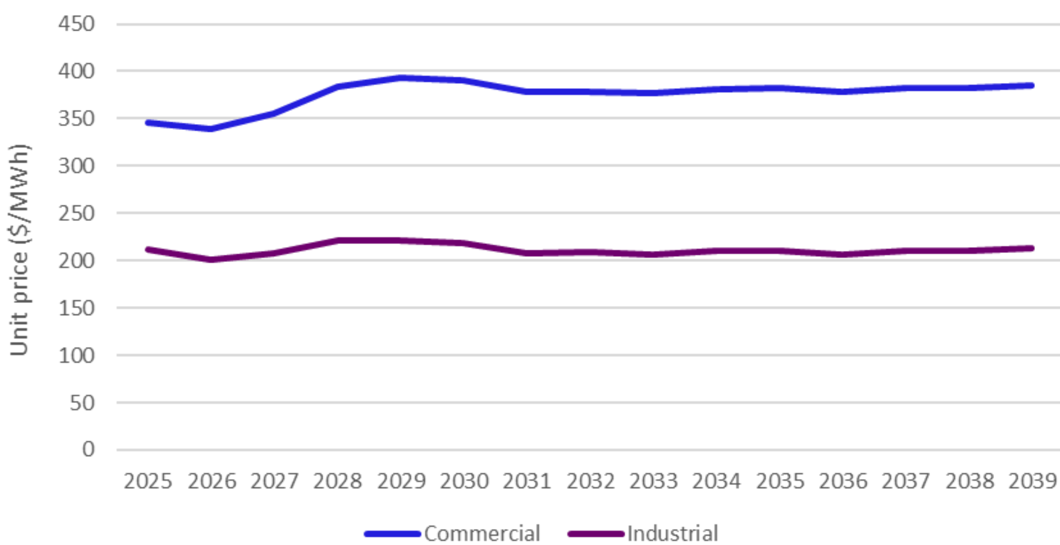
It was assumed for both the commercial and industrial cases, that the PV system size is optimised so that all solar generation output is consumed, and that no generation is exported.

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.

Figure 6 shows the forecast retail electricity price for the commercial sector utilised in analysing the payback of commercial and industrial rooftop PV systems. The 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, very large manufacturing plant and major university campuses.

Figure 6: Forecast retail electricity prices by customer class for New South Wales



Source: Jacobs analysis

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.

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

Table 9: Historical and forecast annual LGC prices

Year	LGC price
2017	83.3
2018	76.8
2019	42.1
2020	37.8
2021	36.7
2022	53.6
2023	51.5
2024	48.8
2025	48.1
2026	39.9
2027	33.8
2028	29.0
2029	23.8

Source: Historical LGC prices obtained from Certificate Prices - Demand Manager; forecast LGC prices are from Jacobs analysis

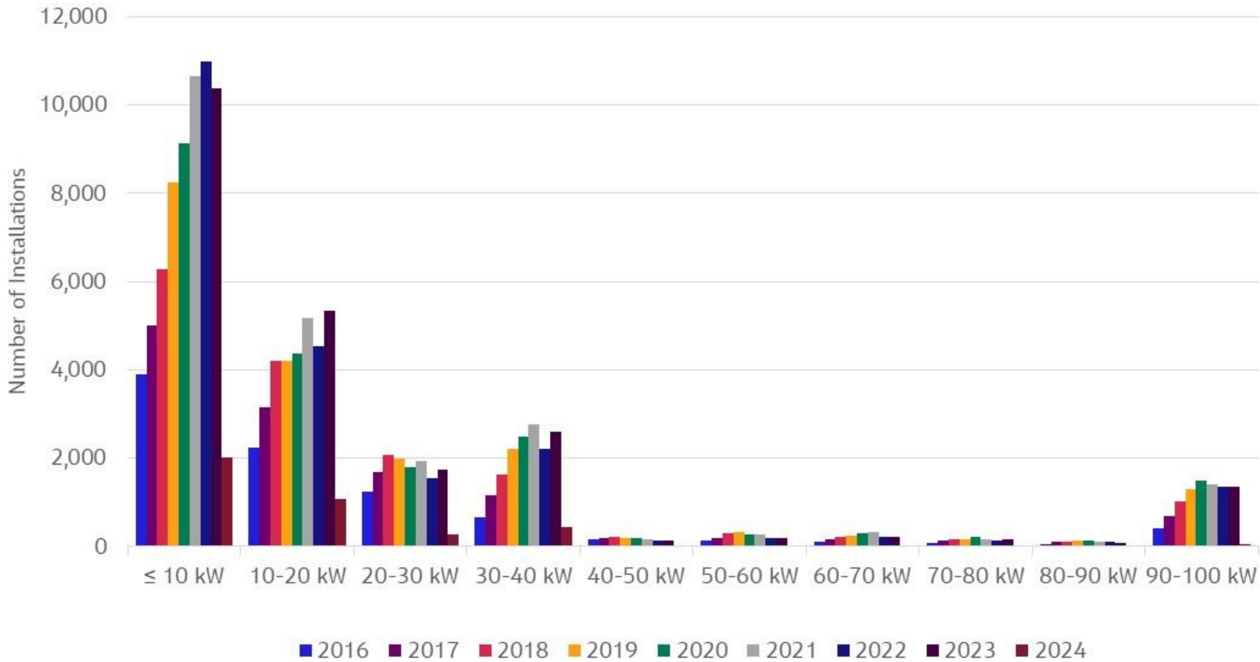
Figure 7 shows the number of commercial small-scale PV installations by size bracket. From 2020 until 2023 there were more than 1,300 behind-the-meter installations in the 90-100 kW bracket per annum, which is more than the entire number of behind-the-meter mid-scale (100 kW to 30 MW) PV systems recorded in the 2016 to 2019 period.

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 that persists until 2030.
- The difference between these benefits is relatively consistent across reference cases (i.e. commercial, industrial systems less than 100 kW).

Figure 7: Number of commercial small-scale installations by capacity bracket, 2016 to 2024



Source: Jacobs' analysis of CER data. 2024 data is incomplete.

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 and they also cannot be created after 2030). 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.[44]

6.2 Economic benefits

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

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

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.

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

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 has reduced markedly over the last two years driven by high wholesale prices as well as increasing network tariffs. It is projected to continue to decline for the remainder of the projection period despite a reduction in the LGC price.

Table 10: Payback period of 250 kW commercial PV systems

Year	Capital cost ($)	1st year cash flows ($)	Payback (years)	Internal rate of return (%)
2025	340,500	108,872	2.9	35
2026	323,750	106,650	2.8	37
2027	308,000	111,791	2.6	39
2028	292,750	120,542	2.5	42
2029	278,500	123,425	2.4	44

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

- Average demand of 850 kW.
- No excess electricity generation that is exported to the grid.

The payback period is not as short as that of the commercial PV system presented above, which reflects the lower value of the avoided electricity for an industrial customer relative to a commercial customer (see Figure 6).

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

Year	Capital cost ($)	1st year cash flows ($)	Payback (years)	Internal rate of return (%)
2025	1,157,700	241,001	4.9	22
2026	1,100,750	229,158	4.8	23
2027	1,047,200	236,706	4.6	24
2028	995,350	251,872	4.4	25
2029	946,900	252,644	4.2	26

Note: Assumed average demand is 850 kW, capacity factor =17%, 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 1,000 kW ground-mounted system is set with single-axis tracking at a 23% 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. A key assumption was that the systems output was for export-only, so no saving by reducing grid demand.

Table 12: NPV and payback estimates of a 1,000 kW, fixed angle ground-mounted system

Year	Capital cost ($)	1st year cash flows ($)	Payback (years)	Internal rate of return (%)
2025	1,414,000	81,539	12.3	4
2026	1,361,000	86,191	12.2	4
2027	1,308,000	69,311	12.1	4
2028	1,256,000	65,683	11.8	4
2029	1,207,000	62,645	11.4	5

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. The reason for this is the lower outlook for dispatch-weighted solar prices in the NEM[45], which is influenced by two key factors:

[45] The trend in the dispatch-weighted solar price is different to the trend in retail prices displayed in Figure 6 as the retail price trend is more reflective of the trend in the time-weighted price (i.e. the average price across all time periods of the day).

- The continuing pace of small-scale rooftop PV uptake applies downward pressure to dispatch-weighted prices of solar generators.

- The Federal Government's expansion to the Capacity Investment Scheme, which seeks to install 23 GW of new renewable capacity across Australia by 2030, is expected to put downward pressure on wholesale electricity prices including the dispatch-weighted price for a solar generator as it will stimulate uptake of large-scale solar PV.

This indicates that for mid-scale ground-mounted single-axis tracking 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 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

A bottom-up approach was utilised to estimate the capacity of installations in the education sector and at airports. For the remaining categories, we fitted a generalised Gompertz curve to the historical installations by utilising sum-of-least squares optimisation. These estimates were then multiplied by the average capacity of these systems in 2023 (493 kW). This was used to calculate the estimated installed capacity of these systems.

Table 13 summarizes our estimates on the projected capacity of solar installations for the identified behind-the-meter sectors. The 2024 estimates are partly sourced from the CER's mid-scale database and the remainder represents a part-year forecast. Projections from 2025 until 2030 are either based on our bottom-up assumptions, which are explained in sections 5.1.4 for airports and 7.2 for the education sector, or they are based on the Gompertz model.

Table 13: Summary of mid-scale solar PV installation capacity projections for behind-the-meter segments, MW

	2024	2025	2026	2027	2028	2029	2030
Education							
Victoria	0.5	0.5	0.5	0.5	0.5	0.5	0.5
NSW	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Northern Territory	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Queensland	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Western Australia	1.2	1.2	1.2	0.9	0.9	0.9	0.0
Tasmania	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ACT	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Australia	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Universities	1.4	1.1	1.1	1.1	1.1	1.1	1.1
Other sectors	137	152	165	180	199	208	221
Airports	0.0	1.0	0.0	0.5	5.0	1.0	0.0
Total	**143**	**157**	**170**	**185**	**203**	**213**	**225**

7.2 Education sector

The education sector has seen strong uptake of rooftop PV installations over the past 5-6 years. This is partly attributed to a range of government incentives and programs aimed at state schools. For these reasons, the education sector was analysed separately from most segments and a bottom up approach to forecasting was utilised.

7.2.1 Schools

The National Solar Schools Program (NSSP) was established in 2007. The NSSP offered primary and secondary schools the opportunity to apply for grants to install solar and a range of energy efficiency measures. A total of 4,897 schools installed solar power under the NSSP until the program ended in June 2013. While the program was successful in delivering solar panels to over 50% of schools in Australia, it occurred at a time when solar PV installations were expensive, and most of the systems installed were less than 10 kW. This accounts for only around 2% of a daily school's requirements[46].

With substantial developments in solar technology and reduction in capital costs over the past decade, there has been a renewed focus by state governments to promote the uptake of solar in schools, with recognition that the currently installed systems are too small.

This section outlines our assumptions on the projection of mid-scale PV capacity in schools, based primarily upon government-based programs and recent trends in uptake. Table 14 summarises the government-based programs per state and their projected mid-scale additions.

Table 14: Summary of school mid-scale solar PV installation capacity projections, MW[47]

Program	2024	2025	2026	2027	2028	2029	2030	Total
Victoria								
Greener Government School Buildings	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3.5
NSW								
Smart Energy Schools Pilot Project	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.4
Queensland								
Advancing Clean Energy Schools	1.9	1.9	1.9	1.9	1.9	1.9	1.9	13.0
Western Australia								
Regional School **Rooftop Solar**	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.9
Schools Clean Energy Technology Fund	0.9	0.9	0.9	0.9	0.9	0.9	0.0	5.4
South Australia								
Sustainable Schools Program	0.3	0.3	0.3	0.3	0.3	0.3	0.3	2.1
Total	4.1	4.1	4.1	3.8	3.8	3.8	2.9	26.3

[46] https://www.pv-magazine-australia.com/2019/01/28/tomorrow-back-to-solar-empowered-schools/

[47] Totals in the table may not add up due to rounding

Northern Territory

In December 2018, the NT Government initiated a $5 million project to install solar PV at up to 25 schools over a three-year period. In addition, 3 schools have installed solar systems under the Capital Works funding program, and an additional school has installed solar panels with its Building Better Schools funding[48].

Analysis of the small and mid-scale CER databases suggests that most of the Northern Territory school PV systems fall in the small-scale range. No schools in NT were observed to have installed PV since 2018 within the mid-scale category.

For the purposes of this study, we assume that any further installations under the Northern Territory government's Solar for Schools program will not contribute to mid-scale PV installations.

Queensland

In 2017, the Queensland Labor government announced a $97 million investment to reduce energy across state schools through solar and energy efficiency measures as part of the Advancing Clean Energy Schools Program[49]. The government acknowledged that most Queensland's 1,241 state schools already offset energy costs with small PV systems installed under the NSSP but noted that more could be achieved because of recent developments in new technologies. Of the total funding, $40 million will be allocated to the installation of 35 MW of PV systems to state schools with the remaining $57 million to be invested in making schools more energy efficient.

In February 2020, the government announced an additional $71.1 million over three years to expand the solar under ACES program, primarily aimed at offsetting the energy needs of new air conditioning installations across the state schools. The program ended in mid-2022 with 80 MW total capacity installed over 912 schools, averaging at approximately 88 kW per school. We therefore assume that the installations under this program have predominantly fallen into the small-scale range.

We assume that installation at Queensland schools not involved in the state school initiative will continue to occur at the same rate that has occurred for the past four years, or approximately 6 schools per year with a 310 kW installation each.

Victoria

The Greener Government School Buildings program was first announced in 2018 in the form of a pilot program, which saw 42 schools receive solar panels in 2019. The full program is now in its third round at a total cost of $20 million[50] with a total of 276 schools participating to receive solar panels.

In 2019, 126 Victorian schools were identified as having small-scale installations and 9 as having mid-scale installations, which indicates that most of these schools receiving solar panels fell into the small-scale category. For the purposes of this study, we assume that most state schools set to benefit from the extension of the program will continue to fall into the small-scale category.

[48] https://newsroom.nt.gov.au/mediaRelease/33461

[49] https://www.queenslandlabor.org/media/20293/alpq-powering-queenslands-future-policy-document-final.pdf

[50] https://www.premier.vic.gov.au/greener-schools-program-deliver-more-power-bill-savings

We assume that private based schools with an enrolment of over 1,000 students would be suitable for mid-scale installations, and these will continue at the same rate that has occurred for the 3 years prior to 2024, at a rate of 2 schools per year with an average 230 kW system.

New South Wales

The NSW Government's Smart Energy Schools Pilot Project commenced in May 2022, where solar and battery energy storage systems were installed at 24 state schools. Stage 2 of the Project included installations at 29 state schools over 2022 and 2023, along with the use of the solar and battery energy storage systems in a Virtual Power Plant. An additional 18 schools have been selected to participate in the Project, bringing the total number of schools to 79.

Once completed it is anticipated that the Smart Energy Schools Pilot Project will have installed approximately 7,488 solar panels across the 79 schools, which averages to 95 panels per school, or an installed capacity ranging in the 10s of kilowatts (unlikely to exceed 60 kW). It is therefore expected that schools selected as part of this Project will have PV installations in the small-scale category.

For private based schools we expect the current trend of installations to continue of approximately 1 school per year at 200 kW.

Western Australia

As part of its 2021 election promises, the Western Australian government pledged $40 million for the Schools Clean Energy Technology Fund and an additional $4.6 million to roll out rooftop solar at 18 Kimberley and 10 Pilbara schools.

The $4.6 million funding package averages to $164,000 per school, which represents about 100 kW of rooftop PV at that scale in Western Australia. Two of these schools are represented in the CER mid-scale database, with an average installed capacity of 217 kW, and both were installed in 2023. It is assumed that on average half of the schools fall into the mid-scale category, installations averaging 100 kW are being rolled out at an average of three of these schools per year for the next three years, starting in 2024.

The $40 million package is more difficult to interpret in terms of rooftop solar potential as the technology mix being rolled out includes energy efficiency measures for lighting and building improvements and the virtual power plants, as well as rooftop solar. Two tiers of funding were available to schools in the first round of funding, where the first tier allowed construction of a virtual power plant and the second tier enabled uptake of clean energy technologies, with a value up to $500,000. The value of the overall package and the second-tier cap suggest that mid-scale rooftop solar installations will likely occur at participating schools in the round one funding, which totalled 84 schools. The total number of schools to receive solar panels has risen to 180 after round 2 of the funding (round 3 has also occurred but only provided for LED light installation). It is assumed this is the final number of schools to receive solar panels and given the 96 successful schools from the second round of funding were predominantly primary schools, it is assumed most of the systems installed at these schools would be small scale.

In the absence of more detailed information, we assume the average capacity to be installed across the 84 schools in round one is 150 kW, and that installations will occur at an average of 6 schools per year over the next 5 years under the Schools Clean Energy Technology fund.

South Australia

The South Australian government announced a $15 million Sustainable Schools Program in 2017 to install rooftop solar systems at 40 schools. Each of these systems were slated to be at least 100 kW[51]. Between 2017 and 2022 (and excluding 2020) an average of 2 schools per year registered mid-scale systems on the CER database, with a median capacity of 200 kW. Without more current state-based initiatives to install solar on schools, the assumption will be that mid-scale solar PV uptake will occur at this same rate of 2 schools per year, with an average installed capacity of 150 kW each (to better align with the funding scheme).

Tasmania

As part of its election pledges in 2021 the Tasmanian government had promised to invest in rooftop solar for all Tasmanian government schools. This included a $5million fund to deliver solar panels to more than 100 schools over the following four years, which it has labelled as its Renewable Energy Schools program. The funding translates to at most $50,000 per school on average, which suggests that most, if not all, systems will fall in the small-scale category.

Mid-scale rooftop solar has not been installed in any Tasmanian school since 2018. We therefore assume no mid-scale systems will be taken up by any Tasmanian schools over the projection period.

7.2.2 Universities

There are 196 university campuses in Australia, the majority of these are expected to be capable of hosting a mid-scale system. A total of 57 university campuses are identified on the CER database, however only 82% of these have systems greater than 100 kW. For this reason, the assumption is that 82% or a total of 162 university campuses would have the capability of installing a mid-scale solar system. The median size of mid-scale systems installed on university campuses is approximately 280 kW.

We assume that 4 campuses per year will have a 280 kW rooftop installation for the projection period. As of April 2024, one university has already applied for accreditation for a system size of 540 kW.

7.3 Front of meter systems

7.3.1 Systems less than 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.

[51] https://www.carbonneutraladelaide.com.au/business/department-for-education

7.3.2 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.

7.3.2.1 Northern Territory: Remote Power Systems Strategy

The Remote Power Systems Strategy encompasses delivery of an average of 70% renewable energy to the 72 remote communities currently serviced by Indigenous Essential Services (IES), being developed by the Territory government. Completion of the detailed analysis and development of proposed investment framework is anticipated for Q2 2024.

Delivery of the strategy is an action under the government's climate change response and a key pillar of the NT's 50% by 2030 renewable energy target. The strategy aims to reduce energy-related diesel consumption in these communities whilst improving energy security and reducing emissions. The government is progressing detailed analysis of each community to map the optimal renewable energy development pathway. Additionally, the project will involve a process of identifying available land for solar development in each community. Pilot projects and studies to facilitate greater levels of distributed energy supplies and emerging technologies, such as hydrogen, will also be investigated.

To kick start activities, 1.2 MW of ground-mounted additional solar PV has been installed at the Wurrumiyanga community in 2023. In the absence of more detailed information, it is projected that this strategy will fund the installation of 1 MW of solar PV per year in the projection period in the NT.

7.3.2.2 Original Power

Original Power is a non-profit project developer founded in 2018 which is a “community focused, Aboriginal organisation” to provide strategic advice, skills-building, campaign support and community connection to resources.

Original Power helped the community in Marlinja, NT, raise funds from benefactors to build a 100 kW ground-mounted solar array, whose construction was completed in mid-2024.

The community of Borroloola in the Northern Territory is working with Original Power and renewable energy experts on a feasibility study to design and build their own solar microgrid – the Ngardara ‘Sun’ Project. The project is in the assessment phase, including a pilot training program aimed at teaching First Nations workers the basics of solar installation. In the absence of detailed information, it is anticipated the Ngardara ‘Sun’ Project will have a capacity of 1 MW and will be commissioned by 2029.

7.3.2.3 Queensland: Energy and Jobs Plan ($28m to Boulia, Burketown, Doomadgee and Windorah PV)

The Ergon Energy Network is planning to install PV and battery energy storage systems alongside several power stations in remote Queensland towns. The project aims to reduce reliance on diesel, save the communities money, and create direct and indirect jobs. The installed solar PV capacity will include 4.5 MW at Doomadgee, 850 kW at Windorah, 1.2 MW at Burketown and 1.7 MW at Boulia. All projects are planned for completion in 2025[52].

7.3.2.4 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. The first 19 of these have been installed in the Beaumont and Mount Ney areas in WA. For the purposes of this study, it is assumed that all these systems will be between 100-150 kW each installed over a five-year period beginning in 2022. For the forecast period we assume 6 systems per annum from 2024 until 2026 with an average size of 125kW.

Table 15 shows the projected installed capacity due to ground-mounted community installations.

Table 15: Projections of capacity by year, mid-scale systems from ground-mounted community installations (MW)

Program	2024	2025	2026	2027	2028	2029	2030
Northern Territory							
Remote Power Systems Strategy	1	1	1	1	1	1	1
Original Power	0.1					1	
Queensland							
Energy and Jobs Plan – remote PV		8.25					
Western Australia							
Recovery Plan – solar and battery	0.75	0.75	0.75				
Total	1.85	10.00	1.75	1.00	1.00	2.00	1.00

7.3.3 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 up to 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

[52] https://www.energyandclimate.qld.gov.au/energy/renewable-energy-in-your-region/far-north-qld#:~:text=In%20Doomadgee%2C%20Ergon%20Energy%20will,and%20Torres%20Strait%20Islander%20councils

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 16.

Table 16: 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 develop multiple embedded solar farms of 5 MW rather than larger non-scheduled systems up to 30 MW, consequently avoiding the interaction with AEMO.[53] This is mainly due to the challenges of processing high volume of connections in an increasingly constrained network. The market collectively is addressing this issue across multiple parties[54] to ensure faster connections and improved investment certainty.

The CER lists 99 PV system projects between 5-30 MW that are either Approved or Under Assessment as of April 2024. The count of projects by capacity is shown in Table 17. There are significantly more projects with capacity of between 5 MW and 10 MW, which are solar farms servicing the grid and supported by battery energy storage system (BESS) or connected to water pump stations. Many of the sites are also part of larger projects, such as Redmud Green Energy (8 sites), Stanhope Solar Project (4 sites) and SA Water's Morgan to Whyalla pump station (4 sites).

Table 17: CER 5-30 MW project capacity breakdown (project count)

Status	>= 5 MW & <= 10 MW	> 10 MW & <= 20 MW	> 20 MW & <= 30 MW
Approved	83	1	5
Under Assessment	8	0	0

Jacobs also reviewed AEMO's NEM Generation Information[55] and grouped solar PV generation that is non-scheduled under Proposed and Committed status. The total list (within the 5-30 MW range) from AEMO is 16 projects with average size of 16.5 MW for a total of 265 MW. Combined, the project pipeline of those 115

[53] 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/
https://www.cleanenergycouncil.org.au/news/australias-energy-transition-needs-new-rules-for-grid-connections

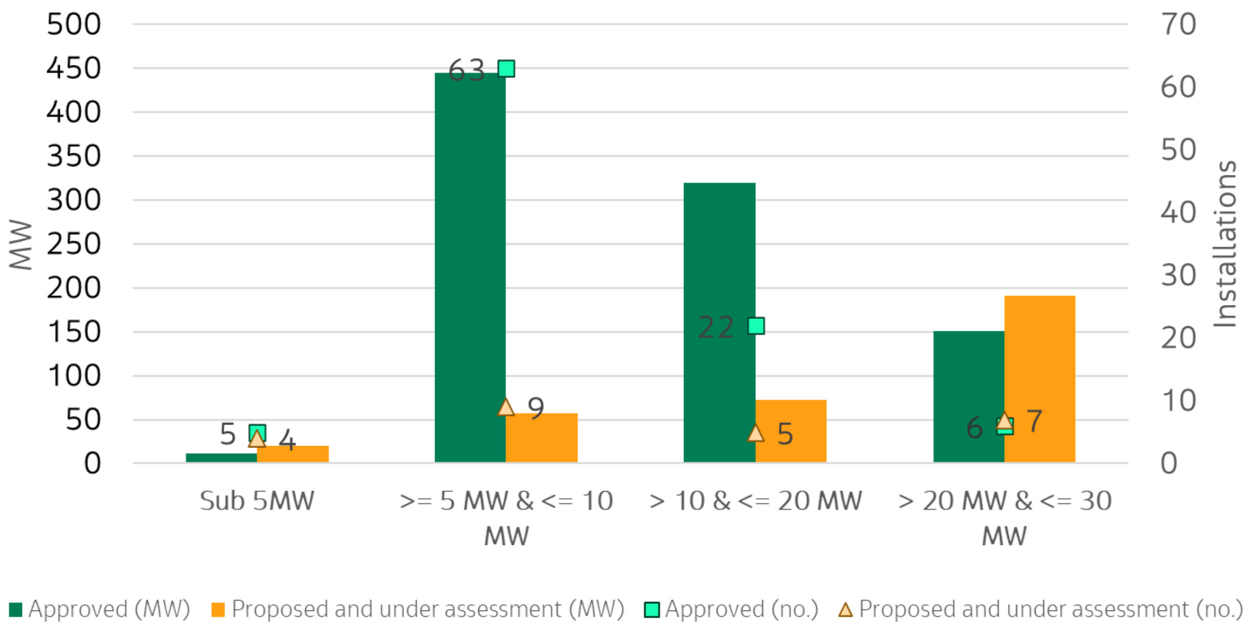
[54] For example, the Connection Reform Roadmap by Clean Energy Council and AEMO: https://www.cleanenergycouncil.org.au/advocacy-initiatives/energy-transformation/connections-reform-initiative

[55] Data for NEM Generation Information is updated on regular basis. Accessed May 2024: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information

ground-mounted solar PV systems underway totals almost 1,236 MW of capacity, representing an average of 10.8 MW per project. Figure 8 shows the total capacity and number of projects for each of the mid-scale categories. For the forecast, we assume 20% of the proposed projects on AEMO's list make it through to commissioning stage.

Several water authorities have also been identified by Jacobs as having assets within the 5-30MW capacity range, which are not captured on either the CER list or AEMO NEM Generation Information. These assets include GWM Water's Nhill Solar Farm[56] (6.5MW), Hunter Water's PV systems at Dungog Wastewater Treatment Works (WWTW), Tanilba Bay WWTW, Karuah WWTW and Balickera Park (totalling over 6 MW)[57], and Melbourne Water's Eastern Treatment Plant solar farm (18 MW). The latter two of these systems were operational only over the last year, and we anticipate installations at water treatment plants will increase with population growth as well as a growing need to upgrade ageing infrastructure.

Figure 8: Overview of mid-scale project pipeline, ground-mounted systems



Source: AEMO NEM Generation information July 2024, and CER database 2024.
Note: "Proposed" does not include predictions for increased PV uptake in water treatment facilities.

Table 18 shows the bottom-up forecast of PV systems for the category 5 MW to 30 MW. The forecast until 2026 includes known projects[58] as well as 20% of AEMO's total capacity of proposed projects in this capacity range. From 2027 onwards we assumed one project would be built in the 5 – 10 MW range and one project in the 10 – 30 MW range and this is sized at the average project size in the respective range. These projections are lower than those of previous studies and reflect the smaller economic returns expected to be delivered by such systems.

[56] Accessed May 2024: Victorian water authority taps into large-scale renewable energy market – pv magazine Australia (pv-magazine-australia.com)

[57] https://www.hunterwater.com.au/community/major-projects-in-your-area/renewables

[58] In the case of 2024 this is known projects not already in CER's database.

Table 18: Projections of capacity by year for systems 5 MW and greater

Segment	2024	2025	2026	2027	2028	2029	2030
5 – 10 MW	12.5	6.5	5	6	6	6	6
10 – 30 MW	17.1	16	29.4	21	21	21	21

7.4 Summary

This section presents a summary of the results (in calendar years) of all the mid-scale PV projections. Table 19 summarises Jacobs' projected incremental installed capacity of mid-scale systems over the 5-year period by segment.

Table 20 summarises this incremental installed capacity per state and capacity range.

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, manufacturing and retail, 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.

With respect to front-of-meter systems, the forecast is muted compared to our previous study, reflecting the lower expected returns available to these systems due to continuing uptake pressure from the small-scale rooftop PV segment and increasing pressure from the large-scale solar PV segment.

Table 19: Summary of incremental projected capacity mid-scale PV installations 2024-2030, MW

Segment	2024	2025	2026	2027	2028	2029	**2030**
Behind-the-meter systems	142	157	170	185	203	213	225
Aged Care	3	3	4	4	3	3	4
Agriculture	5	5	5	5	5	4	5
Airports	0	1	0	0.5	5	1	0
Commercial	37	41	44	44	45	44	49
Education	5	5	5	5	5	5	4
Government	2	2	2	2	2	2	2
Hospitality	0	0	0	0	0	0	0
Hospitals	3	3	4	4	4	5	7
Logistics/Warehousing	8	10	13	17	20	25	30
Manufacturing	27	27	27	27	25	23	24
Mining	1	2	2	2	2	2	3
Recreation	2	3	3	3	3	4	5
Retail	24	32	41	53	67	79	78
Water Treatment	8	5	3	2	1	1	1
Other	17	18	18	17	15	14	15

Segment	2024	2025	2026	2027	2028	2029	2030
Front-of-meter systems	81	32	36	28	28	29	28
0.1-5 MW Systems	2	9	2	1	1	2	1
5-10 MW Systems	32	7	5	6	6	6	6
10-30 MW Systems	47	16	29	21	21	21	21
Total	223	189	207	213	231	242	253

Table 20: Incremental projected capacity per state of mid-scale PV installations 2024-2030, MW

State	Capacity range (MW)	2024	2025	2026	2027	2028	2029	2030
ACT	0.1 to 1	1	1	1	2	2	2	2
	1 to 5	1	1	1	1	1	1	1
	5 to 30	0	0	0	0	0	0	0
NSW	0.1 to 1	26	29	31	34	37	39	42
	1 to 5	16	17	19	20	22	24	25
	5 to 30	19	23	29	0	21	0	0
NT	0.1 to 1	2	3	3	3	3	4	4
	1 to 5	2	3	3	3	3	3	4
	5 to 30	0	0	0	0	0	0	0
QLD	0.1 to 1	18	20	22	24	26	27	29
	1 to 5	11	12	13	14	15	16	17
	5 to 30	0	0	5	0	6	21	0
SA	0.1 to 1	10	11	12	13	14	15	16
	1 to 5	10	11	12	13	14	15	16
	5 to 30	0	0	0	6	0	0	0
TAS	0.1 to 1	1	1	1	1	1	1	1
	1 to 5	0	1	1	1	1	1	1
	5 to 30	0	0	0	0	0	0	0
VIC	0.1 to 1	21	23	25	27	30	31	33
	1 to 5	12	13	15	16	17	18	19
	5 to 30	13	0	0	21	0	0	6
WA	0.1 to 1	6	7	7	8	9	9	10
	1 to 5	5	6	6	7	7	8	8

Mid-scale Solar PV System Projections

State	Capacity range (MW)	2024	2025	2026	2027	2028	2029	2030
	5 to 30	47	0	0	0	0	6	21

Overall, it appears that the impetus to decarbonise the Australian economy along with the rising costs of electricity will spur continued growth for mid-scale PV systems.

Appendix A. Segment to 2-digit ANZSIC grouping

Table 21 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[59]. 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[60].

Table 21: 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
Industrial	36	Grocery, Liquor and Tobacco Product Wholesaling

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

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

Segment	2-digit ANZSIC code	ANZSIC Title
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 B. 2024 Top Australian Airports by Passenger Number

Total passenger numbers include both domestic and international travellers. In the analysis, we assume that the top 20 airports are suitable for rooftop PV installations, and that increasing air travel after Covid-19 will influence passenger numbers.

Table 22: Airport traffic and capacity summary

Airport Location	Total Passengers for year ended February 2023	Total Passengers for year ended February 2024	Current installed PV capacity
SYDNEY	32,505,215	39,720,817	550 kW
MELBOURNE	28,356,165	34,159,040	12.4 MW
BRISBANE	18,492,494	21,632,462	5.7 MW + 3.5 MW
PERTH	9,867,435	12,400,815	
ADELAIDE	7,057,529	8,156,075	1,283 kW
GOLD COAST	6,021,841	6,296,516	
CAIRNS	4,021,955	4,560,336	
CANBERRA	2,608,629	2,798,818	2.4 MW
HOBART	2,482,076	2,661,506	
SUNSHINE COAST	1,545,714	1,937,708	
DARWIN	1,773,610	1,782,955	5.5 MW
TOWNSVILLE	1,595,757	1,699,059	
LAUNCESTON	1,263,829	1,388,820	
NEWCASTLE	1,078,569	1,184,339	
MACKAY	870,151	912,954	
ROCKHAMPTON	510,573	649,821	976 kW
BALLINA	635,237	632,855	~100 kW
KARRATHA	509,973	556,948	1 MW
PROSERPINE	465,742	521,357	400 kW
HAMILTON ISLAND	515,888	495 789	

Source compiled from the Bureau of Infrastructure, Transport and Regional Economics, https://www.bitre.gov.au/publications/ongoing/airport_traffic_data

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.

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.[61] 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.[62]

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

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.

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

[61] "8165.0 Counts of Australian Businesses, Including Entries and Exits, June 2017 to June 2021."
[62] "Mesh Blocks | Australian Bureau of Statistics."

- 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.