Mid-scale PV Projections

14 July 2021

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Project No: IS382000
Document Title: Mid-scale PV Installation Projections
Document Status Final
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Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved
1	28/06/2021	Draft Report	PN/NB	PN		
2	09/07/2021	Final draft report	PN/NB	PN	WG	WG
3	14/07/2021	Final report	PN/NB	PN	WG	WG

Contents

Executive Summary

This report contains forecasts of the capacity of mid-scale photovoltaic (PV) installations for the calendar years of 2021 up to and including 2025 for the Clean Energy Regulator (CER).

Mid-scale PV systems are defined by the capacity range of greater than 100 kW and less than 30 MW. These systems are not eligible for the federal rebates under the Small-scale Renewable Energy Scheme, however may be accredited under the Large-scale Renewable Energy Target scheme to produce Large-Scale Generation Certificates (LGCs) via the renewable energy generated. The LGCs produced may then be sold to market participants, typically retailers who are required to surrender a determined number of LGCs to the CER. This has provided a financial incentive for the installation of larger size PV systems.

High electricity prices coupled with plummeting capital costs of installation and high LGC prices saw a large growth rate in the mid-scale PV sector during 2018, which was over 3 times the capacity installed in 2017. Growth steadied in 2019.

However, a reduction in growth within this sector was observed in 2020. Factors relating to the global COVID pandemic that may have resulted in a decrease in demand for mid-scale systems include:

- Reduced industrial and commercial demand and activity.
- Lower domestic electricity prices.
- Market and policy uncertainty delaying investment decisions.

The trend in 2021 has reversed, and growth has returned to this market segment for both behind-the-meter installations and front-of-meter systems that export all energy to the grid.

Although mid-scale PV systems are eligible to receive LGCs, generators less than 5 MW can be classified as 'non-scheduled generators' who do not participate in the central dispatch process and do not require the Australian Energy Market Operator's (AEMO's) strict grid connection requirements.

The 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. However, generators installed to power remote communities and mining operations are commonly found in the mid-scale range and a growing number of single-axis tracking systems are designed to participate in the wholesale market.

Incentives vary widely amongst the mid-scale PV sector. Large differences exist in financial returns with the avoidance of retail electricity charges in behind the meter use versus selling energy to the wholesale market. There are also differing state-based programs targeting particular sectors and communities.

With such a wide range in applications and incentives, it was deemed to be inappropriate to utilise an all-encompassing model to forecast the 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 to a mathematical uptake function.

The dataset supplied by the CER containing the current and proposed mid-scale installations was segmented based primarily on the type of commercial organisation where the system is installed. This enabled an estimation of the total size of the mid-scale market to be established based upon the 12 largest categories. Of the estimated market size of around 11,654 potential premises, only 1,107 premises have been recorded as having a mid-scale system installed, indicating that there is still room for growth.

The net present value and payback periods of various cases were also calculated to help with the projections. Projected payback periods for behind-the-meter commercial systems have dropped steadily from over 12 years in 2012 to approximately 6 years currently. The payback period is expected to moderately reduce further for the remainder of the projection period, primarily driven by a reduction in capital cost. This indicates that despite the decreasing LGC prices and the lack of new federal incentives, the economic benefit of installing these systems continues to improve.

Systems designed to target the wholesale market were less financially rewarding. The Redmud business model based upon selling LGCs and energy to the South Australian wholesale market was not determined to be economically viable in states with lower wholesale prices. Systems sized at 5 MW with the ability to procure discounted PV panels based on scale also have the benefit of the avoidance of stringent AEMO connection requirements.

Table 1 summarizes the capacity projections for the 5-year projection period for mid-scale PV systems installed across Australia.

Table 1: Summary of projected capacity of mid-scale PV installations 2021-2025, MW

	2021	2022	2023	2024	2025
Behind-the-meter systems					
Education – Schools	4	5	5	5	4
Education - Universities	3	1	1	1	1
Airports	12	1	1	1	1
Other industries	75	112	111	101	109
Front-of-meter systems					
Ground Mounted <=5MW	5	8	4	4	4
5 MW Systems	0	40	40	40	40
5-10 MW Systems	70	0	0	0	0
10-20 MW Systems	15	26	15	15	15
20-30 MW Systems	0	25	25	25	25
Total	180	218	202	192	199

Actual returns on investment for commercial businesses for the installation of a mid-scale system are estimated to be approximately 11% in 2021 and are expected to marginally improve to 12% in 2025, driven by the continued expected decline in capital cost of solar panels and eventual increase in wholesale prices following the retirement of Liddell coal fired power station in 2023. These factors, and the recovery of the economy is expected to continue to see growth in this sector over the projection period.

Annual mid-scale systems installations are projected to increase from 180 MW in 2021 to 199 MW in 2025. This is driven by the economic benefits and relatively low market saturation, the practical application of energy production and consumption at the same site, utilisation of excess rooftop space and the recent announcement of new government and utility programs.

However, the projecting of mid-scale PV systems is inherently difficult. This study bases forecasts primarily on the estimated economic benefit and capability of uptake of the various market segments resulting in robust outcomes. Unless otherwise stated, all results are based upon the assumption that the network is capable of handling the influx of mid-scale PV systems and that no restrictions are imposed to limit these connections.

1. Introduction

The CER has engaged Jacobs to provide projections of uptake of mid-scale PV systems for 2021 to 2025.

The projection of mid-scale PV uptake was based on the completion of several tasks including:

- Modelling of expected installations of mid-scale PV systems over the five calendar years, from 2021 to 2025. 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 (from 100 kW up to and including 5MW, and from 5 MW to 30 MW) for each state and territory in Australia.
- 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 systems.

Historical data has been supplied by the CER containing detailed information on the number of mid-scale systems installed and registered including the location of the unit installed, and in most cases, the name of the enterprise where the installation occurred. The data was provided from 2001 until May 2021 and included a total of 1,454 accredited mid-scale system applications. All analysis and forecasts in this study are based upon PV units determined by either the month of first generation or the initial application date.

The findings presented in this report must be interpreted with an understanding of the limitations of forecasts which are necessarily based on uncertain information about future market conditions. Perceptions of these parameters may change over short time-frames as wider economic, social and technological trends evolve.

Events can also occur for reasons not considered in the forecasting process, such as changes to regulations affecting the use of embedded PVs or development of alternative market arrangements for the output of PV systems.

All monetary values in this report, unless stated otherwise, are in December 2020 dollars.

2. Federal Government Incentives

The CER is responsible for the regulation of the Australian Government's climate change laws and programmes. One of its functions is to administer the Large-scale Renewable Energy Target (LRET).

The LRET is designed to incentivise the development of large-scale renewable power stations in Australia through a market for the creation and sale of LGCs.

PV installations accredited under the LRET are able to create LGCs for electricity generated. Liable entities are required to buy LGCs from the market and surrender these certificates to the CER on an annual basis.

The number of LGCs created is based on an estimate of electricity generated by the renewable energy sources. One LGC certificate is created for each MWh deemed generated by the renewable resource. The accreditation of generators and creation of LGCs continues under the LRET until 2030.

The renewable energy target of 33,000 GWh by 2020 has now been met. This target is legislated to remain constant until 2030.

Figure 1 shows the historical and predicted LGC price. The price exceeded $80 per certificate throughout 2016 to most of 2018, when it rapidly declined to approximately $40 per certificate.

The price of LGCs is expected to decline throughout the 2020s from its present level of about $34 per certificate. There is some evidence to suggest that some companies are installing multiple systems just shy of 100 kW to take advantage of the more generous STC scheme rather than the LGC certificate scheme in anticipation of the decline in these prices.

As the LRET has already been met the value is anticipated to decline rapidly. 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, reductions in marginal loss factor (MLF) values and delays in timing of construction of projects. Additionally, market participants, some of whom will be selling these certificates on a merchant rather than PPA basis, may also be able to bank or withdraw a portion of certificates to keep market prices at levels that better support their projects.

Carbon abatement requirements depend on the emissions intensity of the National Electricity Market (NEM). For the outlook until 2023, the LGC price exceeds that of the Australian Carbon Credit Unit (ACCU) price, an alternative source of income that prices carbon. Renewable developers are assumed to be indifferent between the mechanisms of emission reductions and will decide based on economic attractiveness. From 2023, the NEM emissions intensity is such that ACCU prices are expected to exceed LGC prices. This effectively creates a floor price, which is assumed to be approximately $20, the current ACCU price.

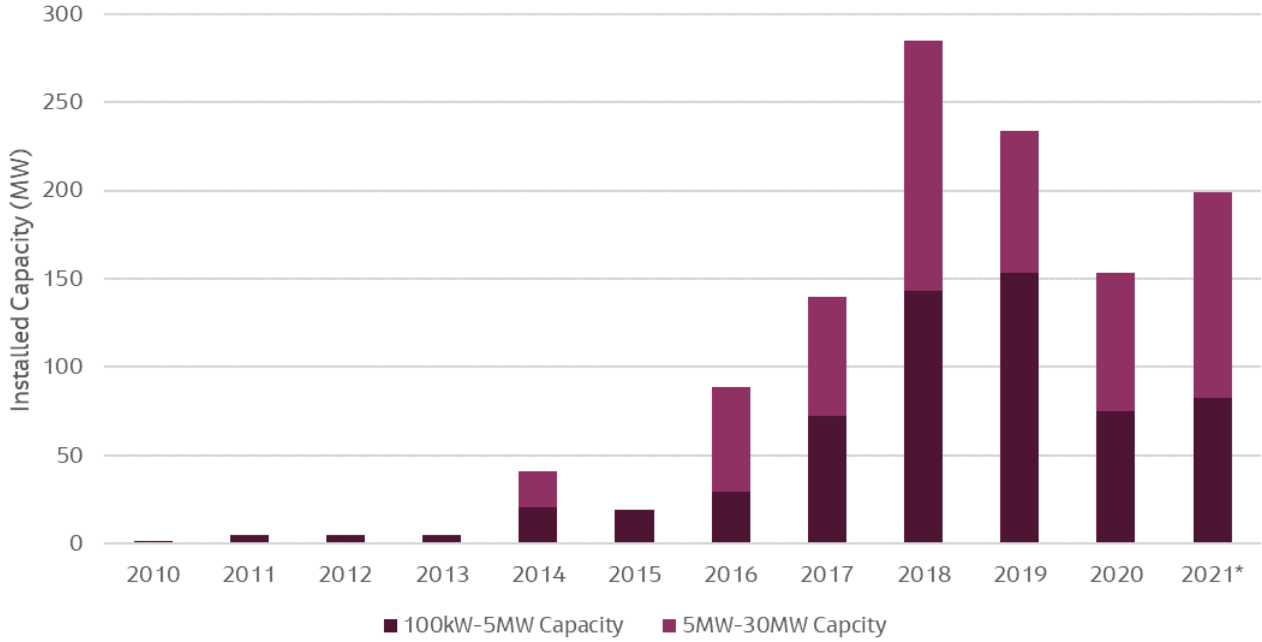
Figure 1: Historical and projected LGC/ACCU prices, $Dec 2020

Source: Demand Manager, Jacobs Analysis.

3. Trends in Uptake

Mid-scale PV installations of 100 kW to 30 MW in size have recently experienced a growth in installation rate. Figure 2 highlights the trends for the installed capacity of these mid-scale systems by state and divided by systems less than 5 MW in size and systems between 5 and 30 MW.

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



*Source CER dataset, *2021 incomplete dataset*

The key reasons behind the separation of these sizes is:

1. The 100 kW – 5 MW segment will predominantly include rooftop systems for behind-the-meter purposes.

2. The >5 MW systems will predominantly be ground-mounted systems. With exception of large-scale industries (e.g. Airports), it is therefore likely that these systems will share a common incentive of exporting most of the energy to the grid.

The year 2018 saw the greatest increase in system sizes between 5-30 MW and a growth rate of 96% of systems between 100 kW and 5 MW. This is attributed to the high LCG prices which remained greater than $80 per certificate between July 2016 to June 2018. A sharp decline in certificate price during 2019 resulted in a decline in uptake of utility scaled systems, however behind the meter systems (<5 MW) still showed a modest growth rate of 5%.

A reduction in installed capacity of mid-scale systems is observed in 2020, but this trend is expected to reverse in 2021 with a greater expected uptake for both 100 kW-5 MW and 5-30 MW systems. While the data for 2021 is incomplete, most enterprises submit applications well in advance of the installation date to secure the LGC income as soon as possible. The data for the year 2021 includes all installations under application, which we believe provides a reasonable estimate for the entire year.

Like other industries, mid-scale PV installations are exposed to new risks from the COVID-19 pandemic, varying significantly by market sector and technology. Restrictions on business activities have reduced energy demand have decreased the consumption of both thermal and renewable energy. However, the reversal of trend in uptake capacity may indicate that deferred investment due to COVID-19 is now behind us.

4. Method

The incentives for the stakeholders within the mid-scale PV capacity market are varied. It includes both rooftop capabilities for large commercial and industrial building sites and additionally larger scale ground-mounted tracking systems that potentially expand over several hectares.

The difference between commercial and industrial retail pricing also is a key differentiating factor, with industrial rates based on high voltage loads and potentially baseline consumption patterns, being almost half of the rates expected by commercial and SME organisations.

The most important motivators for instalment of mid-scale PV systems include:

- Behind the meter reduction of energy usage rates, through self-use of generated solar power (behind the meter systems).
- Export of all generation to the grid for trade in the National Electricity Market, other regional markets or electricity sales through Power Purchase Agreements (PPAs) (front-of-the-meter systems only).

There are additional complex considerations for expansive ground mounted systems within the metropolitan area where land value and other opportunity costs associated with land utilisation may far outweigh the benefits of installing a medium scale ground-mounted system.

For the above reasons, it was difficult to develop an all-encompassing model. Estimations were made from a combination of a bottom up approach, based primarily on available market information, and by fitting a mathematical function based on trend analysis to the identified segments with more homogenous incentives.

The mid-scale PV systems installed in the education sector and ground mounted systems installed for the purposes of exporting energy to the grid was considered separately in a bottom-up approach due to the different incentives from standard commercial behind-the-meter systems.

4.1 Segmentation and market sizing

For the purposes of this study, the historically installed PV systems were categorised into segments. Market segments were identified based on the analysis of the current installations of mid-scale PV systems in the dataset provided by the CER.

The market size of the 12 largest segments were then estimated based on relevant market information. The 12 largest segments formed 96% of the total mid-scale capacity currently installed. These segments are:

- Retail
- Industrial/manufacturing
- Agricultural
- Education
- Logistics/warehousing
- Water treatment
- Health
- Recreation

- Mining
- Airport
- Government
- Aged care

Other notable segments in the dataset include commercial, hospitality, tourism, churches, data centres, construction, markets, showgrounds and community facilities.

4.2 Assessment of economic benefit

To form a view on the economic benefit over the life of a PV system, we have developed a model to forecast 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 levelized, these cash flows can either be used to assess the life-long benefit of either a rooftop PV system or a ground mounted grid scale PV system. These can also be compared to the estimated upfront cost of installing such a system so that comparisons can be made on the actual net benefit of the system and to assess the payback period.

Critical inputs and assumptions in assessing future cash flows, and thereby net benefit, include expected electricity cost, capital cost of the system, projected energy consumption and consumption patterns.

Other important factors in the calculations include the expected annual output of a PV system, considering solar insolation levels, capacity factors and degeneration.

To determine the average net export of electricity to the grid for rooftop systems, a typical daily commercial consumption profile was utilised with 12 typical rooftop solar generation profiles to represent each month of the year. The difference between the matching generation and consumption patterns was then used to calculate expected reduction in demand and thereby expected energy savings for each of the twelve months. This figure is then annualised to represent the yearly energy savings.

4.3 Estimating uptake

Most mid-scale installations in the CER dataset have been identified as behind-the-meter solar PV systems. Based on the assumption that these systems are subject to the projected economic benefits, we have adopted an approach to forecasting utilising a mathematical function to fit the available trended installation data. A variety of mathematical functions were considered for this purpose, however, the Gompertz function was selected on the basis that it has been used to model the uptake of new technology and provided a good fit to the trended dataset.

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

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

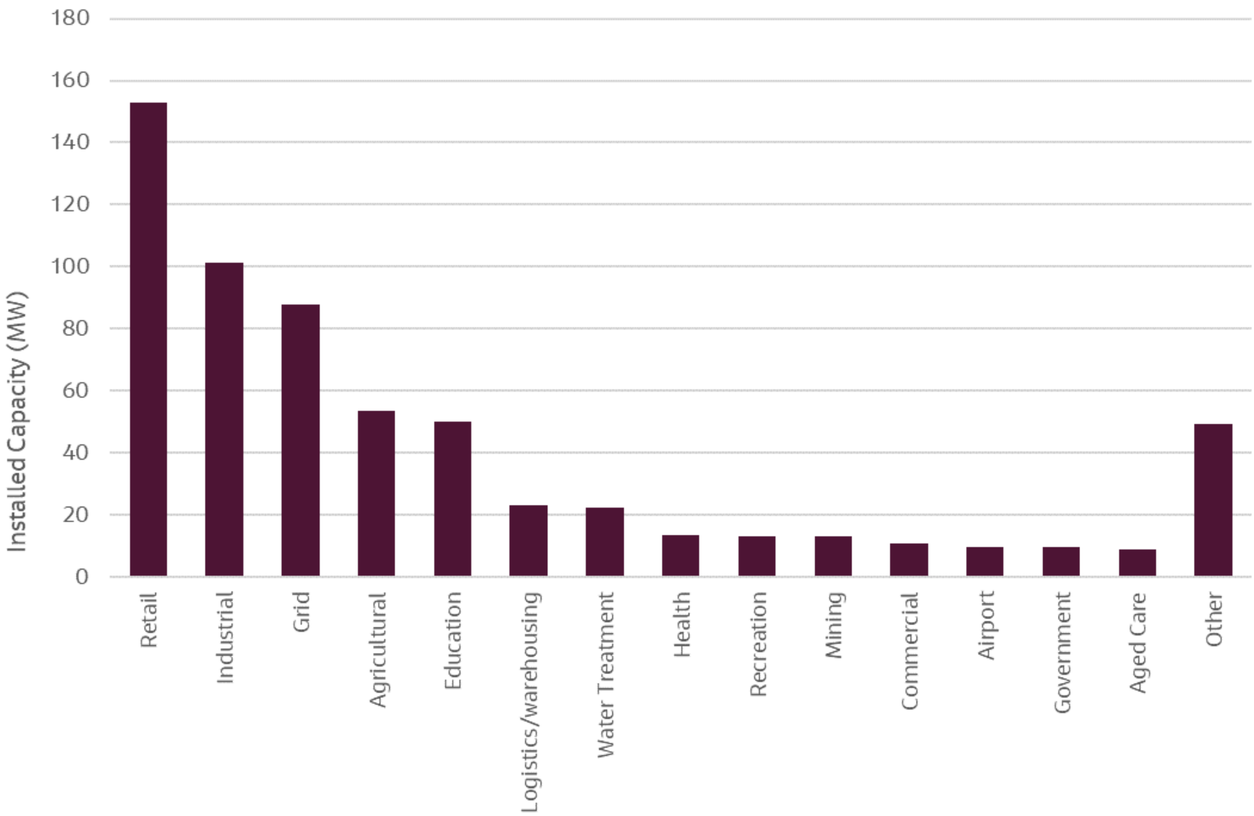
The prediction accuracy was found to be acceptable for short-term predictions (5-10 years). The total market size of all segments is considered as an input to the model as the asymptote constant (a in the Gompertz function), and the other two parameters b (halfway point or x-axis displacement) and c (growth rate or y-axis scaling) were selected based upon fitting the trend of PV installations via the sum of least squares. All mid-scale installations with exception of the education sector, airports and the 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 estimated capacity of mid-scale installations.

With a suite of government incentives targeting the education sector and many remote communities, the uptake of mid-scale solar PV for these segments was estimated using a bottom up approach. 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 major difference in incentives compared to the behind-the-meter categories. Market analysis was conducted to understand the current drivers, likelihood and capabilities of businesses and industries to install such systems to arrive at estimates of future capacity.

5. Segmentation of Market

Figure 3 shows the breakdown in installed capacity across various identified segments in the 100 kW to 5 MW range. With over 153 MW installed, the retail segment remains as the greatest contribution to PV installations in the mid-scale category. The industrial sector (predominantly manufacturing and food processing industries) is the second largest sector contributing 101 MW and the community and other ground-mounted systems as the third largest segment with around 88 MW installed across Australia.

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



There are many other 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 plant, cool storage warehouses and hospitals have all been quick to enter the market. In the last year, the mining industry has also shown large increase in uptake of behind-the-meter systems.

6. Economic Benefit

The net economic benefit and payback period of the installation of mid-scale PV systems is considered one of the key drivers for the recent increase in uptake of mid-scale PV systems within the commercial sector. For the purposes of projecting the future uptake of such systems, it is therefore important to establish a trend in the economic benefits that PV systems would bring commercial enterprises.

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 3 different scenarios as outlined below:

1. Commercial 250 kW rooftop systems (e.g. most manufacturing, retail, educational, aged care).

2. Industrial 850 kW rooftop systems (e.g. large-scale manufacturing, hospitals and large universities).

3. Ground-mounted front-of-meter fixed angle 200 kW system.

Table 2 outlines the parameters and key assumptions utilised for the net economic benefit calculations.

It is 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 utilised by the enterprise or traded on the market. The capacity factor of the commercial installations is assumed to be 16%, which is typical of rooftop installations in the NSW region. It is assumed that the industrial sized installations would under-take an east-west configuration on the rooftop, and a 17% capacity factor was allowed. In the case of fixed angle ground-mounted systems, the capacity factor is assumed to be 19%, and for ground-mounted single-axis tracking a capacity factor of 23% was assumed.

Net present value (NPV) calculations for rooftop systems are based upon 10 years of future cash flows, due the potential shorter life cycle of the business hosting the system. For ground mounted systems and industrial systems, the net present value is based upon 15 years of future cash flows. Cash flows from energy savings or sale of electricity to the grid are discounted at a real rate of 7.5%.

Table 2: Summary of assumptions utilised for net economic benefit calculations

	Commercial	Industrial	Ground Mounted
Capacity	250 kW	850 kW	200 kW
Solar Profile	NSW rooftop	NSW rooftop	NSW rooftop
Solar degeneration			
Capacity Factor	16%	17%	19-23%
Demand Profile	Commercial demand	Industrial demand	N/A
Real WACC[1]	7.5	7.5	7.5
NPV time	10 year	15 years	15 years
Electricity Price	Commercial	Industrial	Wholesale

[11] Weighted average cost of capital

6.1 Assumptions

6.1.1 Demand

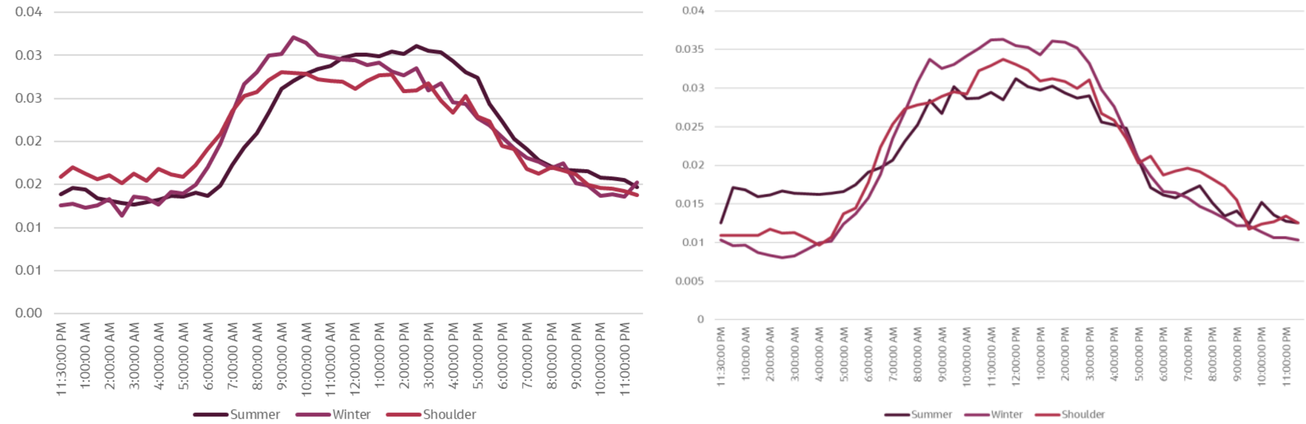
Industrial and commercial demand shapes were obtained from a study conducted by the CSIRO and illustrated in Figure 4. These were measured and normalised over different periods of the year including summer, winter and shoulder periods.

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

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

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

Figure 4: Normalised average daily load profiles for commercial customers (left), industrial customers (right).



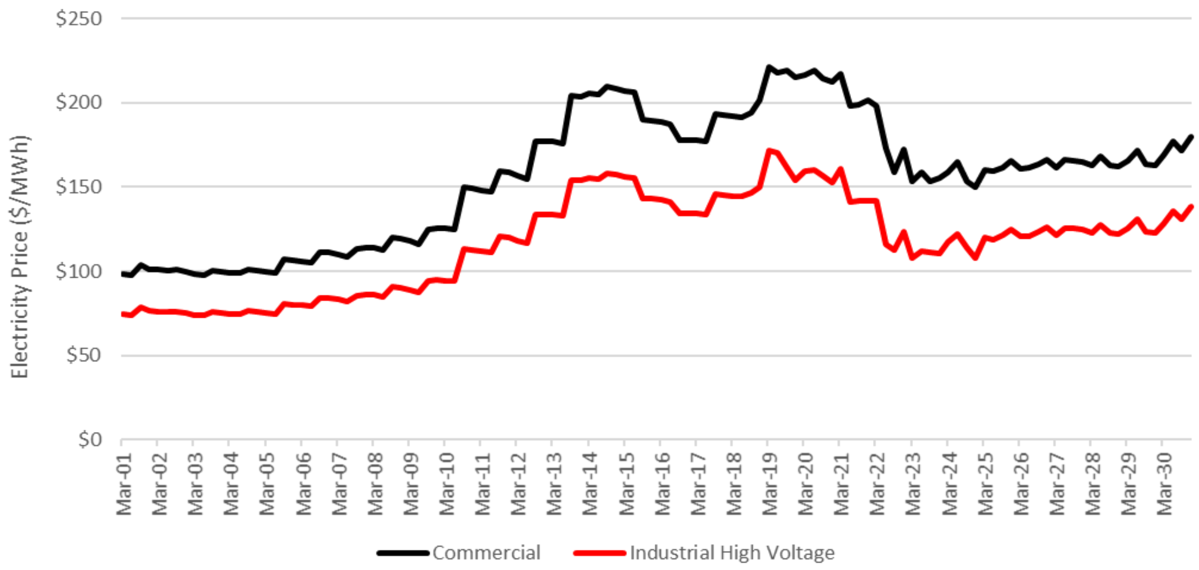
Source: CSIRO technical report: Load and solar modelling for the NFTS feeders, 2015

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 Electricity Prices

Figure 5 shows the historical and projected 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 5: Commercial and industrial retail electricity price assumptions, 2001 – 2030, $ Dec 2020



Source ABS index, Jacobs' analysis

6.1.3 LGC and STC schemes

Table 3 shows the averaged LGC price per calendar year utilised to estimate the annual benefits provided to mid-scale systems from the generation of renewable energy. **Table 3** also includes average annual STC and ACCU spot prices, and future projections of these prices are based on projections of the spot market.

For the purpose of calculating benefits of mid-scale system, the MLF for commercial and industrial mid-scale systems is assumed to be 1.

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

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

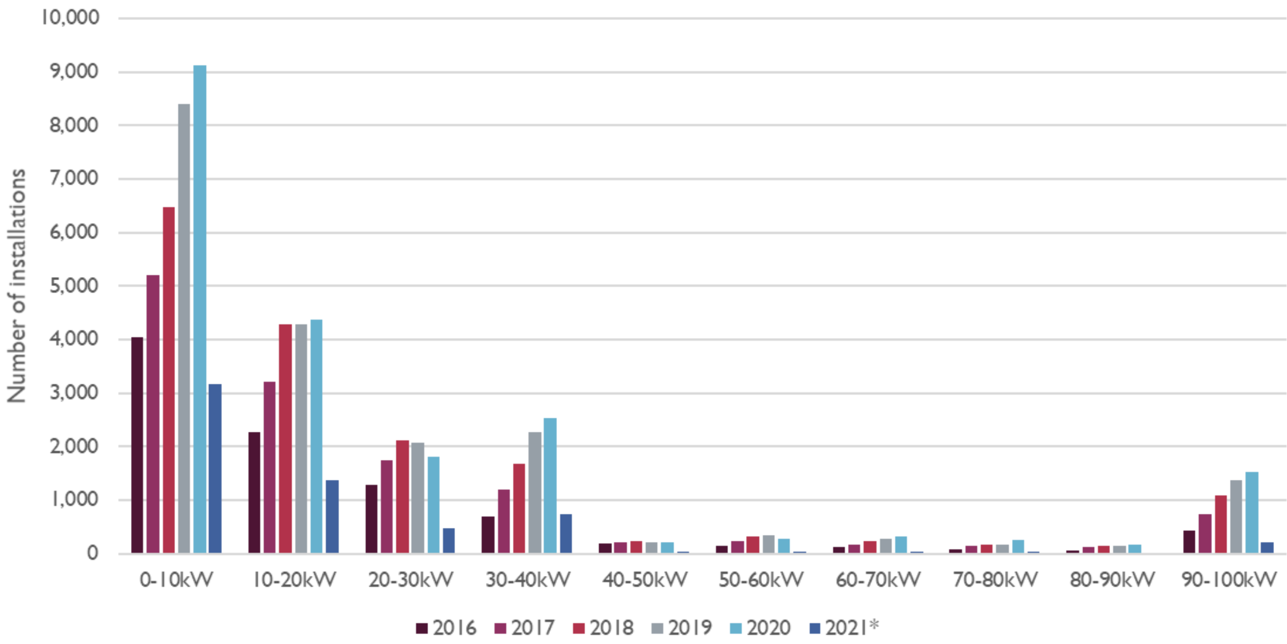
Table 3: Historical and projected annual LGC, STC and ACCU prices, $ Dec 2020

	LGC price ($ Dec 2020)	STC price ($ Dec 2020)	ACCU price ($ Dec 2020)
2015	58.6	43.0	-
2016	89.6	42.9	-
2017	88.3	37.6	-
2018	78.9	38.3	-
2019	42.8	37.8	16.6
2020	38.2	38.9	16.7
2021	34.0	38.0	18.1
2022	25.9	38.4	19.2
2023	21.0	37.5	19.7
2024	13.8	36.6	20.0
2025	10.5	35.7	20.0

Figure 6 shows the number of small-scale PV installations by size bracket. In 2020 there were 1,531 installations within the 90-100 kW bracket, which is more than the entire number of behind-the-meter mid-scale PV systems recorded. Additionally, the average system size in this category is 99 kW, this suggests that companies are taking advantage of the more generous STC scheme by remaining below the 100 kW threshold, even if they could install larger systems above the 100 kW range. 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 generous once-off STC rebate. This trend appears to have ended in 2021 as there are only 209 systems in the 90 kW-100 kW range. This is low compared to the 2020 year even when accounting for the part year.

With the STC rebate paid as a once off lump sum and LGC payments dependent on the electricity generated, we levelized the higher of future LGC or equivalent ACCU payments so that an appropriate comparison between the schemes could be made. **Table 4** shows the estimated STC benefits against a series of levelized LGC/ACCU benefits[2]. Both calculations are based upon a 100 kW system, operating at a 16% capacity factor. The LGC cash flows are levelized at a real rate of 7.5%, and prices are based upon the information outlined in **Table 5**.

Figure 6: Number of small-scale installations by capacity bracket, 2016 to 2021



*Source Jacobs' analysis of CER data, *2021 data is incomplete*

Two observations about the calculations are:

1. The STC rebates have a clear economic advantage for a 100 kW system over the LGC certificates; and

2. The difference between these benefits is relatively consistent.

Despite the projected decline in deemed creation of STCs, the difference between benefits from the STC certificates is still expected to be greater than from creating LGCs during the projection period (as LGC prices are also declining). We therefore assume that companies will continue to install systems just shy of 100 kW at the current increasing trend (estimated in Jacobs' Small-Scale Technology Certificate Report), and that the effect of LGC price decreases will not have a substantial impact on the mid-scale PV uptake.

[2] Levelised over 10 years

Table 4: Comparison of estimated levelized LGC/ACCU and STC rebates based upon a 100 kW PV system, 2012 to 2024, $Dec 2020

Year of Installation	STC rebate	Levelised LGC or ACCU benefit (10 payments)	Difference between STC and LGC levelized benefits
2012	68,324	57,858	10,466
2013	74,907	57,090	17,817
2014	86,779	56,392	30,386
2015	88,857	56,365	32,492
2016	88,675	52,456	36,219
2017	72,518	43,577	28,942
2018	68,588	34,177	34,411
2019	62,514	25,417	37,097
2020	58,956	21,396	37,560
2021	52,387	17,253	35,134
2022	47,680	13,427	34,252
2023	41,348	10,525	30,823
2024	35,297	8,154	27,143
2025	29,517	6,682	22,835

6.2 Economic benefit estimates

The economic benefits of PV installations where the PV generation matches well with the typical daily demand results in a continuing high growth rate within this sector.

The Payback period is calculated as:

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

The NPV is calculated as:

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

6.2.1 Commercial 250 kW behind-the-meter system

Commercial rooftop systems 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 5**. Payback periods have dropped steadily since 2012 to be under 7 years in 2020, driven by a continual drop in capital cost and high LGC prices. The payback period is projected to continue to decline for the remainder of the forecasting period despite a reduction in LGC prices and electricity prices. Since 2019 projected payback periods for commercial business have been below 7 years and internal rate of returns above 10%, which is consistent with the rapid increase in installations observed within this sector since 2017.

Another observation is that the first year of cash flows (including expected LGC rebate and energy savings) was highest in 2017 and 2018 when the highest growth rate in these mid-scale systems occurred.

Table 5: Payback period of 250 kW commercial system

	Capital cost	1st year cash flows	NPV (10 Year)	Payback (years)	IRR
2012	926,408	70,272	-354,403	12.6	-2%
2013	771,835	74,751	-195,514	10.6	1%
2014	702,713	73,493	-130,186	9.8	3%
2015	588,260	81,437	-19,469	8.4	6%
2016	540,472	93,515	15,798	8.0	8%
2017	506,078	99,659	24,069	7.8	8%
2018	460,358	98,731	35,781	7.4	9%
2019	406,218	83,921	54,286	6.9	10%
2020	387,831	79,074	50,178	6.8	10%
2021	355,628	78,409	63,628	6.4	11%
2022	355,628	66,306	43,369	6.6	10%
2023	340,645	57,947	49,226	6.4	10%
2024	327,359	55,936	61,521	6.1	11%
2025	314,637	56,301	75,801	5.8	12%

6.2.2 Industrial 850 kW behind-the-meter system

The key differentiator for the economic analysis of industrial systems is based on the retail price assumption. The electricity retail price for industry is generally less than for commercial businesses. With a lower retail price to offset, payback periods and internal rates of return (IRRs) are likely to be not as good as for the commercial sector.

In 2021, industrial systems are projected to have a 10% IRR and a payback period of under 9 years. With the anticipated decline in the capital costs, the IRR is expected to increase to 11% by 2025, while the payback period is projected to fall below 8 years.

Table 6: Payback period of 850 kW industrial high voltage system

	Capital cost	1st year cash flows	NPV (10 Year)	Payback (years)	IRR
2015	2,000,085	230,494	-142,541	11.2	6%
2016	1,837,606	270,009	-23,547	10.6	7%
2017	1,720,666	282,937	2,182	10.4	7%
2018	1,565,217	278,361	47,439	9.9	8%
2019	1,381,142	235,213	119,107	9.2	9%
2020	1,318,626	213,709	107,994	9.1	9%
2021	1,209,135	201,947	160,471	8.6	10%
2022	1,209,135	167,167	111,280	8.8	9%
2023	1,158,194	147,084	145,791	8.4	9%
2024	1,113,019	143,818	194,381	8.1	10%
2025	1,069,767	146,346	245,108	7.7	11%

6.2.3 Fixed angle ground mounted front of meter system

The assumptions for assessing the uptake of ground mounted systems are that a 200 kW ground mounted system is set with fixed tilt at a 19% capacity factor in NSW. Average annual wholesale solar dispatch-weighted prices for NSW were utilised as inputs.

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/ACCU payments at a real discount factor of 7.5%.

The results of the NPV and payback period are outlined in Table 7. With positive NPVs not achieved over the projection forecast, 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 network.

This indicates that for mid-scale ground mounted fixed tilt PV arrays to be a reasonable investment, either expected energy prices must be higher (such as the case in South Australia) or they must be installed in behind-the-meter applications and/or have a reasonable PPA arrangement. The other case where front-of-the-meter fixed tilt systems would be financially beneficial is in the case of remote communities where the solar generation displaces the cost of diesel generators.

Table 7: NPV and payback estimates of 200 kW, fixed angle ground mounted system

	Capital cost	1st year cash flows	NPV (10 Year)	Payback (years)	IRR
2012	741,126	24,715	-477,854	28.9	-7.3%
2013	617,468	26,721	-354,076	24.6	-5.6%
2014	562,170	21,760	-300,620	22.9	-4.9%
2015	470,608	27,879	-205,903	19.4	-2.8%
2016	432,378	42,358	-170,802	18.4	-2.0%
2017	404,863	52,817	-162,378	18.5	-2.1%
2018	368,286	46,164	-156,605	18.8	-2.2%
2019	324,975	35,975	-139,394	18.3	-1.7%
2020	310,265	29,270	-141,626	18.7	-1.9%
2021	284,502	22,420	-127,301	18.0	-1.4%
2022	284,502	20,951	-132,672	18.3	-1.6%
2023	272,516	19,286	-124,861	17.9	-1.3%
2024	261,887	16,946	-116,754	17.3	-0.9%
2025	251,710	16,371	-106,557	16.5	-0.3%

7. Market Sizing

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

This evaluation was conducted on the top 12 behind-the-meter categories identified by installed capacity, which represents 90% the installed capacity within the mid-scale range. **Table 8** summarises the estimates on number of suitable locations for these categories, along with an indication of the current level of uptake within each segment.

Table 8: Potential market for mid-scale rooftop installations and current installations

Segment	Market size (number of potential sites)	Current number of installations
Retail	1,786	279
Water treatment	129	36
Airports	20	9
Manufacturing	5,156	203
Agricultural	1,387	112
Logistics/warehousing/transport	487	53
Government	268	31
Leisure, sports and aquatic centres	322	43
Hospitality	875	32
Aged care	776	55
Hospitals	290	25
Mining	157	11
Total	11,654	889

7.1 Background and assumptions

7.1.1 Retail sector

The retail industry has played a significant role in the uptake of rooftop PV systems, with their opening hours matching well with the 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 and hardware warehouses, department stores and shopping centres.

Several of these companies have already began initiatives to roll out rooftop solar PV as part of their economic and sustainability objectives. Aldi has announced a commitment to source 100 per cent of its electricity from renewables by the end of 2021, while Woolworths and IKEA Australia announced 100 per cent renewable targets by 2025.

By the end of 2020, Woolworths had installed rooftop PV on 150 of their supermarkets across Australia and Aldi had installed systems on 250 of their Australian stores.

Queensland Investment Corporation (QIC), owner of multiple shopping centres across Australia, installed rooftop PV across these centres in 2021 and has indicated further investment in renewable technologies. It has recently expanded its interests in the large-scale market through the Powering Australia Renewables (PowAR) company and its acquisition of Tilt Renewables.

According to the Urbis Australian Shopping Centre Industry report (Baker Consulting 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, which include at least one discount department store.
- 1,120 neighbourhood or supermarket-based shopping centres, which include at least one supermarket as the major anchor.
- 96 CBD centres.

The CBD centres were not considered to be suitable for a mid-scale PV installation.

We also assumed that the shopping centres include all suitable supermarkets and therefore we will not make additional inclusions for supermarket chains.

In addition, there are 297 chain hardware retail outlets in Australia. All chain hardware stores will be considered as a potential to host a mid-scale PV system.

The analysis considered the retail segment to comprise the regional shopping centres plus sub regional centres plus the supermarket-based shopping centres plus chain hardware outlets to give a total of 1,786 retail premises that are considered suitable for the installation of a mid-scale PV system.

7.1.2 Water Treatment Plant

We used several sources to piece together the market share and uptake of solar PV systems at water treatment facilities in Australia. For this category we are including water treatment plants, pumping stations and desalination plants.

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

- 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[3] of which 9 entries are applications that have been submitted in 2021. Of the remaining 43 entries, 3 entries have commenced operation and have been accredited in the last 12 months.

SA Water has committed to 150 MW of rooftop PV across its operations as part of its Zero Cost Energy Future strategy. This is a $300 million project across 33 sites for SA Water operations to reach net zero emissions. As of May 2021, 24 sites had been fully commissioned[4] and this has been cross checked with the CER data and AEMO generation information page.

According to the CER data, the average size of the solar PV plants at the water treatment sites is 1.03 MW. Plants accredited and under application over the past financial year (2020/21) have an average size of approximately

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

1.9 MW, indicating that the average size of these projects is increasing. The largest of these projects are powering the water pumping stations in SA.

To estimate the market size of the water treatment sector we have utilised ABS statistical data and information available on the website of Sydney Water[5] about their water, recycled water and wastewater networks.

According to the ABS data there were a total of 635 water treatment sites across Australia at the end of 2020, of which 116 sites (18%) had a turnover of more than $2 million. Over 50% of all large water treatment sites are in NSW and Victoria.

The turnover of these sites has fallen compared to 2019 turnover, which we assume to be linked to the impact of COVID-19. We therefore apply the 2019 turnover proportion of 20% to the 635 sites, gives us 129 potential sites for PV installation.

To substantiate the above assumptions, we have 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 therefore represents a good mix of urban, suburban and regional/rural coverage and can be considered a good scale representation of Australia's water treatment activities.

According to the latest Sydney Water data, published on their website, the Sydney Water network includes 9 water filtration plants, 16 wastewater treatment plants and 14 water recycling plants and one desalination plant. We assume 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,7 recycling plants and 8 wastewater plants fall in this category. This would bring the total suitable sites for Sydney Water to 25 (including the desalination plant).

The ABS data for NSW suggested a total of at least 32 plants with a turnover of more than $2 million. This suggests that at least another 7 sites in regional NSW would be large enough to host a mid-scale solar PV plant.

Therefore, the Sydney Water specific data broadly supports the ABS data. Jacobs used the assumption that 129 sites with a turnover of at least $2 million are likely suitable for mid-scale solar PV. The $2 million threshold has been 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.

7.1.3 Airports

Appendix B lists the twenty busiest airports in Australia during 2020 and the capacity of solar currently installed at these airports. With over 400,000 passengers per year (excluding the year 2020), 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.

Melbourne Airport has now installed in the beginning of 2021 a 12.4 MW (DC) solar farm, one of Australia's largest behind-the-meter arrays to power all four terminals.

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. We therefore expect the remaining airports on the list to install solar panels within the foreseeable future. For this study, we will assume 1 MW per year will be installed from 2022 until 2025. This is much lower than the amount installed at Melbourne airport because the remaining airports without a current installation are mainly regional with a much smaller volume of annual passengers.

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

7.1.4 Manufacturing, agricultural and warehousing/logistic industries

Table 9 shows the expenditure and net usage of electricity for the select economic sectors. With a significant margin, the largest consumers of electricity are the mining and manufacturing sectors.

Table 9: Net electricity consumption and expenditure in different economic sectors, Australia, 2018 - 2019

Industry sector	Expenditure ($m)	Electricity Consumption (GWh)
Agriculture, forestry and fishing	827	2,222
Manufacturing	7,309	78,889
Transport	1,222	4,722
Construction	569	1,944
Mining	5,414	41,389

Source: ABS and Jacobs analysis of the data[6]

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

Table 10 shows the number of manufacturing businesses in Australian states and territories with a turnover of greater than $5 million. Larger manufacturing businesses generally have more working capital, factory floorspace and thus more rooftop space. Therefore, we assume that these businesses would have both the financial means and rooftop capacity to host a medium-size PV system.

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

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

The ABS also provide the survival rate of businesses that existed in 2016 and are still operating in 2020. This gives an indication of the percentage of businesses that would potentially be in an economic state to still exist in the next 4 years. This is important as a typical payback period of a mid-scale commercial system is around 4 years and so businesses surviving at least four years would more likely be taking up solar PV systems. We therefore have reduced the potential market size of agricultural, manufacturing and warehousing/logistics businesses by this survival rate.

[6] ABS - 46040DO0005 Energy Account, Australia, 2017-18 and 46040DO0007 Energy Account, Australia, 2017-18. Jacobs used a conversion factor of 277.778 to convert Petajoules to GWh.

Table 10: Market size assumptions for manufacturing, agricultural and transport sectors

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

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

7.1.5 Mining Industry

The Australian mining sector consumes roughly 570 petajoules of energy per year, 10% of Australia's total energy use, and consumption has risen at 6.0% per annum over the last decade, driven primarily by increased mining volumes[7].

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

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

According to the Australian Operating Mines Map 2020, there are 375 operating mines in Australia, primarily coal, bauxite, precious metals, base metals, battery/alloy metals, heavy mineral sands, lithium and fertiliser elements[8].

For this study, we will consider all copper and gold mines as potential for installation of solar farms, which brings the number of eligible mines to 157.

7.1.6 Government buildings

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

There are 537 councils in Australia[9]. It is assumed that each one of 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 LGA.

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

[7] https://arena.gov.au/assets/2017/11/renewable-energy-in-the-australian-mining-sector.pdf
[8] https://ecat.ga.gov.au/geonetwork
[9] Australian Local Government Association: https://alga.asn.au/facts-and-figures

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

7.1.7 Recreation, leisure, sports and aquatic centres

There are approximately 1,077 public swimming pools in Australia[10]. These are commonly associated with a full leisure centre such as gym and other sports facilities. The need for large amounts of water pumping for any aquatic centre, results in a large consumption of energy and these are therefore considered suitable for the installation of mid-scale PV systems.

According to the ABS, there are approximately 355 sports and leisure centres with an annual turnover greater than $2m. Of these, the four-year survival rate for the period of June 2016 to June 2020 is 83%. The number of facilities has decreased over the last year due to Covid-19 impacts (lower turnover), but the survival rate is similar. We have therefore assumed that the total market size for the sports and recreation sector is unchanged at 322, as turnover would be expected to increase again in 2021.

7.1.8 Hospitality industry

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

The number of businesses that represent gambling, sporting, recreational and social clubs or associations that generate income predominantly from hospitality services in 2020 are estimated at 5,753.[11] The industry has shown decline since 2018 and is expected to decline even further in the foreseeable future due to overall maturity of the industry, increased competition and declining per capita alcohol consumption. In addition, the current COVID19 crisis is expected to negatively impact the sector's revenue by more than 22% in 2020. The sector has seen some recovery in 2021, with the survival rate of businesses with over $2 million in turnover improving from the 2020 data set.

Without the impact of the COVID19 crisis we would include hospitality business with an average turnover greater than $2 million. However, due to the crisis we are now assuming the businesses with a turnover of more than $5 million and an average survival rate of 89.78%, to be resilient enough to take up solar PV.

Upon evaluation of Todae Solar's portfolio of PV installations on social clubs, just under 50%, or 19 of the 40 installations had been less than 100 kW and therefore cannot be considered for the mid-scale market.

After applying the above adjustments, the total market size for this sector is estimated at 875 suitable locations.

7.1.9 Aged care industry

As of June 2020, there are 2,722 residential aged care facilities in Australia[12]. A number of these have already taken up rooftop solar panels. We assume 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 776, which is assumed as the total market size of suitable aged-care facilities for a mid-scale system.

7.1.10 Hospitals

Due to the nature of services provided, hospitals are very energy intensive. Hospital electricity usage is often so large that it is likely rooftop solar could only provide for up to 15% of its energy, even for lower-level hospitals[13]. Rooftop solar is more suited for smaller facilities in sunny locations. Based on this, we assume that a mid-scale

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

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

[12] https://www.gen-agedcaredata.gov.au/Resources/Access-data/2019/September/Aged-care-service-list-30-June-2019

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

system would power 15% of the facilities total generation requirements. For example, the minimum capacity for a mid-scale system is 100 kW and this is likely to produce around 200 MWh of energy across the year. Hospitals would therefore need to consume over 1,300 MWh of energy a year for mid-scale rooftop PV to meet this criterion.

A study conducted by VicHealth estimated that in the year 2016-2017, Victorian Public health services consumed approximately 650 GWh of electricity. The total number of hospital beds in Victoria is 15,120. This amounts to an average of approximately 43 MWh of energy consumed per hospital bed and 11,870 MWh of electricity consumed per day per public hospital in Victoria[14].

Combining the results above, a criterion based on bed size can be formulated. We assume a hospital would need a minimum of 30 beds to consume enough electricity to enable installation of a mid-scale rooftop PV system.

Table 11: Number of Australian public hospitals by bed size and remoteness

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

Victoria has announced recently that Government operations, including schools, hospitals, and police stations, will be powered by 100 per cent renewable energy by 2025. Of this around 5% is targeted to be on-site renewables by 2023.

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

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

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

Therefore, we have limited the potential market size of hospital installations to the percentage of hospitals that are located in regional or remote areas with greater than 30 beds.

This brings the assumed market size of the public hospital sector to 22% of the total number or 149 of the 692 potential premises, as per details provided in Table 12.

[14] https://www2.health.vic.gov.au/hospitals-and-health-services/planning-infrastructure/sustainability/energy/energy-use

Table 12: Number of Australian public hospitals by bed size and remoteness

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

Source: Hospital Resources 2018-19: Australian hospital statistics

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

The total potential market size for public and private hospitals all together in Australia is 290.

8. Uptake

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 Gompertz curve to the historical installations but utilising a sum-of-least squares. These estimates were then multiplied by the average capacity of these systems in 2021 (470 kW). This was used to calculate the estimated installed capacity of these systems.

We treated the water treatment sector slightly differently in light of SA Water's announcement of 150 MW of solar PV to be installed at their 34 sites by 2025. In this case we added in an assumed timeline for the installations (informed by their current status according to AEMO), but adjusted for the contribution of the water treatment sector to the Gompertz projection (calculated to be 6.7% of all capacity, which was based on the sector's contribution over the last two years).

Table 13 summarizes our estimates on the projected capacity of solar installations for the identified behind-the-meter sectors. The 2021 estimates are mainly sourced from the CER's mid-scale database, which means that they are based on existing projects. Projections from 2022 until 2025 are either based on our bottom-up assumptions, which are explained in sections 7.1.3 for airports and 8.1 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

	2021	2022	2023	2024	2025
Education					
Victoria	1.68	1.2	1.2	1.2	1.2
NSW	0.53	0.4	0.4	0.4	0.4
Northern Territory	0	0	0	0	0
Queensland	0.81	1.2	1.2	1.2	1.2
Western Australia	0.18	1.66	1.66	1.66	1.36
Tasmania	0	0	0	0	0
ACT	0	0	0	0	0
South Australia	0.85	0.16	0.16	0.16	0.16
Universities	2.52	1	1	1	1
Commercial & government					
Other government and commercial sites*	74	112	111	101	109
Airports	12.4	1	1	1	1

*Including retail, water treatment, manufacturing, agricultural, logistics, government, hospitality, sports & leisure, aged-care, hospitals and mining.

8.1 Education sector

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

8.1.1 Schools

In the lead up to the 2007 Federal election, the Australian Labor Party (ALP) established the National Solar Schools Program (NSSP). The plan was to make all 9,500 Australian schools a solar school within eight years. The NSSP offered primary and secondary schools the opportunity to apply for grants to install solar and a range of energy efficiency measures. At the time, $50,000 was offered for the installation of panels greater than 2 kW in capacity, or $30,000 for solar panels less than 2 kW in capacity.

Following the election, funding for the program of $481 million was provided. A total of 4,897 schools installed solar power under the NSSP until the program ended in June 2013.

While the NSSP 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[15].

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.

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. The rollout of this program is expected to occur in three phases as follows[16]:

1. Ten schools selected for round 1 - expected for completion in 2018/2019.
2. Eight schools selected for round 2 - expected completion in 2019/2020.
3. Seven schools selected for round 3 - expected completion 2020/2021.

In addition, 3 schools are installing solar systems under the Capital Works funding program, and an additional school has chosen to install solar panels with its Building Better Schools funding[17].

Analysis of the small and mid-scale CER databases suggests that the majority 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, while 11 schools were identified in the small-scale database as having PV installed during 2019, 6 in 2020 and 4 in 2021 (see Table 14).

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

Table 14: Solar PV installations at Northern Territory schools, 2019 - 2021

Year of installation	Installed capacity (kW)	Number of installations	Average installed capacity (kW)
2019	580.0	11	52.7
2020	506.9	6	84.5
2021	213.5	4	53.4

[15] https://www.pv-magazine-australia.com/2019/01/28/tomorrow-back-to-solar-empowered-schools/
[16] https://www.pv-magazine-australia.com/2020/02/13/northern-territory-schools-set-for-solar-savings
[17] https://newsroom.nt.gov.au/mediaRelease/33461

Advancing Clean Energy Schools Program

In 2017, the Queensland Labor government announced a $97 million investment to reduce energy across state schools through solar and energy efficiency measures[18]. 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 as a result 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. More than 800 of Queensland's state schools are being assessed to identify where energy costs can be reduced through solar and energy efficiency measures.

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 expanded ACES program is expected to deliver a further 26 MW of PV systems across the state.

With a total of 61 MW installed across 800 schools, this averages at approximately 76 kW per school. We therefore assume that the installations under this program would predominantly fall into the small-scale range.

We assume that installation at Queensland schools not currently involved in the state school initiative will continue to occur at the same rate that has occurred for the past four years, or approximately 4 schools per year each with a 300 kW installation.

Victoria

The Greener Government School Buildings program has been announced and is expected to install solar panels on Victorian government schools. The announcement follows the success of a pilot program which saw 42 schools receive solar panels in 2019.

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.

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 2020, at a rate of 5 schools per year with an average 240 kW system. There were no installations at schools in 2020, presumably due to the stricter COVID lockdown environment in Victoria.

New South Wales

There is a push for the NSW state government to pursue a similar initiative for state government schools to install solar panels. As with similar programs in Victoria and Queensland, we expect that these systems would fall into the small-scale category.

We expect the current trend of private school installations to continue (except for 2020, when no systems were installed) of approximately 2 schools per year at 200 kW.

Western Australia

As part of the Western Australia economic recovery plan, $4 million is to be spent on the installation of solar panels at ten schools. At an average of $400,000 per school, we expect that this would provide enough funding

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

for a mid-scale system. We assume that two schools will have a 150 kW system installed per year from 2022 until 2024 under the WA Economic Recovery Plan package.

As part of its 2021 election promises, the Western Australian government has 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 100kW of rooftop PV at that scale in Western Australia. We assume half of the schools will fall into the mid-scale category, and that 120kW installations will be rolled out at three schools per year for the next four years, starting in 2022, under the $4.6 million election package.

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 virtual power plants as well as rooftop solar. It has already been announced that six schools in Kalgoorlie and Geraldton (at the edge of the main grid) will have virtual power plants installed, although there is no indication what the size and composition of these plants will be. Two tiers of funding will be available to schools, where the first tier will allow construction of a virtual power plant and the second tier will enable 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 absence of more detailed information, we assume a total of 1MW of mid-scale rooftop solar capacity is built in each of the projection years under the Schools Clean Energy Technology fund.

South Australia

Without current state-based initiatives to install solar on schools, the assumption will be that mid-scale solar PV uptake will occur at the same rate that it has occurred for the last two years in South Australia, excluding 2020.

Three schools had accredited mid-scale solar installations with a median capacity of approximately 160 kW and there were three schools with a median capacity of 160 kW for the first 6 months of 2020.

Tasmania

In Tasmania there were no schools identified in 2019 or 2020 as having a mid-scale PV system installed. However, as part of its election pledges the current liberal government had promised to invest in rooftop solar for all Tasmanian government schools. This includes a $5million fund to deliver solar panels to more than 100 schools over the next 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.

8.1.2 Universities

There are 171 university campuses in Australia, the majority of these are expected to be capable of hosting a mid-scale system. A total of 42 university campuses are identified on the CER database, however only 79% of these have systems greater than 100 kW. For this reason, the assumption is that 79% or a total of 135 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 250 kW.

We assume that 4 campuses per year will have a 250kW rooftop installation for the projection period. In 2021, two universities have already applied for accreditation for a total system size of 2.52 MW.

9. Front-of-Meter Projections 1- 5 MW

There are two main categories identified that fall within this segment:

1. Solar farms in remote communities to offset diesel consumption;

2. Mid-scale solar farms designed for trading on the wholesale market.

The establishment of solar farms in remote communities to offset diesel consumption is considered only upon government programs. The establishment of mid-scale solar farms designed for trading on the wholesale market is considered to have different economic incentives from commercial based behind-the-meter systems.

A bottom up approach was also adopted for both these categories. This section outlines the assumptions surrounding our estimates on these remote community and front-of-meter system projections less than 5MW in capacity.

Table 15 summarizes our estimates on the projections of the front-of-meter sub 5 MW PV installations.

Table 15: Summary of front-of-meter 1-5MW installation capacity projections, MW

	2021	2022	2023	2024	2025
Remote Community					
Western Australia	1	1.5	0.5	0	0
Western Australia recovery plan	0	0	1	1.5	1.5
Main Grid Connection					
Redmud SA	2.67	2	2	2	2
Esperance power project	0	4	0	0	0

9.1 Ground mounted community installations

An increase in mid-scale community based solar systems has been observed over the past few years. The incentive for the establishment of such units is not only to supply green energy to remote communities, but also to offset diesel consumption.

9.1.1 Solar Energy Transformation Program

The Solar Energy Transformation Program (SETuP) was an initiative by the Northern Territory Government to integrate 10 MW of solar PV into 25 remote locations with existing diesel power stations[19]. The majority of these were expected to achieve 15% of diesel fuel displacement. The $59 million project was designed to create a platform for greater use of renewable energy in communities. Construction began mid-2014 and has recently been completed. It is therefore assumed that no further major PV projects will occur in Northern Territory remote communities for the remainder of the projection period.

9.1.2 Decarbonising Remote Communities program

The $3.6 million Decarbonising Remote Communities program formed part of a broader scheme for investment in renewable energy generation established by the Queensland government during the 2017 state elections[20].

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

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

Four Indigenous communities in Queensland's far north (Doomadgee, Mapoon, Pormpuraaw and the Northern Peninsula area) have been selected as part of this program to have renewable energy systems installed to reduce the use of diesel power.

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

Ergon Energy owns and operates 33 standalone power stations in Queensland that supply 38 remote communities, typically operated by diesel generators[22]. This opens the opportunity for further solar PV installations to partially offset diesel generation at these communities. It is assumed in this study that any PV installations at these sites would be small-scale (less than 100kW).

9.1.3 South Australian remote mid-scale solar

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

The Central Power House is the primary electricity generation facility which supplies 8 different aboriginal communities, and a further four power stations are in other aboriginal communities.

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

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

9.1.4 Western Australia remote communities solar project

As part of its commitment to clean energy, the Western Australian government announced plans to invest $11.6 million for the construction of solar farms in remote Kimberley Aboriginal communities[23].

Six remote community towns have been identified as part of the program that will involve up to 4 MW of solar PV installed at around 400 kW to 600 kW per site. Planning is underway for projects to be completed in the east Kimberly remote communities of Warmun and Kalumburu. It is assumed that 500 kW will be installed at each of these sites.

Construction was scheduled for solar farms in the west Kimberley communities of Ardyaloon, Beagle Bay, Djarindjin-Lombadina and Bidyadanga in 2021. However, none of the solar projects in these Kimberley communities have appeared in the CER's mid-scale database. We assume that the original timing for all projects has been delayed by one year.

9.1.5 Western Australia Recovery Plan

In July 2020, the Western Australian government announced plans to invest $66.3 million in renewable energy, most of which would be spent on solar and battery projects. This formed part of a $5.5 billion "Recovery Plan" to combat the economic impacts of COVID-19.

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21 https://arena.gov.au/projects/doomadgee-solar-project/

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

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

Approximately $6 million is expected to go towards the installation of solar panels for social housing and another $4 million is to be spent on the installation of solar panels at ten schools.

The stimulus package has also allocated funds to an additional 50 standalone power systems, largely aimed at regional communities and remote indigenous communities. For the purposes of this study, we assume that these systems will be 100-150 kW each installed over a five-year period beginning in 2022.

9.2 Redmud Green Energy

Redmud Green Energy, based in Riverland, South Australia offers land-owners the opportunity to re-purpose their properties for the construction and implementation of small ground mounted solar farms[24]. These farms are designed solely to export generated energy into the grid, enabling revenue to be gained via energy sold to the National Electricity Market and in the form of LGCs.

Since the retirement of the Northern Power Station in South Australia in 2016, wholesale electricity prices have been high. During this period, LGC prices also averaged well above $70 per MWh. The combination of these two factors would have potentially allowed for these relatively small systems to receive good returns from participating on the wholesale market in South Australia.

However, according to our NPV and payback period analysis this business model would not be so profitable with the lower wholesale prices observed in other states in combination with the declining LGC prices. For these reasons, it is assumed that this business model will not be replicated in other states in Australia for the forecasting period. Furthermore, the number of the these relatively small size systems (200-300kW) have steadily declined since 2018 and only three have been identified during the year 2020.

Table 16: Summary of Redmud front-of-meter installations, kW

Year	LGC price	Number of installations	Average size
2017	88.3	12	289
2018	78.9	23	250
2019	42.8	18	233
2020	38.2	4	223
2021	34.0	2	1,336

Redmud has recently formed a new entity “Green Gold Energy” in a joint venture with Chinese-based Golden Investment Group to engineer, procure and construct small solar farms across South Australia. The new joint venture has an agreement with a major international client to develop a portfolio of small solar farms in South Australia totalling 65 MW over the next three years.

The joint venture appears to target solar farm sizes between 1 and 5 MW. These solar farms allow for greater economies of scale, more sophisticated tracking systems while still enabling direct connection to the distribution system[25]. One of the 2021 Redmud installation in the CER’s mid-scale database fall within this category.

Currently Redmud Green Energy have a pipeline of five solar farms approximately 5 MW in size, which fall into our 5-30 MW projections (section 10) and a further two sites between 1 and 2 MW in size. A further ten sites are identified on their website as being shovel ready without supplying information about system sizes.

We project that the joint venture will contribute approximately two 1 MW sites per year for the projection period.

[24] https://redmud.net.au/
[25] https://onestepoffthegrid.com.au/green-energy-project-racks-up-50-solar-farms-in-south-australia/

9.3 Esperance power project

Horizon power will be building a hybrid power plant to contribute to the power supply of Esperance. It will consist of 9 MW of wind turbines, 4 MW of solar panels as well as a battery energy storage system. The plant is scheduled to be operational by 2022.

10. Front-of-Meter Projections 5-30MW

This section includes a discussion of the mid-scale solar PV projections for systems between 5 and 30 MW capacity. These solar PV plants are considered utility scale or community projects, ground mounted and in most cases directly connected to the high-voltage distribution or sub-transmission network. The latter usually makes them less costly to connect as voltage levels in the sub-transmission and high voltage distribution networks are generally between 11 kV and 132 kV, which allows for less expensive and complex connection assets (e.g. smaller transformers, overhead lines, cables).

For the 5 MW solar PV systems the connection process to the grid is less time-consuming and costly for developers and owners of these assets. Systems up to 5 MW can submit a network connection application as an embedded generator under Chapter 5, Part A of the National Electricity Rules. These embedded generators will then negotiate a connection agreement with the applicable Network Service Provider, who generally imposes less stringent requirements upon the proponent.

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 in excess of 30 MW. These systems are typically considered non-scheduled generating units. Classification of generator size by AEMO is summarised in the table below

Table 17: AEMO classification

AEMO Classification	Exempt	Non-scheduled	Semi-scheduled	Scheduled
Nameplate Capacity	Up to 5 MW	5-30 MW	>30 MW	>30 MW
Note	Cannot be over 5 MW	Does not participate in central dispatch.	The generating unit participates in central dispatch in specified circumstances	The generating unit participates in central dispatch

Source: AEMO

As observed over the past few years through anecdotal evidence, there is a tendency for proponents to avoid the interaction with AEMO by developing multiple embedded solar farms of 5 MW rather than larger non-scheduled systems up to 30 MW.[26] This may be due to the strict requirements for obtaining connection approvals, combined with delays in processing of these applications by AEMO.

Desktop research was performed to understand the current pipeline of 5-30 MW solar PV plants that are announced, have received planning approval, are under development or are being constructed. References to at least 72 solar PV projects between 5-30 MW under development have been found. The projects are outlined in Table 20.

Results of this research also confirms the popularity of 5 MW ground mounted solar PV systems, as the research suggests at least 35 different solar projects of 5 MW are currently being developed in the NEM, totalling 175 MW. Almost 90% of these projects are being developed in NSW, Victoria and South Australia. A further 40 solar PV NEM projects between 5-30 MW are also in the pipeline, with the bulk of these being developed in NSW, Victoria and Queensland.

[26] 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/

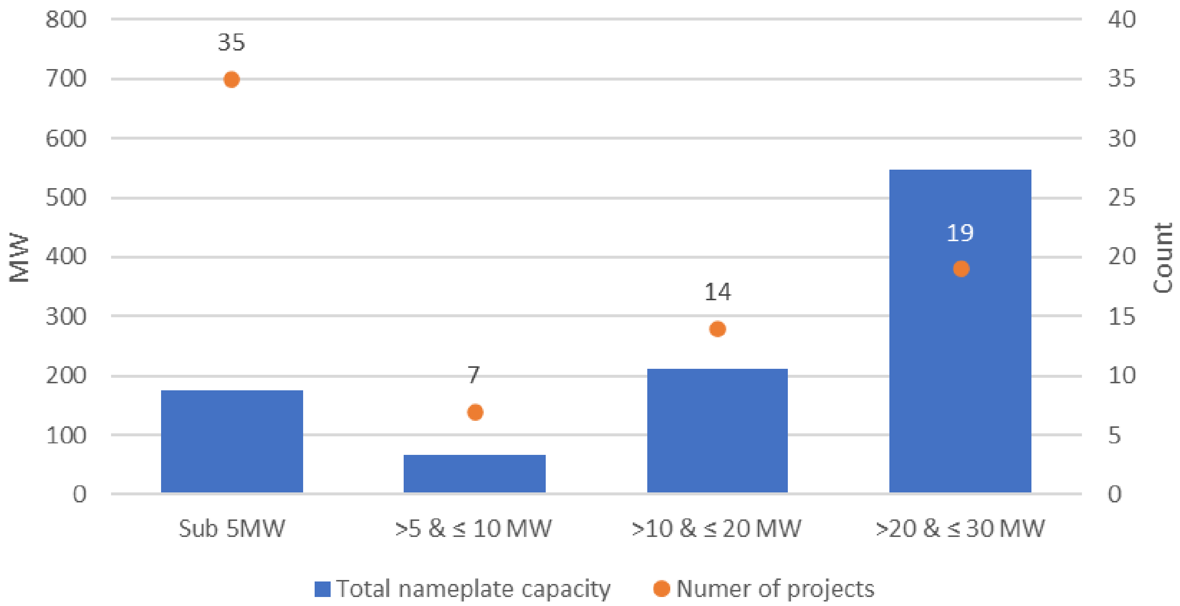
The research also found another 5 solar PV projects (5-30 MW) being developed in Western Australia and the Northern Territory. However, the developments in these states are harder to track as less information is available online. Therefore, we believe that there are likely more projects in the pipeline.

Based on Jacobs' assessment, the total project pipeline of ground mounted solar PV systems in Australia in the category 5-30 MW totals just over 1 GW of capacity based on 72 projects (an average of 13.3 MW per project).

Figure 7 shows the total capacity and number of projects for each of the medium scale categories defined as:

- Sub-5 MW systems.
- Systems greater than 5 MW up to and including 10 MW.
- Systems greater than 10 MW up to and including 20 MW.
- Systems greater than 20 MW up to and including 30 MW.

Figure 7: Overview of mid-scale project pipeline, ground mounted systems of 5-30 MW



Source: Jacobs analysis of multiple sources as included in Table 20

The number of 5 MW systems connected to the grid in Australia is anticipated to grow significantly over the next 4 years and that this will impact the development of larger systems between 5-30 MW (i.e. the chance of these systems being build). Therefore, based on the current data, we are assuming that at least 8 projects of 5 MW (40 MW) will be connected every year up to 2025. This number is on par with the number of projects that are currently being developed (or are announced) and an average lead-time of 2 years for these kinds of projects. As indicated earlier, there are likely to be more 5 MW projects being developed than those that have been announced publicly.

In addition, it is highly unlikely that any projects between 5 and 10 MW will be built, as they are likely either reduced to 5 MW or split-up to make the connection process easier and less costly.

For projects larger than 10 MW we assume that roughly 20% of the current pipeline will be completed over the next five years. For projects between 10 and 20 MW this assumption equals 15 MW per annum (about 1 project per year) and for 20 to 30 MW this is 25 MW per annum (about 1 project per year).

11. Projections Summary

This section presents the results of the mid-scale PV projections. All results are presented in calendar years.

Table 18 summarizes our projected installed capacity of mid-scale systems over the 5-year period by segment, and Table 19 lists the projection by capacity band. The estimates on actual installations are outlined in Appendix C.

Table 18: Summary of projected capacity of mid-scale PV installations 2021-2025, MW

	2021	2022	2023	2024	2025
Behind-the-meter systems					
Education – Schools	4	5	5	5	5
Education - Universities	3	1	1	1	1
Airports	12	1	1	1	1
Other industries	74	112	111	101	109
Front-of-meter systems					
Ground Mounted <=5MW	5	8	4	4	3.5
5 MW Systems	0	40	40	40	40
5-10 MW Systems	67	0	0	0	0
10-20 MW Systems	27	26	15	15	15
20-30 MW Systems	0	25	25	25	25
Total	180	218	202	192	199

Table 19: Summary of projected capacity by capacity band of mid-scale PV installations 2021-2025, MW

	2021	2022	2023	2024	2025
100 kW to <5 MW	85	126	122	112	119
5 MW	0	40	40	40	40
5 MW – 10 MW	67	1	0	0	0
10-20 MW	27	26	15	15	15
20-30 MW	0	25	25	25	25
Total	180	218	202	192	199

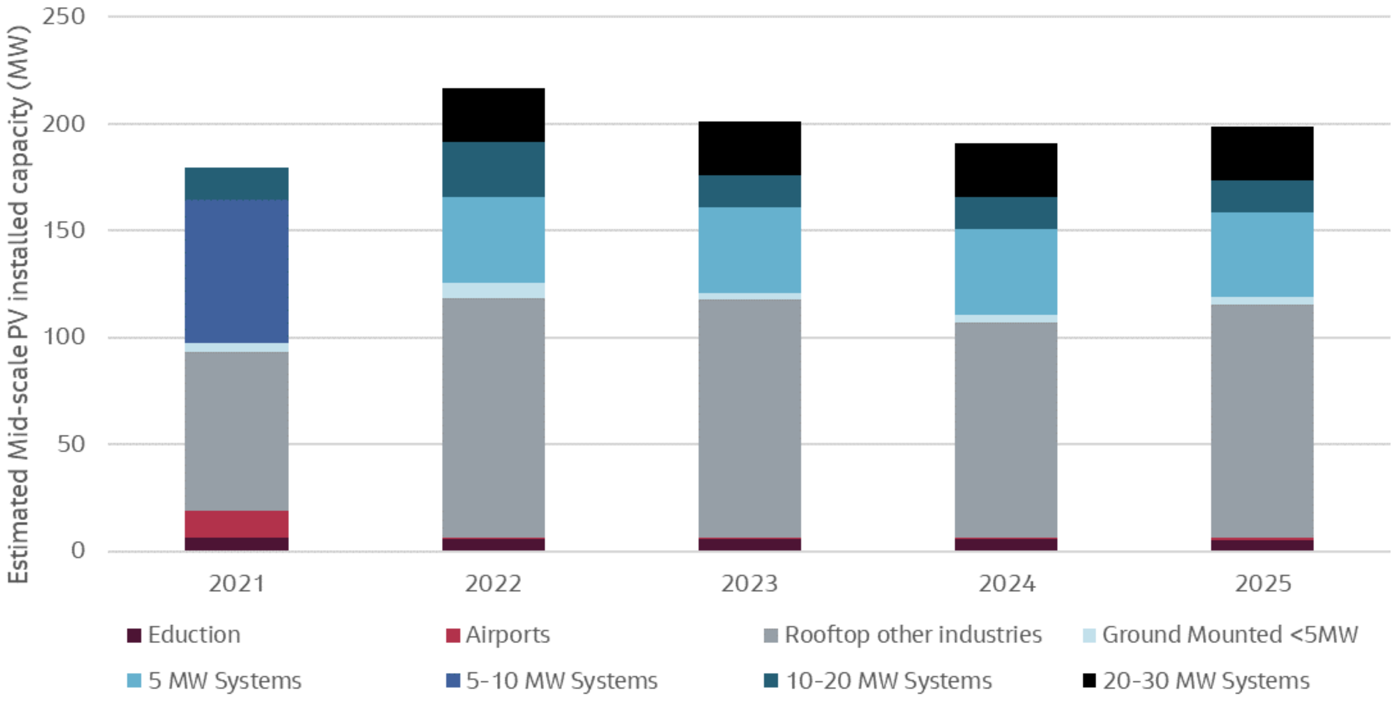
With only 1,107 recorded installations out of a total estimated market size of 11,654 suitable premises (excluding the education sector and in front of the meter systems), there is still substantial room for growth within the mid-scale PV behind-the-meter sector.

Projected installations are dominated by the commercially installed behind-the-meter systems, 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 is both economic and practical.

Actual returns on investment for commercial businesses for the installation of a mid-scale system are estimated to be approximately 11% in 2021 and are expected to improve over the forecasting period to 12% in 2025, driven by the continued decline in capital cost of solar panels and eventual increase in wholesale prices following the retirement of Liddell coal fired power station in 2023. These factors, and the recovery of the economy is expected to continual to increase growth in this sector over the projection period (Figure 8).

With recent connection issues regarding large scale solar projects, deteriorating marginal loss factors and recent extensive curtailing of large-scale solar generation, development companies are pushing the risk of meeting grid connection technical standards back onto the project owners. This has opened the opportunity for sub 5 MW systems to act on the wholesale market by circumventing some of these network connection issues. There are considerable proposed <5 MW plant that are expected to be built over the projection horizon, which we expect to largely replace the utility systems from 5-30 MW in size.

Figure 8: Projected installed capacity of 100 kW-30 MW PV systems by segment, MW



Appendix A. Ground Mounted 5-30MW Project Assumptions

Table 20: Australian ground mounted utility and community scale solar PV projects between 5 and 30 MW capacity

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
Batchelor SF	NT, Batchelor	NT Solar Investment/ENI (acquired from Tetris on 3/10/2019)	10	Announced	Completion by 3rd quarter 2020		Eni/ Tetris websites
Bell Bay SF	Tas, George Town	Climate Capital	5	Announced		Council approval application submitted in July 2020	Reneweconomy
Bergalia SF	NSW, Moruya	Rio Indygen	10	Announced		Latest news dates to Feb 2019	Rio Indygen/ Reneweconomy
Boma SF	Qld	Solis Industria	15	Announced			AEMO
Bordertown SF	SA, Bordertown	Tetris Capital	5	Announced, under development		In collabo-ration with Tatiara District Council	Tetris website
Brocklehurst SF	NSW, Brocklehurst	Unknown	29	Announced			AEMO
Carag Carag SF	Vic, Stanhope	Enerparc	12	Announced		Planning approved May 2019	Vic planning website
Congupna SF	Vic, Shepperton	X-Elios	30	Approved		Approved by VIC state Government in Oct 2018	AEMO/ Reneweconomy
Coonalpyn SF	SA, Coonalpyn	Flow Power	5	Construction	Mid-2021	Acquired from Tetris	Tetris/ Reneweconomy

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
				commenced			
Daisy Hill SF	NSW, Hillston	VivoPower	5	Announced		Under development, expected to receive connection approval in next few months	Reneweconomy
Dalby SF	Qld, Dalby	FRV	30	Announced		Announced back in July 2016, no mention on FRV website	AEMO/ Reneweconomy
Eurobodalla SF	NSW, Eurobodalla Shire	Rio Indygen	10	Announced			Reneweconomy
Fifth Street Merebin SF	Vic, Mildura	Powervault Global	7.5	Announced			Vic planning website
George Town SF	Tas, George Town	Epuron	5	Announced, planning approval		Planning approval received 18 April 2018	AEMO/ Epuron website
Gidginbung SF	NSW, Gidginbung	Epho	15	Announced, planning approval		Planning approval received in May 2016 Project website offline	AEMO/ Aussierenewables website
Girgarre SF project 2	Vic, Girgarre	ACEnergy	5	Announced		Planning approval received	Vic planning website
Greengold Numurkah SF	Vic, Numurkah	GreenGold Energy	5	Announced			Vic planning website

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
Greentech 2 SF	Vic, Yarroweyah	ACEnergy	5	Announced		Planning approval received July 2019	
Greentech 3 SF	Vic, Rochester	ACEnergy	5	Announced		Planning approval received	Vic planning website
Greentech 5 SF	Vic, Shepparton	ACEnergy	5	Announced		Planning approval received	Vic planning website
Greentech 6 SF	Vic, Tatura	ACEnergy	5	Announced		Planning approval received	Vic planning website
Greentech 8 SF	Vic, Raywood	ACEnergy	5	Announced			Vic planning website
Guryere mine SF	WA, Cosmo Newbery	APA	13	Announced			PV magazine
GVCE Mooroopna SF	Vic, Shepparton, Moorroopna	GV Community Energy/ Akuo Energy	17.5	Announced	2021-22	Planning permit submission June 2020 Construction 2021	AEMO/ GVCE Mooroopna solar website
Inverleigh SF	Vic, Inverleigh	Inverleigh Wind Farm	19	Announced			Vic Planning website
Junee SF	NSW, Junee	Terrain Solar	30	Under construction	2nd half 2020	10 year PPA with Coles	Terrain Solar website/ AEMO
Katamatite Project	Vic, Katamatite	ACEnergy	5	Under construction			Vic planning website
Katherine SF	NT, Katherine	Eni/ Jacana Energy	25	Under construction	2020	Develop-ment approval Feb. 2017	Eni/ Epuron websites

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
						Sold by Epuron to Eni Feb 2019 12-year PPA Jacana Energy	
Kennedy Energy Park Solar	Qld, flinders Shire	Windlab/ Eurus	15	Committed	Oct 2020		AEMO/ Kennedy Energy Park website
Kingaroy SF	Qld, Kingaroy	Metka EGN	30	Announced		Developed by Terrain Solar, bought by Metka EGN in 2019	AEMO/ Terrain Solar website
Lakeland 2	Qld, Lakeland	Green Investment Group (GIG)	20	Announced		GIG is owned by Macquarie and acquired Conergy Australia Aug 2018	PV-magazine-Australia/ AEMO/ Aussie Renewables websites
Ledcourt SF	Vic, Stawell	Neoen	5	Approved		Approved Nov 2020	Vic planning website
Leeton SF 1	NSW, Leeton	Photon	5	Construction started	2021		Photon
Leeton SF 2	NSW, Leeton	Photon	5	Construction started	2021		Photon
Maffra SF	Vic, Maffra	ARP Australian Solar	30			Planning approval received July 2018	Vic planning website
Mannum SF	SA, Mannum	Canadian Solar/ Tetris/ Flow Power	30	Announced		Phase 1 (5 MW) completed, this is phase 2.	Tetris website

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
						Acquired by CS	
Manton Dam SF	NT, Manton Dam	NT Solar Investments/ Eni	10	Announced	2022	According to Eni to be completed by 3rd quarter 2020, acquired from Tetris on 3 October 2019	Eni and Tetris website
Maxwell SF	NSW, Muswellbrook	Malabar Coal	25	Announced		EIS submitted and being assessed by state government, public consultation completed	Malabar Coal website, AEMO, NSW planning dept.
Moama SF	NSW, Moama	Metka EGN	30	Announced, awaiting grid connection approval		Acquired from Terrain Solar, PPA with Coles, construction likely to start 2nd half of 2020	Terrain Solar, Seymour Telegraph, AEMO
Mokoan SF	Vic, Glenrowan	Lightsource BP	30	Announced		Planning approval received	Vic planning website
Mokoan SF 2	Vic, Glenrowan	Lightsource BP	30	Announced			Vic planning website
Moorambilla SF	NSW, Coonamble	unknown	5	Announced, planning approval		Planning approval received by NSW Gov. in	AEMO, NSW planning website

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
						December 2017	
Nana Glen SF	NSW, Nana Glen	Rio Indygen	17	Announced			Reneweconomy
Newstead SF	Vic, Newstead	Renewable Newstead	10	Announced			Vic planning website
Nhill SF	Vic, Nhill	Vibe Energy	5	Announced			Vic planning website
Numurkah Project	Vic, Numurkah	ACEnergy	5	Announced		Planning approval received	Vic planning website
Numurkah Project 2	Vic, Numurkah	ACEnergy	5	Announced		Planning approval received	Vic planning website
Orange Community Renewable Energy Park	NSW, Orange	ITP Renewables	5	Announced		Development application submitted in Jan 2020	Reneweconomy, ocrep.co.au
Ouyen SF	Vic, Ouyen	Future Energy/ BayWa r.e. (?)	10	Announced		Development application approved	VIC Planning, AEMO, Energymatters.com.au
Padthaway SF	SA, Padthaway	Tetris	5	Announced		Received development approval and offer to connect	Tetris website
Peak Hill SF	NSW, Peak Hill	Enerparc	5	Under Construction	Summer 2020		Enerparc, Reneweconomy websites
Red Cliffs SF	Vic, Mildura	Australian Solar Group	28	Announced		Planning approval received October 2015	Vic planning website

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
SA SF 1	SA	MPower/ Astroenergy	5	Announced		Design & Construction in 2020	Reneweconomy
SA SF 2	SA	MPower/ Astroenergy	5	Announced		Design & Construction in 2020	Reneweconomy
Stanhope SF	Vic, Stanhope	Globird	30	Announced		Planning approval received March 2020	Vic planning website
Stanhope Project 2	Vic, Stanhope	ACEnergy	5	Announced		Planning approval received June 2019	Vic planning website
Stanhope Project 3	Vic, Stanhope	ACEnergy	5	Announced		Planning approval received	Vic planning website
Stanhope Project 4	Vic, Stanhope	ACEnergy	5	Announced		Planning approval received	Vic planning website
Stanhope Project 5	Vic, Stanhope	ACEnergy	5	Announced		Planning approval received	Vic planning website
Summerhill SF	NSW, Newcastle	City of Newcastle	5	Announced			AEMO, PV Magazine
South Fremantle SF	WA, Freemantle	Epuron	5	Announced		Planning approval received 13 April 2018	Epuron website
SSE 331 Sydney Road SF	Vic, Benalla	SSE Australia	5	Approved		Approved August 2020	Vic planning website
Tallygaroopna SF	Vic, Tallygaroopna	X-Elio	30	Announced		Planning approval received	Vic planning website

Project name	State/ Location	Developer and/or Owner and/or EPC	Namepla te Capacity (MW AC)	Stage	Planned	Note	Source(s)
Toolern Vale SF	Vic, Toolern Vale	Tetris	16	Announced		Environ-metal assessment completed, start of connection agreement process	Tetris
Trundle Hill SF	NSW, Trundle	Enerparc	5	Under constructio n	Summer 2020		Enerparc website, Renew-economy
Upper Hunter Energy Park SF	NSW, Scone	Pamada	10 - 25	Announced	Mar 2021	Stage 1: 10 MW, stage 2: 25 MW, stage 3: 35 MW	Pamada website, AEMO
Vacy SF	NSW, Dungog	Rio Indygen	25	Announced			Reneweconomy
Wagga Wagga SF	NSW, Wagga Wagga	Metka EGN	30	Under constructio n		Sold to Metka EGN by Terrain solar	Terrain Solar website, AEMO
Walgett SF	NSW, Walgett	Epuron	26	Announced	2020	Developme nt approved on 14 July 2017	Epuron website, AEMO
Wangaratta SF	Vic, Wangaratta	Sun Farms Australia/ Energy Estate	29.9	Announced		Constructio n in Q3 of 2020	Reneweconomy
Wesley Vale SF	Tas, Wesley Vale	Epuron	12.5	Announced		To be built in stages, may include storage in the future	Epuron website, AEMO
Whyalla SF	SA, Whyalla	SSE Australia	12	Announced		Total 18 MW, Stage 1 6MW is operational	Whyalla council website, SSE, AEMO

Project name	State/ Location	Developer and/or Owner and/or EPC	Nameplate Capacity (MW AC)	Stage	Planned	Note	Source(s)
Wungnhu SF	Vic, Wungnhu	ACEnergy	5	Announced		Planning approval received April 2019	Vic planning website
Yoogali SF	NSW, Griffith	VivoPower	15	Announced		Developer is considering breaking-up project in smaller 5 MW parts	Reneweconomy

Appendix B. Top Australian Airports by Passenger Number

Total passenger numbers include both domestic and international travellers. Note that the total passengers for the 12 months to March 2021 are impacted by Covid measures such as closure of international borders and also of domestic borders where appropriate. In the analysis, we assume that the top 20 airports are suitable for rooftop PV installations and that passenger numbers will rebound into the medium term as borders begin to reopen.

Airport Location	Total Passengers for year ended March 2020	Total Passengers for year ended March 2021*	Current installed PV capacity
SYDNEY	42,439,936	4,203,894	550 kW
MELBOURNE	35,549,974	3,356,608	12.4 MW
BRISBANE	23,292,632	4,957,063	6MW
PERTH	12,190,384	2,077,996	
ADELAIDE	8,225,943	1,616,454	1,283 kW
GOLD COAST	6,274,787	970,495	
CAIRNS	4,556,424	1,311,419	
CANBERRA	3,118,331	618,255	
HOBART	2,693,915	595,447	
DARWIN	1,931,763	572,213	4,000 kW + 1,524 kW
TOWNSVILLE	1,580,445	682,283	
LAUNCESTON	1,336,438	317,576	
SUNSHINE COAST	1,238,780	265,081	
NEWCASTLE	1,231,933	265,713	
MACKAY	832,985	414,090	
ROCKHAMPTON	558,888	251,199	235 kW + 651 kW
BALLINA	520,419	444,223	
ALICE SPRINGS	510,327	190,158	
AYERS ROCK	468,309	32,418	1,000 kW
KARRATHA	465,225	253,970	

**Number impacted by COVID-19. Source compiled from the Bureau of Infrastructure, Transport and Regional Economics, https://www.bitre.gov.au/publications/ongoing/airport_traffic_data.aspx*

Appendix C. Projected number of mid-scale installations

Table 21: Projected numbers of mid-scale PV installations by segment, 2021-2025

	2021	2022	2023	2024	2025
Behind-the-meter systems					
Education – Schools	12	24	17	17	15
Education - Universities	2	1	1	1	1
Airports	1	1	1	1	1
Other industries	171	158	173	192	211
Front-of-meter systems					
Community <=5MW	7	6	5	5	5
Utility 5MW System	0	8	8	8	8
5-10 MW Systems	10	0	0	0	0
10-20 MW Systems	1	2	1	1	1
20-30 MW Systems	0	1	1	1	1

Table 22: Projected numbers of mid-scale PV installations by capacity band, 2021-2025

	2021	2022	2023	2024	2025
100kW to <5MW	192	190	197	216	233
5 MW	0	8	8	8	8
5MW – 10 MW	10	0	0	0	0
10-20 MW	2	2	1	1	1
20-30 MW	0	1	1	1	1
Total	204	201	207	226	243